STUDENTS' UPTAKE OF PHYSICS: A STUDY OF SOUTH AUSTRALIAN AND FILIPINO PHYSICS STUDENTS

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Chapter 1

Issues in Physics Education

1.1. Introduction

One of the problems that confront physics education, whether it is in high school or university level, is whether students' choose to enrol in physics courses or not. This has been a focus of science education researchers for several decades, but despite the perceived social and economic importance of physics (which will be discussed in more detail in the later parts of this chapter), over the years students seem to have developed a *dislike* for this field of Science. This presents a problem for a number of aspects of our society, especially the economic aspect, so this negative social impact clearly demands attention from educationalists, policy makers, and the public in general.

Declining physics enrolments

It seems that a subject's or a course's perceived difficulty can overshadow its importance in terms of its usefulness in the society (see Stables & Wikeley, 1997). Physics is a good example. Physics has always been perceived by most students as a difficult subject or area of study, especially because of its mathematical component. Unfortunately though, as mentioned earlier physics' contribution to the progress of science and technology cannot be denied, and the perception of its difficulty has led to a wide-spread problem with the decreasing student interest in physics as a course, and as a career, since the early 1960s. This has occurred in many countries, including the United States, England and Germany (see Strassenburg, 1968).

Over the years, this problem of students losing interest in physics has worsened. Many countries have reported a downward trend in physics enrolments, particularly where the educational system is characterised by a great freedom of choice, so this decline has been particularly observed in many Western countries (Jorgensen, 1998). In the USA, for instance, physics is an elective subject in high schools. Only those who plan to enrol in science and technology courses at university level study physics in high school, and for many of them the choice of physics is only because it is an entrance requirement to university courses (e.g. engineering, applied sciences, etc) (Woolnough, 1994). In the UK, Bell (2001) examined the patterns of Year 11 students' subject uptake, and examination entry from 1984 to 1997 and found that there was a drop of physics uptake of over 27% during this span of time. This declining pattern is also shown in Reid and Skryabina's (2002) study on students' attitudes towards physics also carried out in the UK (see Table 1.1b). Later, Osborne (2003) showed that the percentage of English and Welsh students pursuing science, or science and mathematics, into the senior secondary school level has declined by more than one-half. Furthermore, Osborne highlighted in his report that analysis by gender showed that the male to female ratio of students in physics remained high at around 3.4:1. A review of a number of research endeavours on students' physics choice, and students' attitudes towards physics, by Angell, Guttersrud, Henriksen, and Isnes (2004) confirmed this under-representation of girls in physics education. In addition, Millar and Toscano (2006), through an Institute of Physics (IOP) commissioned report, found that during the previous decade there has been a decline in recruitment in A-level physics, particularly for girls, which had resulted in the closure of several university physics departments. Some of the trends mentioned above are shown in Figure 1.1a and 1.1b.

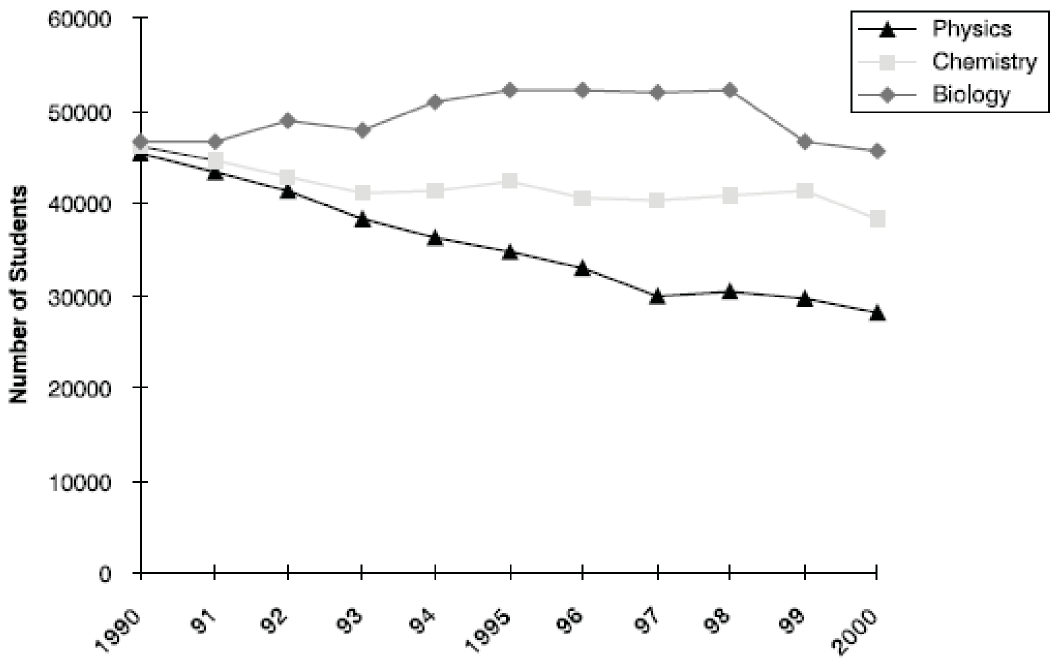


Figure 1.1a. Data for number of students examined in physics, chemistry and biology from 1990 to 2000 in England and Wales at A-Level (Adapted from Osborne et al., 2003)

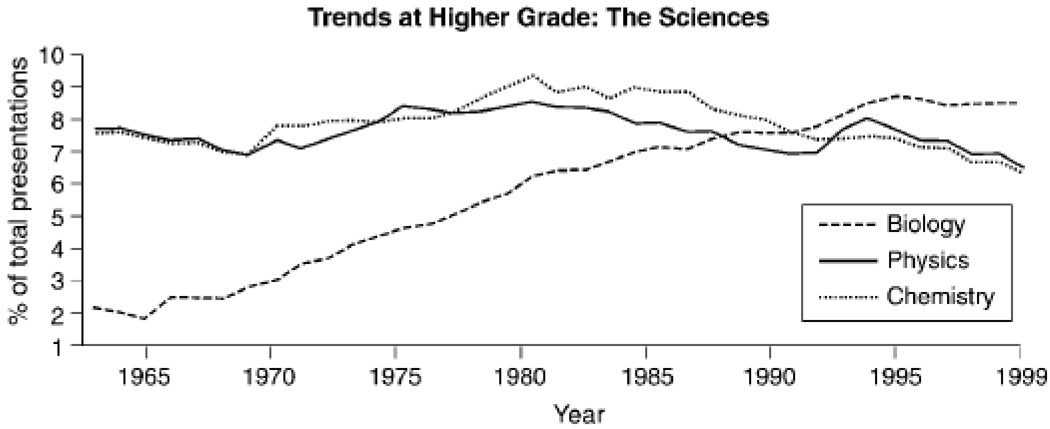


Figure 1.1b. Distribution of entries in Higher Grade Physics, Chemistry and Biology for the last 36 years in the UK (Adapted from Reid & Skryabina, 2002).

As enrolments decrease it is obvious that the declining participation of students in physics in both school- and university-level studies will result to shortages of staff and personnel in workplaces which need someone who has qualifications in physics, including physics departments in universities. Because of these declining numbers, Government initiatives have been put in place to attract and retain people who have physics qualifications, especially women who always seem to be under-represented in this field of science (D'Iorio et al., 2002). In Canada, an example of such initiative was one that was instituted by the Natural Sciences and Engineering Research Council for women in physics that offered salary support, a guaranteed research grant, and a tenured position at the end of the program. This shows how the urgent need and importance of physics and what governments need to undertake to attract and retain qualified people in physics, especially women.

Recognition of the importance of physics

As mentioned earlier, physics – widely recognized to be the most fundamental of all the sciences – has also been recognized as the foundation of our society (Pravica, 2005). Even if perhaps the society does not realise it, many of the advances in science and technology that we know and enjoy today have been the result of scientific research where physics played a key role. In addition, it is believed that knowledge of physics and physics-related sciences are indispensable in many professions and for economic development (Stokking, 2000). Abdus Salam (in Ford and Wilde, 1999, p. 215), a Nobel Prize winner in physics in 1979, wrote in a book: "If a nation wants to become wealthy, it must acquire a high degree of expertise in physics, both pure and applied."

Researchers like Zohar and Bronshtein (2005) support this belief by asserting that a shortage of qualified professionals in physics and physics-related fields may hamper the economic improvement of a country. To further support this claim about the importance of physics (and other *hard* sciences, such as Chemistry) to the economic growth of a country, Rodriguez Espinosa (2005) reviewed two studies carried out by the Committee on Economic Development and the Science Committee of the U.S. Congress. He noted that both studies concluded that the economic return of investments in Science, particularly physics, had been in the order of 30% per year, consistently over the previous 50 years. According to Rodriguez Espinosa (2005), this figure is significantly higher than the return of investments in more traditional activities (such as tourism and the arts), which is about 10% per year when the economy is in the period of growth. He added that a good example to illustrate the economical benefits derived from physics on the technological advances that contribute to economic drive is the development of the Global Positioning System (GPS). The GPS system would not be possible without an understanding of the Theory of Relativity and the concept of the Atomic Clocks. This navigation system has improved so much in terms of its accuracy, speed, graphics and ease of use since its market debut, and has gained great popularity resulting in a skyrocketing demand.

In the UK, physics-based industries (PBI), such as photonics and nanotechnology, continue to play an increasingly important role in the country's manufacturing and the economy (The Institute of Physics, 2003).

Physics is not only important to a country's economic progress; it is also important to individuals to be able to cope up with the rapidly changing society as a result of advances in technology. Goodstein (1999, p. 186) believes that "a solid education in physics is the best conceivable preparation for the lifetime of rapid technological and social change that our young people must expect to face."

But who is going to provide even the most basic foundation of physics knowledge if there are a decreasing number of physics teachers to staff science classes in physics? Even in the most recent times, this problem, where schools are struggling to adequately staff science classes in physics and other *hard* science such as Chemistry, has been reported by many educational researchers (e.g. Harris & Farrel, 2007). Clearly, something needs to be done to address this problem.

The role of physics in our society

It can be argued that Science in general, and physics in particular, has always played a key role in the development of our society in terms of the technological advances that brought to human existence many of our conveniences, and, at the same time, raised global-scale issues resulting from these advances. An example could be the development of the automobile. The automobile has become a very important necessity in many people's lives because of the convenience and the utility it provides when going places. However, there would be widespread agreement that it is also one of the key contributors to what has become a major global issue: that of *Global Warming*. There are many other technological advances which, through physics, have enriched our modern society, and physics, as a fundamental science, has made a big contribution to changing the way we live in the present times as compared to the way people lived, say, fifty years ago. Because of physics we are now living in what others would call a technological society. Of all the sciences, physics is at the heart of the technology driving our economy (National Research Council, 2001) and is present in almost every facet of modern life. In other words, physics is a very important science applied in engineering and in the design aspects of different technologies. That is, physics can be seen as related to the fundamental understanding of phenomena and these ideas are then picked up and applied to technologies. Physics may also be considered the most fundamental of all the sciences because others like Chemistry, Biology, Geology, etc., deal with systems that obey laws of physics. This is one of the reasons why physics has become an essential part of being *scientifically literate*.

In order to cope with the demands of a technological society, it is important that an individual is scientifically literate. This has been a common theme presented in large scale studies such as the Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), and education programs such as the 'Science, Technology, Engineering and Mathematics' (STEM). The PISA report released by the Organisation for Economic Cooperation and Development (OECD) stressed the importance of scientific literacy by stating that "...science and technology are so pervasive in modern life that it is important for students to be 'literate' in these areas" (Thomson & De Bortoli, 2008, p.ii). The importance of science (along with mathematics) was also highlighted in the TIMSS which, through the International Association for the Evaluation of Educational Achievement (IEA), aims to improve teaching and learning in science and mathematics for students around the world (Thomson & Buckley, 2007). The STEM education programs were conceived and implemented in a number of countries, including the United States and Australia in recognition of the importance of science, technology, and mathematics for economic growth. In the United States for instance, STEM education programs are being implemented because of the concern that the country, playing a role as leader in scientific innovation, is not preparing enough students, teachers and practitioners in the areas of science, technology, engineering and mathematics (Kuenzi, 2008). In Australia, STEM (where 'S' consists of the 'enabling sciences' including physics) are important as they are considered as key drivers of innovation that drives economic growth (Department of Education, Training and the Arts, 2007). It is therefore very important that physics education must have a goal of providing the society with broad scientific literacy at all levels (National Research Council, 2001). Because of the significant changes in the environment and society over the past many years, science (and, therefore, physics) education has to be changed to make it effective and relevant for a much larger fraction of the student population (Wieman & Perkins, 2006). These changes in the environment and society that necessitate change in science education, as outlined by Wieman and Perkins (2006, p. 36), are as follows:

- Society now faces critical global-scale issues that are fundamentally technical in nature – for example, climate change, genetic modification, and energy supply. Only a far more scientifically and technically literate citizenry can make wise decisions on such issues.
- Modern economies are so heavily based on technology that having a better understanding of science and technology and better technical problem-solving skills will enhance a person's career aspirations almost independent of occupation.
- A modern economy can thrive only if it has a workforce with high level technical understanding and skills.

It is apparent from the above dot-points that knowledge of fundamental science is necessary for every individual and especially for policymakers if they are to ensure economic security. This is especially highlighted in Richter's (1995) article about the role of science in the society: for instance (p. 44):

> Science *enables* industry to develop new technologies, and to reduce scientific discovery to practical applications effectively and quickly, there must be a continual interaction between scientists in the laboratory and engineers in industry.

From a non-economic point of view, keeping students' interest in Science, particularly Physical Sciences, at a high level is important not only for the continuity of scientific endeavours but also to ensure scientific literacy of future generations (Trumper, 2006). With a relative abundance of recent literature on scientific literacy, it is just fitting to discuss this concept in more detail and how it ties up to this study.

Scientific literacy

The term *scientific literacy*, or *scientifically literate*, has been mentioned in the preceding section of this chapter and in many articles relating to science and the society. So what is it? How is it important? Scientific literacy is a concept that broadly covers several ideas such as the exposure to science knowledge, technology and mathematics, the usefulness of science to peoples' daily lives, and the integration of science into knowledge systems (Popli, 1999). However, since it was illustrated earlier how physics plays an important role in both technology and the economy, it seems important, therefore, that a significant "portion" of being scientifically literate will involve knowledge in physics.

Scientific literacy has become one of the well-known slogans or catch-phrases within the educational community around the world (Laugksch, 2000) for more than 20 years, although the term first appeared in a publication by Paul Hurd during the late 1950s (DeBoer, 1991; Roberts, 1983, cited in Laugksch, 2000). There are several definitions of the term *scientific literacy*. One of the more simple definitions was provided by Durant (1993, p. 129) where scientific literacy is "what the general public ought to know about science." A more detailed, but relatively comprehensible, definition was provided by Hurd (1998, p. 410) who defined scientific literacy as a concept "seen as a civic competency required for rational thinking about science in relation to personal, social, political, economic problems, and issues that one is likely to meet throughout life." This definition implies that scientific literacy empowers an individual to be aware of the issues/problems in his/her surrounding environment, and to participate and contribute to the decision making to address them. In other words, a person can ask questions, many times out of curiosity, about everyday experiences or natural phenomena and be able to describe and explain them. However, these descriptions of the concept of scientific literacy may be too limited to cover everything that pertains to it since the concept itself has earned quite different interpretations from other authors. This was highlighted in Laugksch's (2000) review of literature in a paper he wrote about scientific literacy. In this review, Laugksch cited Lawrence Gabel who, in his doctoral thesis, based his theoretical model of the concept "based on a large dataset of interpretations of the meaning of scientific literacy" (p. 72). Since it has been established that the concept of scientific literacy is broad, it can be concluded that a person who is scientifically literate possesses a lengthy list of attributes. Hurd (1998, pp. 413-414) listed 25 characteristics of a scientifically literate person that, according to him, may also serve as a guideline for re-inventing the science curricula in schools. These focus on science knowledge (i.e., their internal and external relationships) and science processes. Hurd defined a scientifically literate person to be one who:

- distinguishes experts from the uninformed.
- distinguishes theory from dogma, and data from myth and folklore. Recognizes that almost every fact of one's life has been influenced in one way or another by science/technology.
- knows that science in social contexts often has dimensions in political, judicial, ethical, and sometimes moral interpretations.
- senses the ways in which scientific research is done and how the findings are validated.
- uses science knowledge where appropriate in making life and social decisions, forming judgments, resolving problems, and taking action.
- distinguishes science from pseudo-science such as astrology, quackery, the occult, and superstition.
- recognizes the cumulative nature of science as an "endless frontier."
- recognizes scientific researchers as *producers* of knowledge and citizens as *users* of science knowledge.
- recognizes gaps, risks, limits, and probabilities in making decisions involving a knowledge of science and technology.
- knows how to analyse and process information to generate knowledge that extends beyond facts.

- recognizes that science concepts, laws, and theories are not rigid but essentially have an organic quality; they grow and develop; what is taught today may not be the same meaning tomorrow.
- knows that science problems in personal and social contexts may have more than one "right" answer, especially problems that involve ethical, judicial, and political actions.
- recognizes when a cause and effect relationship cannot be drawn. Understands the importance of research for its own sake as a product of a scientist's curiosity.
- recognizes that our global economy is largely influenced by advancements in science and technology.
- recognizes when cultural, ethical, and moral issues are involved in resolving science-social problems.
- recognizes when one does not have enough data to make a rational decision or form a reliable judgment.
- distinguishes evidence from propaganda, fact from fiction, sense from nonsense, and knowledge from opinion.
- views science-social and personal-civic problems as requiring a synthesis of knowledge from different fields including natural and social sciences.
- recognizes there is much not known in a science field and that the most significant discovery may be announced tomorrow.
- recognizes that scientific literacy is a process of acquiring, analysing, synthesizing, coding, evaluating, and utilizing achievements in science and technology in human and social contexts.
- recognizes that symbiotic relationships between science and technology and between science, technology, and human affairs.
- recognizes the everyday reality of ways in which science and technology serve human adaptive capacities, and enriches one's capital.
- recognizes that science-social problems are generally resolved by collaborative rather than individual action.
- recognizes that the immediate solution of a science-social problem may create a related problem later.
- recognizes that short- and long-term solutions to a problem may not have the same answer.

The list can be summarised, according to Hurd, as the cognitive insights needed by students to select, organise, and utilise science knowledge for a productive life. A person possessing most, if not all, of these attributes of a scientifically literate person can be considered as essential for an ideal citizen of a society. Therefore, scientific literacy is key to good citizenship (Lee & Roth, 2003). In addition, scientific literacy promises an outlook for a better world (Hobson, 2003). In order to achieve this, citizens of our modern society, particularly school-aged children, need a good education in science to become aware of the importance of science in our lives. However, a major challenge confronting the science education community is attracting more students to study science, particularly physics.

One curriculum reaction to this need for scientific literacy has been through the Science, Technology and Society (STS) approach. In science and technology education, the STS approach aims to provide scientific literacy by focusing on what the student needs and not on using pure science content (Aikenhead, 1994). Science knowledge is not presented solely in abstract form, but in a practical way where it is linked to both technological development and related social implications (Dawson, 2003). In addition, Dawson pointed out that this approach not only increases the students' scientific literacy but also their critical thinking skills. However, Dawson also added that despite growing evidence that STS approaches can generate high levels of interest, they are not evident in most current science curricula.

Based on the list above, one could argue that a person does not really need physics to be scientifically literate. In other words, one could study only Biology (where there is a positive enrolment trend) or only Chemistry to become scientifically literate. So why then is physics important in scientific literacy? Studying Biology or Chemistry only does not provide a well-rounded approach to scientific literacy. This is not to undermine biology and chemistry but physics "has led to developments in technology, some of which (for example, radio communications and electrical appliances) have had a profound impact on social structures" (Board of Studies, 1994, in Wilkinson, 1999, p. 388). Therefore, physics is an essential part of being scientifically literate. Scientific literacy cannot be complete with one essential part missing. According to Popli (1999, p. 131)

> ...without knowledge of elementary chemistry (elements, compounds, reactions, proteins, etc.), physics (the motion of bodies, density, temperature, pressure, etc.), and biology (human anatomy, physiology, cells, genes, the transformation of energy, etc.), [Scientific Literacy] cannot be complete; even

> matters like health, environment, and agriculture in the context of today's and tomorrow's world cannot be discussed adequately.

Knowledge of physics empowers people with awareness of technological principles that could serve as "sound basis for assessing the use of new technologies and their implications for the environment and culture" (Eisenhart, Finkel & Marion, 1996, p. 264). With all these reasons, it is important to keep a reasonable number of people to study physics at basic or advanced levels to sustain the skills needed in the engineering and technological industries and in the academia. "The physics students of today are tomorrow's scientists, engineers, medical doctors and teachers at the secondary and tertiary levels." (UNESCO, 2005, p. 2).

1.2. Statement of the problem

Despite the importance of physics in the society, student participation has been declining. This is clearly a problem that should be addressed. Of primary concern is the attitudes of students towards physics that could influence their uptake of the subject. Thus, the main thrust of this study is to examine the attitudes of students towards physics. It is imperative that students' avoidance of physics could be caused by their negative attitudes towards it. Certainly, they are influenced by a number of factors.

The following sections highlight some figures and facts that prompted the researcher to carry out this study. The focus of the study is also implied. Moreover, the locations where the study was carried out are defined and elaborated.

The need to examine the problem

With the different statistics outlined in the earlier part of this chapter on the declining numbers of students opting to choose physics in senior school years and university levels, it is evident that it is necessary to probe deep into the problem to determine what may have caused it. Finding what may have caused the problem may lead to possible solutions to address it. As a fundamental science, physics is one of the major keys to technological and economic progress of our society. Therefore, losing more people, particularly students, participating in physics poses a major threat to achieving this goal of technological and economic progress.

Since the 1960s, researchers in science education started to conduct studies on students' perceptions of the difficulty of different subjects. In science, the subjects perceived by students to be difficult are sometimes called the *hard* sciences. Related research, aimed at investigating reasons for the perceived difficulty included the influence of school-related factors such as teachers (e.g. Trumper, 2006; George & Taylor, 2001) and school effects (e.g. Smyth & Hannan, 2006), parental effects (e.g. McNeal, 1999; Dryler, 1998), and students' perceptions of, and attitudes towards, the different sciences (e.g. Trumper, 2006). In addition, researchers have also taken interest in the differences between males and females with regards to their choice of school science subjects and their perceptions of science (Murphy & Whitelegg, 2006). This is due to the highly publicised under-representation of females in physics (see e.g. Ivie & Stowe, 2000; Feder, 2002; Women in Physics, 2002; Women in Physics in South Africa, 2005) and in other technology-enhanced science careers (e.g. Mayer-Smith et al., 2000).

Unsurprisingly, the majority of the research carried out to examine these factors and their effects on students' uptake of *hard* science, particularly physics, by secondary and tertiary school students were mostly done in European and North American countries. Similar research is slowly picking up in Australia, but only a few studies have been carried out in Asian countries. This posits interesting research considering the fact that students from Asian countries topped the recent TIMSS (Gonzales, Guzmán, Partelow, Pahlke, Jocelyn, Kastberg, & Williams, 2004) and PISA (OECD, 2004) studies. In addition, examining the attitudes of students towards physics from a combination of Asian and Western perspectives could shed light on questions about what factors affect their choice of physics at schools/universities. These are few of the reasons why this study was carried out at selected schools and universities from Australia and the Philippines. These two countries have major differences in terms of their education systems and culture. Although the Philippines has an education system established by the United States (hence, its relation to the American system of education) after the Second World War (Congressional Commission on Education, 1993), it could be argued, however, that it is still different in a number of ways due to cultural differences.

For many years researchers have examined students' declining interest in physics in many countries (Perkins et al., 2006). However, information as to what the cause of this decline is still fragmented and further research is needed with a focus on a number of factors which might cause it. By examining the trend in physics participation in two countries with different cultural backgrounds, socio-economic status and educational system more information could be extracted to explain this declining trend.

Physics enrolment trend in Australia

In Australia, the Federal and State levels of the policy on science and technology have generally agreed about the importance of science education (Dekkers & De Laeter, 2001) to drive and maintain its strong economy. Dekkers and De Laeter, 2001, p. 488) further added that

> The scientific community in Australia has made a number of significant contributions to science education at both the primary and secondary school levels to ensure that science education features prominently in schooling and that curricula are appropriate and relevant.

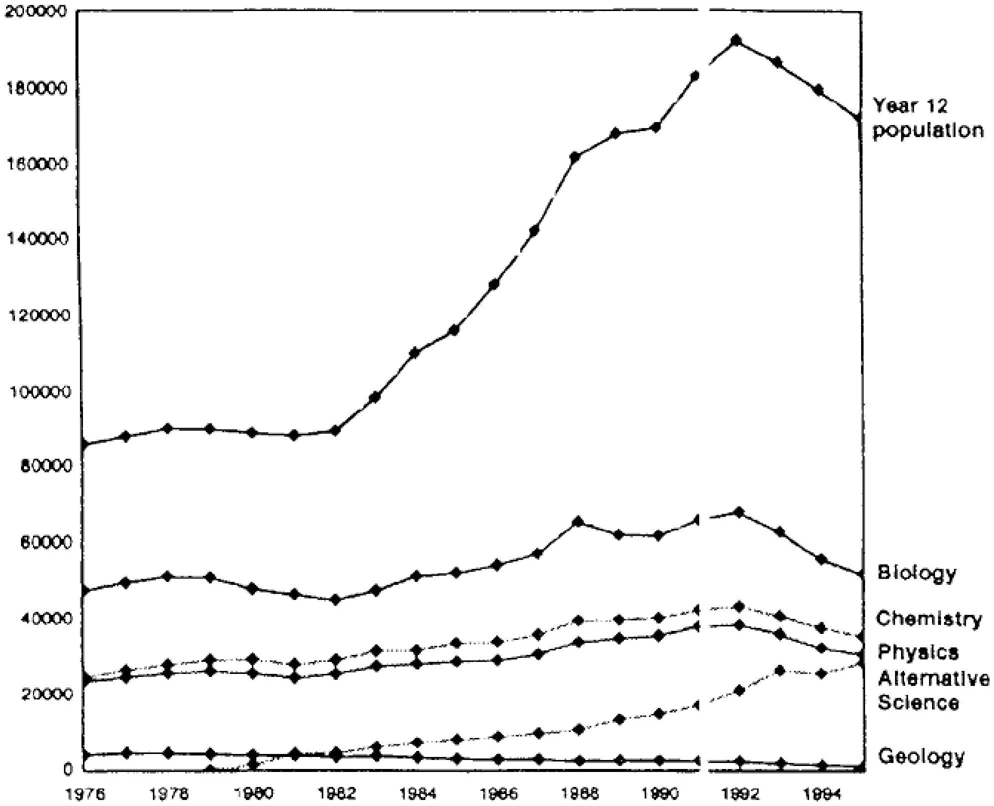


Figure 1.2. National trends for enrolments in the final year of secondary education for biology, chemistry, geology, physics, and alternative science from 1976- 1994 (Adapted from Dekkers & De Laeter, 2001, p. 496).

Table 1.1. University enrolment trend in the enabling sciences (Adapted from DEST Annual Report 2007 available at www.aph.gov.au)

NOTE:
This table is included on page 14
of the print copy of the thesis held in
the University of Adelaide Library.

Excellent as they may sound, however, since the early 1990s, Australia has faced a problem in its student population participating in science, particularly in physics (see Figure 1.2). This problem has not changed in the recent years, even in the university setting (see Table 1.1). In a review of similar studies on Year 12 students choosing science courses in Australia, Lyons' (2006) noted that between 1998 and 2001, physics enrolments fell by 17%. In addition, a decline noted by Lyons was in the New South Wales physics enrolment down by 32% between 1991 and 2004. In another report, recently published by the Australian Council of Deans of Science (ACDS) (2007), it was concluded that the proportion of students studying physics for any reason in Australia has dropped to only 33% of what it was about 20 years ago. The ACDS also pointed out that the proportion of students who are trying to become physicists have dropped even further. The situation in South Australia is not looking any better, as shown in a newspaper article written by Kleinig & Wheatley (2007), where figures of yearly student completions in physics dropped below 2000. According to Kleinig and Wheatley, this number is 600 below figures recorded a decade ago albeit with increased numbers completing high school certification. Clearly, this raises a concern about maintaining a pool of personnel for future scientific endeavours for economic purposes and for providing scientific literacy for future generations (Lyons, 2006).

Physics enrolment trend in the Philippines

In the Philippines, students' participation in physics would not be a concern in the secondary schools because physics is one of the compulsory subjects in the Senior Years. This makes it unfair to compare the Philippines to countries where physics becomes an elective subject during the final years of secondary schooling. However, the decline in physics participation in the Western countries extends to university level studies. This is where the Philippines is showing an interesting trend as shown in Figure 1.3.

NOTE:
This figure is included on page 15 of the print copy of the thesis held in the University of Adelaide Library.

Figure 1.3. Trends of enrolment in physics from 1994 – 2004 at the tertiary level in the National Institute of physics of the Philippines (Adapted from National Institute of Physics, 2003, p. 6)**.**

The figure clearly shows (third bar from left of each group of 4 bars) that there was an increasing trend in the enrolment of students in the Bachelor of Science in Physics course at university level from 1994 to 2004. The enrolment trend for the Bachelor of Science in Applied Physics (BSAPhys) shows a dramatic increase in 1999 and levelled off from 2000 to 2004. Enrolments in both Master of Science and Doctor of Philosophy in Physics remained almost static, or slightly increasing during these years. Although the graph in only shows figures pertaining to enrolment at the National Institute of Physics (NIP), this should generally represent the university-level physics enrolment trend of the country. There are two reasons for this claim: first, the NIP (located in the University of the Philippines in Quezon City, Philippines) is the country's largest and premier institution for degrees in physics and applied physics. Most of the students who wish to pursue a career in physics research, or in physics-related jobs, would want to finish a physics or physics-related degree from this institution. Second, the NIP has by far the biggest population of physics/applied physics undergraduate students among the 18 institutions in the country that offer degrees in physics/applied physics (see Saloma, 2003).

In contrast to Western countries, interestingly, while many published research findings in the United States, Europe and Australia show a significant disparity between the number of males and females who choose to do physics, the Philippines is showing otherwise. According to Saloma (2003, p. 18), the population of undergraduate physics students has a "gender ratio…close to unity." This may be a reflection of the little difference between male and female students in their attitudes towards school science (Talisayon et al., 2006). Indeed, in the recent ROSE study (Sjoberg & Schreiner, 2005), Filipino female students seemed to have a more positive opinions about Science and Technology than males (Talisayon et al., 2006) although more thorough research is needed to probe this. According to Talisayon, perhaps the reason for these findings is the more positive attitudes of society in a developing country to the importance of science and technology to economic development.

Australia's education system

Australia has an education system that looks structurally rather similar across all of its six states and two territories. It has 12 years of basic education. School education is compulsory for every child between the ages of 6 and 16, which is equivalent to academic Year levels 1 to 9 or 10 (Commonwealth of Australia, 2008). Primary schooling consists of Years 1 to 7 (usually, though in some states it is 1 to 6) and secondary schooling consists of Years 8 to 12 (Australian Education International, 2006). But that is where the similarity between states ends. Each State in Australia has its own policy and structure for its curriculum independent of other States and Territories. In other words, curriculum is State-based – States and Territories control their own curriculum (Reid, 2005). Currently, however, a national curriculum is being developed for Mathematics, Science, English and History (Commonwealth of Australia, 2009). A draft of the Australian Curriculum for English, Mathematics, Science and History is made available by the Australian Curriculum, Assessment and Reporting

Austhority (ACARA) for consultation from March to May 2010 (see, http://www.acara.edu.au/).

Since this study was only interested in South Australian physics students in Australia, only the South Australian education system will be described in detail.

South Australia's education system

South Australia's school education is provided by two sectors – the Government (or public) schools sector and the Non-Government (or private) schools sector. The Department of Education and Children's Services (DECS) is responsible for providing public education throughout South Australia (Department of Education and Children's Services, n.d.). The Non-Government schools sector on the other hand provides private education. It consists of two divisions – the Association of Independent Schools in South Australia (AISSA) and the Catholic Education Office (CEO) of South Australia. The AISSA, consisting of 89 member schools, is an advocate of the non-government independent school education (Association of Independent Schools of South Australia, n.d.) and it claims to have contributed significantly to improvements in education. The CEO works in partnership with a total of 104 Catholic schools around South Australia to provide a range of facilities and resources to support Catholic education (Catholic Education Office, n.d.). Up to Year 10, curriculum is school-based, usually around the South Australian Curriculum Standards and Accountability (SACSA) framework. However, in both government and non-government schools, the senior years students tend to follow the curriculum prescribed by the South Australian Certificate of Education (SACE). Senior years in high school are Year 11 and Year 12, or otherwise known as Stage 1 and Stage 2, respectively, and it is at these levels where students can choose to study individual sciences, including physics, following a compulsory, more integrated science course in early years.

SACE is the basic entry requirement to tertiary education (SACE Board of SA, n.d.). The entire curriculum statements of subjects which can be studied in the senior years of high school are developed by the SACE Board of South Australia (SACEBSA) (formerly known as the Senior Secondary Assessment Board of South Australia [SSABSA]). SACEBSA is an independent statutory authority of the South Australian Government that is also responsible for certification and assessment of student achievement in the prescribed subjects (Senior Secondary Assessment Board of South Australia [SSABSA], 2008). In addition, SACEBSA also serves as an assessment body for student achievement in the Northern Territory and at some centres in Southeast Asia.

Physics education in South Australia

Students in Years 8 to 10 usually undertake some physics as part of their General Science subject; however physics is usually only offered as an elective subject in the final years of secondary schooling, Years 11 and 12 in particular. Because of physics curriculum differences across the Australian states, only the South Australian physics curriculum will be elaborated for the purposes of this study.

In South Australia, physics in Year 11 and Year 12 are also known as Stage 1 Physics and Stage 2 Physics, respectively (Senior Secondary Assessment Board of South Australia [SSABSA], 2007). Stage 1 Physics covers a range of areas of study, including mechanics, heat, waves, optics, electromagnetism, and introductions to quantum physics and astronomy. The mathematics component of these topics is all algebra-based. Stage 2 Physics areas of study that are essentially the continuation of the areas covered in Stage 1 Physics, but in more depth and detail. Table 1.2 summarizes the areas of study in Stage 2 Physics.

Table 1.2. Stage 2 Physics areas of study (adapted from SSABSA, 2007, p. 21).

NOTE:
This table is included on page 19 of the print copy of the thesis held in the University of Adelaide Library.

Based on the most recent SSABSA (2008, p. 6) Physics Curriculum statement, the study of physics are described in four strands. These are:

- Acquiring Knowledge of Physics
- Understanding and Problem-solving in Physics
- Using Knowledge of Physics
- Communicating Knowledge of Physics.

Philippines' education system

The Philippine education system is considered one of the largest in terms of enrolment, at the same time, it has the shortest education cycle (or shortest time to complete) in the world (De Guzman, 2006). It is also considered to be closely related to the system of education of the United States. The chief government agency responsible for providing school education from elementary through to secondary schooling is the Department of Education (DepEd).

Generally, there are ten years of basic compulsory education in the Philippines – 6 years of elementary schooling and 4 years of secondary (or high school) schooling. A school/academic year typically commences in early June and finishes during the last week of March of the following year. Schools can be government or privately owned. Funding for government-owned schools come from the national government's yearly budget allocation for education. Privately owned schools' funds can come from capital investments, loans, grants, and other financial sources, as long as they are within what is allowed by the current country legislation. Figure 1.3 shows the structure of the Philippine education system.

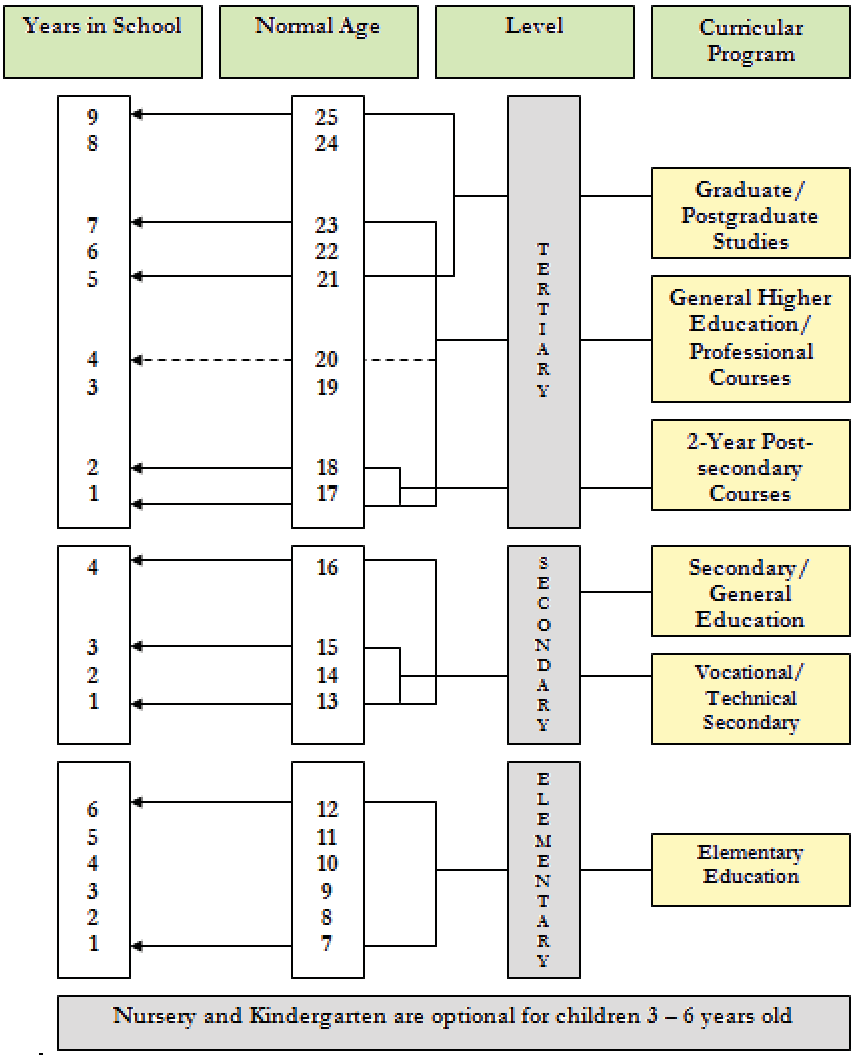


Figure 1.4. Structure of the Philippine education system (partly adapted from www.seameo.org).

Physics education in the Philippines

For the purpose of this study the secondary schooling part will be elaborated in terms of its science/physics contents.

In the first year of secondary schooling, one of the subjects that students must take is Integrated Science. This is roughly the equivalent of the General Science subject that students in Australia and the United States do in Year 8 and Grade 8, respectively. The main difference is, perhaps, the Physics content of this Integrated Science subject. For about half a year, students study, among others, basic physics concepts such as simple machines (pulleys and levers), electricity and energy (where students have to make a DC motor work using a lead-acid battery that they themselves built). In addition, students also study how physics is applied to other sciences such as chemistry and biology. Mathematics is minimal in Integrated Science.

Physics becomes a separate and full-time compulsory subject in the Third Year (only in some schools classified as Science High Schools) and Fourth Year of secondary schooling. Back in the 1980s until about the year 2000, there was only one full-time compulsory physics subject at Fourth Year high school level. The increase is, perhaps, a response to the results of the TIMSS studies where the Philippines ranked poorly against other participating countries.

The Fourth Year physics curriculum in the 'regular' or 'ordinary' (not specifically science-oriented) high schools in the Philippines generally includes the basic study of algebra-based mechanics, heat and thermodynamics, electricity and magnetism, wave motion, optics, relativity, and modern physics which includes relativity, nuclear physics and the study of elementary particles.

Another recent development in the Philippine's education system is the establishment by the government, through its Department of Science and Technology (DOST), of more schools that heavily focus on science (particularly physics and chemistry) and mathematics. In other words, science high schools offer science-oriented curriculum different from that of ordinary national high schools (Rimando, 2004). According to Rimando (2004), these schools are designed to promote and strengthen secondary school science education throughout the country. This may again be due to the disappointing performance of Filipino high school students in the recent TIMSS studies. These schools are commonly known in the Philippines as 'Science High

Schools', and have more rigorous mathematics and science subjects. Students are admitted through an entrance test to ensure that only the 'talented' elementary school graduates can enter them. This may be the reason why science high schools in the Philippines have the reputation as schools only for the 'brainiest' students. There were very few science high schools in the Philippines until the late 1990s, but by 2001 there were 16 regional science high schools throughout the country – at least one science high school for most of the Philippines' 17 regions administered by the Department of Education (DepEd) (Rimando, 2004). Two more science high schools were inaugurated in 2003 and 2006 in the Northern and Central Philippines, respectively (see www.pshs.edu.ph).

In these science-oriented schools, Third Year Physics is called 'Basic Physics', which is basically similar to the 'Conceptual Physics' subject offered in U.S. high schools. Fourth Year Physics is called 'Advanced Physics'. It covers topics similar to the Basic Physics in Third Year, but in more depth and involves more mathematical problem solving. Mathematics becomes a prominent component of physics during the final year of secondary schooling. This is also where students get the chance to apply what they have learned from their Integrated Science subject during their First Year and Basic Physics in their Third Year of high schooling. Both Third and Fourth Year Physics subjects are an everyday one-hour-a-day subject that also includes one 2.5-hour laboratory session per week.

However, with all these efforts put forward by the government to improve its science education, the Philippines' education system seems to be plagued with greater problems. Orleans (2007) described the current situation of physics education in the Philippines, with problems relating to teachers (such as academic qualification deficiency and low continuing professional involvement), and limited instructional materials and technologies.

Other factors that contribute to the Philippines' problems in its education system are the overwhelmingly increasing student-teacher ratio and the seemingly limited educational funding support from the government.

An undergraduate degree in physics or applied physics can be obtained from one of the 18 universities that offer physics degrees throughout the country. Two universities were sampled in this study, as they are the only two universities that offer physics in the district considered in this study.

1.3. Importance of the study

Combined with recognition of the importance of a formal study of physics by a reasonable proportion of the population, the interesting set of graphs on enrolment trends, which were shown in the previous sections, is one of the reasons prompting this investigation. Furthermore, the Philippines could be considered as an unexplored source of information to address issues in physics education. No studies with regard to factors contributing to students' choice of physics, or any physics-related courses, have been conducted there to date. In addition, no gender studies on physics uptake have been reported. Heavy teaching loads given to faculty members in almost all science departments/faculties in universities may partly be blamed for this. By exploring the educational and socio-cultural aspects of physics education in the Philippines, the results of this study should provide a significant amount of useful information, and a deeper understanding of the existing gender gap in physics in other countries. In addition, the results should also contribute to explanations of queries about students' declining interest in physics in many countries. Furthermore, the information drawn from this study may suggest keys that could be used to develop a better physics classroom atmosphere to stabilise, if not increase, the student interest in physics subjects or courses. Education policy makers in South Australia, and perhaps the whole of Australia, as well as in all countries experiencing a 'downward' trend in physics participation could benefit from this study.

Potential benefits of this study include, but are not limited to, providing academic communities and policy makers with information on the declining participation of students in physics in the Western countries including Australia. The Philippines greatly benefits from this study as well. In the absence of this kind of research in physics education, the results of this study will provide evaluative information on many aspects of the physics curriculum and education in the Philippines. One of these aspects is the teachers' and students' perception of their curriculum and education, as it is believed that quality of education is a problem in developing countries (Danskin, 1979). The quality of the physics curriculum in the Philippines, for instance, may be assessed in this study to determine its strengths and weaknesses. The quality of education that a student receives partly depends on the quality of the curriculum (e.g., McCaffrey, Hamilton, Stecher, Klein, Bugliari & Robyn, 2001)

Teachers and their qualifications is another aspect that was examined in this study. The teacher questionnaire used in this study included items about their undergraduate or postgraduate degrees. Additionally, teaching practices and behaviour in the classroom that are believed to have an effect on students' attitudes towards and subsequent uptake of physics (George & Taylor, 2001) were also examined.

Another important aspect of this study is its contribution to what is already known about the relationships of the factors that influence students' subject choices. Understanding how and why students choose a particular subject is something of a puzzle because not much information is available regarding the relationships of factors, and how, or whether, they influence students' decision to choose a particular subject (Lyons, 2006).

1.4. Research questions

The study seeks to answer the following questions, which are grouped into general and specific categories.

Generally, the study will address the following questions:

1. What are the factors that affect high school and university level students' attitudes towards physics that could influence their choice of physics as a stand-alone subject/course in their course of study?
2. How do these factors interact to influence students' attitudes towards physics?

These general questions lead to the following specific questions under 3 broad headings:

1. *School-level factors*
    a. What is the influence of school type (government or private, coeducational or single-sex), on students' attitudes towards physics?
    b. How does school curriculum influence classroom climate in the two sample groups?

c. Does school curriculum have an influence on students' motivation to study physics?

2. *Classroom-level factors*
   a. How does classroom climate influence students' general self-esteem?
   b. How does classroom climate affect students' attitudes towards physics?
   c. How does classroom climate affect students' motivation to learn physics?
   d. What is the influence of teachers on the physics classroom climate that could affect students' attitudes towards physics?
   e. How do teachers' teaching methods impact on physics classroom climate?

3. *Individual-level factors*
   a. Do motivation and self-esteem affect students' attitudes towards physics?
   b. Does self-esteem affect students' motivation to learn physics?
   c. Does gender have an influence on students' motivation to study physics? Does it influence their attitudes towards physics?
   d. Is there a significant difference between genders towards their attitudes towards physics?
   e. Does gender have an effect on general self-esteem?
   f. Does the use of computers have a positive impact on students' attitudes towards physics?
   g. How do parents' aspirations for their children affect students' attitudes towards and their choice of physics or physics-related courses?
   h. How do parents' aspirations affect their children's general self-esteem?
   i. What are the students' perceptions of physics and physics-related courses in terms of job availability, status of jobs related to these courses in the society, and financial security from these jobs?

1.5. Aims of the study

The study intended to investigate the factors affecting students' attitudes towards physics in senior high school and university levels that could have an influence on their uptake of physics. In this study, the phrases "students' decision to study physics" and "students' uptake of physics" have the same meaning and are used interchangeably.

The study specifically examined the following factors: individual student's gender, motivation, general self-esteem, their attitudes towards physics; teachers; school type and curriculum; classroom environment; parental influence; and media access with particular focus on computers. Many existing studies about students' attitudes towards physics involve both groups of students – students who are doing physics and those who decided not to study physics. Compared to the samples used by existing related studies, this study has taken a different approach by sampling students who are enrolled in physics courses, both in senior years in high school and early university. It aimed to capture why students opted to study physics taking into consideration the role of the factors mentioned above and how they interact to shape students' attitudes towards physics.

More specifically, the goal of this study, as addressed by the questions enumerated above, was to investigate the similarities and differences in ways in which the school environment and family environment affect the students' uptake of physics in Australia and the Philippines. In this study, school environment pertains to the classroom climate as perceived by the students and family environment pertains to parents' aspirations and support for their children's learning as perceived by the students. These factors, along with the rest of the factors examined in this study, were measured using questionnaires. With reference to Australia's and the Philippines' difference in enrolment statistics presented earlier, it was expected that there will be differences between Australia and the Philippines on how school and family environments affect the students' attitudes towards physics that could lead to their decision to study physics.

In addition, knowing that this study involved two different countries, a comparative study may be implied. However, because of the differences in the two countries' education systems and curricula, it was difficult to carry out a comparative study, although some comparing was carried out in terms of how the factors under study behaved in terms of how they influence students' attitudes towards physics.

1.6. Participants in the study

Participants in this study were students enrolled in physics classes or courses in government, private, catholic, and independent schools: Years 11 and 12 high school, and First Year University students in South Australia, and 4th Year High School and First Year University physics students in the Philippines. Figure 1.5 shows the target population of this study. The figure also shows a side-by-side bird's eye view comparison between South Australian and Philippine systems of education. These year levels are chosen because this is the time when students can elect physics as a separate subject or course. In contrast to all other physics courses studied, in the Philippines, physics is a compulsory subject in 4th year high school. Physics teachers were also included in this study. Teachers were asked to fill out questionnaires and to respond to interview questions. This was carried out in anticipation that teachers' approach to teaching physics greatly defines the classroom environment that students are in.

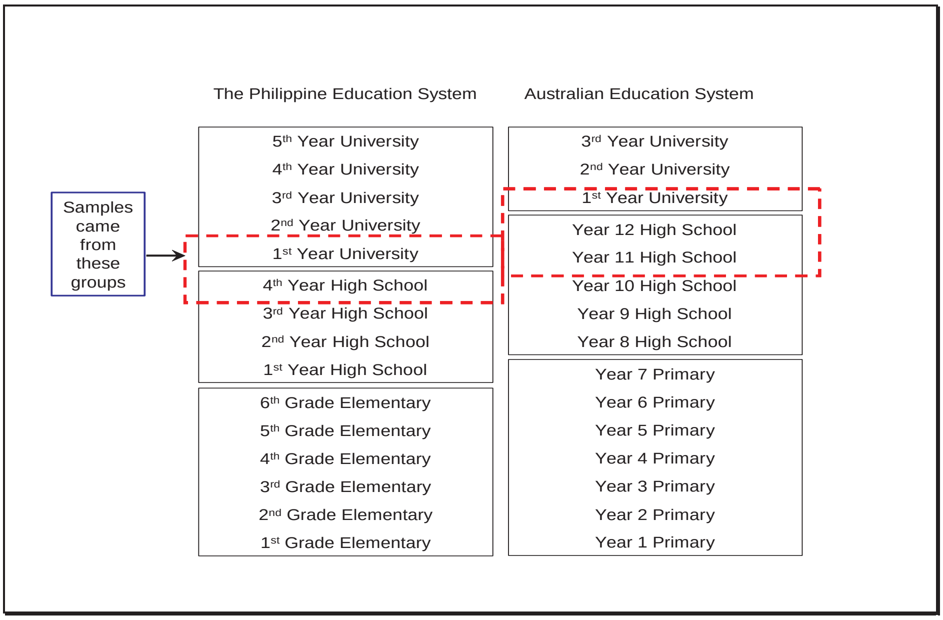


Figure 1.5. Participants in the study.

1.7. Limitations

Like all other research undertakings, this also had a number of limitations. These limitations resulted from the fact that this study's data collection was carried out within a relatively short time frame. Because of this reason, this study had a number of constraints. First, it would have been more preferred to use a longitudinal-type study rather than a cross-sectional-type. Longitudinal studies allow researchers to make an observation of a group of individuals through different time frames (say within 3 years) to more accurately capture changes in their attitudes, for example. Since the same individuals are 'tracked' over some period of time, the differences observed are less likely to be the result of some factors such as cultural or, perhaps, differences across groups in the case of a cross-sectional study. The cross-sectional nature of this study, however, gives a wider 'snap-shot' of what different groups are being observed for at a specific point in time. It also benefited from other advantages offered by a cross-sectional study (Cohen & Manion, 1994, p. 71):

- less expensive
- produce more findings quickly
- less likely to suffer from control effects
- more likely to secure the co-operation of respondents on a "one-off" basis
- generally able to include more subjects than longitudinal designs.

In addition, a cross-sectional study design has the advantage of measuring current attitudes and practices (Creswell, 2005) which suits this study's needs.

Another constraint would be any generalisation based on the results of this study. Taking into consideration the importance of this study during these times of 'physics education crisis' in terms of the dwindling numbers of physics participation, it would have been more preferable to have samples coming from across both countries and not just samples coming from one small area. This was not possible mainly due to excessive costs. However, even when the samples only came from a small area in both countries, there were still challenges encountered (which will be described in detail in Chapter 3). Therefore, the conclusions in this study can only be based on the sample. However, any conclusions could also become a basis from which other similar studies, be it smaller or bigger in scale, could be derived and used in other contexts.

1.8. Summary

This chapter highlighted the problem confronting the Science Education community, more specifically in physics education. This problem is the declining participation of students in physics, a concern considering its importance in our modern day society. The implications of the problem to economic aspects and the society's scientific literacy were also developed.

The general locations where this study was conducted were also defined. These were Australia and the Philippines. These countries were chosen for this study because of their contrasts not only in terms of their culture and education systems, but also of the important contrast in physics enrolment statistics shown and accessibility to the researcher. An overview of the education systems of both countries was also provided.

Furthermore, the general aims, importance and focus of the study were discussed and research questions were also enumerated. A core feature of this research highlighted in this chapter was the fact that the participants in this study were students who were enrolled in senior high school and university level physics, and the study aimed to capture what influenced these students to study physics in spite of its 'very challenging' reputation.

Limitations in terms of the study's nature, time allocation, sample size and generalisation restrictions were provided. The next chapter provides a literature review of the factors considered in this study and their effects on students' attitudes towards and perceptions of physics.

Chapter 2

Factors Affecting Students' Participation in Physics

2.1. Introduction

This chapter contains a literature review that describes the point reached by other researchers on students' attitudes towards, and participation in, physics, of which this particular study would form a part. It also aims to highlight the issues and inter-relationships associated with what has been discovered about the declining trend in student participation in physics. Furthermore, the review describes what has been written about problems in physics participation, with a focus on the factors that have been found to have an impact on students' attitudes towards, and their decision to choose, physics as a school subject or a university course. These factors broadly include individual student characteristics, school-related factors, and family-related factors.

This chapter starts with identifying the venues and circumstances that were used as basis for the formulation of the problem that was investigated in this study. It is followed by the discussion of the theoretical framework that acted as a guide to the conduct of this study. This is then followed by a review of related literature about the extent to which the problem has been studied by previous science education researchers. This review is then broken down into sections that highlight what has already been known about each of the factors examined in this study. Finally, a summary of the chapter is provided.

2.2. Where did the problem come from?

This decline of the popularity of physics among students has been observed since the 1960s. Since then researchers have been undertaking investigations as to what causes this problem. Many researchers consider this decline in physics participation as a serious problem for society, especially considering its economic aspects and the scientific literacy of future generation. But what caused this decline in the student participation in physics? The following paragraphs will discuss what appear to be the changing perceptions of students for science (especially physics) education during the last three decades.

During the 1960s, secondary education became accessible to the masses and no longer just for the elite (Fensham, 1988). This was also the post-Sputnik time when there was a growing awareness of the importance of science education that prompted countries such as the United States to put in place government-sponsored science education reforms. According to Fensham (1988), these reforms were brought about by what appeared to be a failure of secondary science education to provide the necessary preparation for tertiary-level science education. This prompted education policy makers to come up with revisions in the secondary science curriculum to meet the requirements of the tertiary level science education. However, trying to meet tertiary level requirements did not "cure" the dwindling participation of students in the hard sciences, especially for females. Decades of research on this problem accumulated a number of theories from researchers who examined the possible causes. These theories can be summarised to include three major areas that appear to contribute to the causes of students' negative attitudes towards the hard sciences (particularly physics), hence moving away from them. These areas include school, parents, and individual-level factors. These factors became the basis of the theoretical framework for this study.

2.3. What is already known about the problem

It is an established fact that this problem of declining participation in physics has long been examined by science education researchers who have considered a number of factors to play key roles in shaping students' attitudes towards physics. This is evident through a considerable amount of the ever growing literature available about this problem. According to Smyth and Hannan (2006), students choose the subjects they study based on their interests and ability, and also in the perceived usefulness of the subject, especially to a future career. But what affects these? Some researchers have examined one or two factors that may affect students' attitudes towards sciences which may shape their decision to (or not to) study them. Others have examined a combination of different factors. These factors broadly include students' gender, students' family or parental backgrounds and students' teachers and school environments.

This chapter brings together the results of many studies done by researchers seeking, ultimately, to increase the level of interest in physics and physical sciences and to minimise the existing gender gap in physics. It is divided into sub-sections for organisation and clearer distinction of one area from the others. It begins with the school-related factors (e.g. teachers and curriculum) that may have an impact on students' perception of and attitudes towards physics and physics-related courses. A review of studies on family impact follows, and finally, individual factors such as motivation, achievement, and general differences and similarities between the sexes in terms of their choices and interests will be discussed. The last two sections describe and discuss some of the comparative studies carried out to further contribute to the existing knowledge about why students lose interest in physics, which also includes how they perceive the subject.

School- and classroom-related factors

Perhaps, broadly, the factors that can be considered as the most researched are the school- and classroom-related ones. The most common school-related factor that researchers have taken interest in is the school curriculum and intervention strategies. Classroom intervention strategies came about as a result of the earlier studies carried out to examine physics participation problems. For classroom-related factors, teachers form arguably the most researched factor, for teachers are the ones who impart knowledge to their students and therefore have the most contact time with them in the subject. Another important classroom-related factor examined by science education researchers is the classroom environment, which includes a look at the single-gender classroom approach which, like classroom intervention strategies, can be considered as a proposed solution that resulted from suggestions by early science education researchers.

School curriculum and intervention strategies

Research in physics education has shifted its focus several times during the past few decades. According to Grayson (2006) the shift ranges from research on students' misconceptions in the early 80s, to the use of computers in mid-80s, to curriculum matters in the early 90s. It then again shifted to another area which was about the STS approach in the late 90s to about the year 2000. In the recent years, research on physics education seems to cover them all.

As an example, an area which is a focus of attention of recent researchers is the school curriculum, especially in the middle and early high school years where attitudes appear to develop and progress. It is during these years at school that girls and boys tend to develop negative attitudes towards physics (Labudde et al*.,* 2000; Reid & Skryabina, 2002; Rodriguez and Zozakiewicz, 2004). Some related studies, like Dawson's (2000), noted that these attitudes begin to develop even in primary school years. At this stage, school students develop the image that physics is boring, difficult and not useful for everyday life. This is because physics has been often presented in a decontextualized manner that lead many students to consider school science as irrelevant and boring (Trumper, 2006). Tobias (1994) asserted that student boredom and apathy in the classroom usually mean indifference to the school's curriculum. These findings have strong similarities with what has been reported by Häussler and Hoffmann (2002) where they have identified secondary level schooling as the period when students begin to get disinterested in physics because they cannot not see any connection between what is being taught and how it can be applied in everyday life. They have also added that girls' have more pronounced disinterest in physics than boys, hence the gender gap issue. To rectify the issue, although Häussler and Hoffmann (2002) focussed more especially on girls, they have suggested intervention measures to reverse the declining trend in physics-related interests. These include (p. 870):

- Suggesting curricular changes to do justice to the specific interests and experiences of girls.
- Improving the ability of teachers to support girls in the development of positive physics-related self-concept, and
- Changing to an organizational setting that gives girls a better chance to improve their self-concept about physics.

Reid and Skryabina (2002, p. 79) asserted, "if physics is to attract pupils and university students, the key lies in establishing an effective curriculum structure, an attractive syllabus, and a committed teaching force at the senior high school level". An effective curriculum, as Murphy and Whitelegg (2006) suggest based on the related studies they have reviewed, is a context-based or humanistic curriculum that is found to increase students' motivation and enjoyment of physics. Consequently, modification of Science curricula, particularly physics, have been suggested to include several teaching and learning strategies to make physics appeal to students, especially females, such as gender-inclusive, multicultural, inquiry-based (Sociotransformative Constructivism or sTc) learning activities in science and mathematics (Rodriguez & Zozakiewicz, 2004), the integration of individual preconceptions, student orientation, physics as an experience, discussion among students and everyday physics (Labudde et al., 2000), and interactive engagement methods like 'Peer Instruction' and 'Tutorials' (Lorenzo et al., 2006). All of these teaching and learning strategies imply that good experiences and reinforcement of the perceived positive and contributory value of physics in the society are key factors to attract females (as well as males) towards physics. But due to the pressures to complete an overcrowded curriculum, concerns about laboratory and field safety, and associated costs for procuring scientific equipment and consumables (Spall et al., 2003) most physics teachers everywhere, especially the less experienced ones, could not really afford to be 'adventurous' in the classroom and execute strategies that are more active and exploratory to facilitate their students' learning. Moreover, teachers tend to stick with the traditional lecture and chalkboard way of teaching physics, as they tend to teach the way they were taught by their teachers (Mazur, 1997).

The literature review presented above summarises the few published studies of how school curriculum affects students' choice of a subject or a course, though a large number of studies have looked at how school curriculum affects student outcomes such as achievement.

Teacher effects

Studies such as the one carried out by Perkins, Gratny, Adams, Finkelstein and Weiman (2006) on teacher effects on students' interest in physics yielded findings that showed a strong correlation between school instruction and student interest in pursuing further studies on a subject. A more recent study validates this. The results of a study carried out by Michelsen and Sriraman (2009) suggest that it is possible to increase the students' interest in a subject by using a method known as interdisciplinary instruction, which they consider as an interest-based learning approach. Their study findings suggest that the interest-based learning approach significantly impacted students' interest in a particular subject. Similar research conducted by Athanasou and Petoumenos (1998) examined the finer details of different instructional components. The results of their analysis suggest that, among the different components of instructions they have considered and examined, two of these components stood out as the most important to influence students' interest in a subject. These are ability to explain concepts clearly thereby helping students to understand and demonstrating the relevance of the subject.

Furthermore, findings from several studies that examined teachers and their teaching approaches have pointed out some presence of gender bias in student/teacher interactions, with teachers not taking responsibility for girls' low participation in physics, and teachers' unawareness of the gender gap (Mid-Atlantic Equity Consortium & The NETWORK, Inc., 1993; Warrington & Younger, 2000; Zohar & Bronshtein, 2005). A recent report also highlighted that teachers of physics hold lower expectations for girls (Millar & Toscano, 2006). All of these reports suggested that teachers significantly contribute to students' attitudes towards physics and the existing gender bias towards males in physics.

Studies carried out on teacher effects were only about the negative effects. However, some studies also looked at teachers' positive effects on students' attitudes to physics. Young students tend to look at their teachers as role models (Nixon & Robinson, 1999; Roger & Duffield, 2000). A similar study also showed that teachers can reduce students' physics anxiety (Udo et al., 2001). Hence, it can be argued that teachers can have a very significant effect on students' attitudes towards a subject; that is why teachers are thought to play a key role in improving girls' (and boys') attitudes and achievements by properly implementing strategies in their classrooms that would give the "desired outcomes" (e.g. the integration of individual preconceptions, student orientation [in particular the cooperation between teacher and students], physics as an experience, discussion among students and everyday physics) (Labudde et al., 2000). Some researchers, such as Parker and Rennie (2002) call these strategies 'gender-inclusive instructional strategies'. However, these strategies are considered ineffective when a physics teacher's 'quality' is in question.

There is a dire problem of an inadequate number of physics teachers and teacher candidates in many countries (Wenning, 2004). This is a consequence of the dearth of physics graduates (Spall et al., 2003). As a result, many teachers in both developed and developing countries are requested to teach physics with little or no qualification to teach the subject (Ingersoll, 1999; Wenning, 2004). Physics phenomena are not easy to explain because they are abstract and involve a number of factors and a number of activities which could lead students to a lot of confusion rather than facilitate understanding (Johnston & Ahtee, 2006). This is a result of teaching students physics "like a book". In other words, students are taught physics with less enthusiasm and feel for the subject (Spall et al., 2003), as less qualified teachers often feel uneasy and lack confidence teaching the subject. This feeling of uneasiness implicitly could convey negative messages to the students that could make them develop negative attitudes towards physics and lack of confidence in their own knowledge of the subject. Teachers have a profound effect on students' learning and achievement in the classroom; that is why teachers' excellence in teaching (Hattie, 2003) and adequate knowledge of the subject is needed. This has been the constant suggestion from a number of similar research endeavours reviewed by Osborne et al. (2003, p. 1068) that:

> …findings strongly suggests that the quality of teaching is an important determinant of attitude and subject choice…[F]actors identified as contributing to such teaching included a supply of well-qualified, enthusiastic graduate science staff (including graduates in physics and engineering), who not only have a good spread of expertise across science, but also have individual subject loyalty.

Hence, for teachers to teach science effectively they have to have a solid foundation in the practice of science (Harris & Farrell, 2007).

To address the problem of out-of-field teaching, and teacher under-qualification, in many countries pre-service and in-service training programs for teachers to improve content knowledge and pedagogical expertise are provided to raise instructional quality (Chapman et al., 2000). An example is the Project in Basic Education (PROBE), a continuing education program for teachers who can reflect on their own teaching practices and become better teachers as a result (Beasley, 1999). This was a joint project of the Philippines and the Australian governments. In the United States, the No Child Left Behind (NCLB) policy mandated by a 2006 deadline that all of its states ensure that all of their teachers are highly qualified (Escalada & Moeller, 2006). Escalada and Moeller enumerated three requirements that teachers have to meet in order for them to be considered qualified: a bachelor's degree, full state certification or licensure, and proof that they know how to teach the subject. However, this provision presented challenges since teachers in the United States are often asked to teach more than one academic subject of different fields (e.g. science and social science).

Part of Murphy and Whitelegg's (2006) report on 'Girls in the Physics Classroom' contains elaborate information about teacher effects on students' participation in physics including issues such as: teacher-student relationships, teachers' questioning and feedback strategies, students' and teachers' expectations, and teaching strategies to encourage participation. This is the result of their review of numerous related studies that found profound effects of teachers on students' attitudes and interest in physics. Murphy and Whitelegg (2006, p. 23), from their review, highlighted that "teachers' practices are key in determining students' experiences of and attitudes to science and to physics in particular."

Classroom environment

It should be noted that in this study, the terms classroom environment and classroom climate are used interchangeably. Studies on the effects of classroom environment on students' subject interest have been carried out since the 1970s. Lawrenz (1976) carried out a large scale study that investigated the perceptions of high school students of the classroom learning environment in chemistry, biology and physics. She has suggested that the loss of interest in the Physical Sciences due to the classroom learning environment is more pronounced than in Biological Sciences. She has further put forward that

> Perhaps this differential interest loss is related to a difference in the manner in which students perceive the environment of their biological and physical science courses. (p. 315)

Teaching approaches/strategies greatly contribute to classroom environment. Different ways of teaching physics concepts have been explored by science education researchers to find an optimum classroom environment that would enhance student learning and interest towards challenging sciences such as physics. Researchers suggest that an essential part of a good physics classroom climate is one that has an air of support from teachers. In addition, physics taught in the way that students can see how it is applied in real life contributes to a preferable classroom environment. Reports such as those from Reid and Skryabina (2002) and Murphy and Whitelegg (2006) stressed the importance of a supportive learning environment (i.e. students need appropriate encouragement encouragement, and their needs must be identified and treated with respect). They further asserted that students would prefer a classroom environment where they learn physical concepts by really seeing where these concepts are applied in real life. In other words, students want a classroom where they see physics applied to everyday life through some investigative activities.

Strategies were also explored to promote positive experiences in the classroom in the hopes of attracting more student participation in physics especially for girls. A strategy used to minimise the gender gap was the creation of single-gender classes in schools, which is considered by some educational researchers as a debatable instructional strategy (see Koppel et al., 2003). It was used not only in physics subjects but also in other subjects where the gender differences are apparent. This move to change the classroom environment was especially developed for girls in the belief that attitudes towards, and preference for, stereotypically 'male' subjects, such as physics, would improve. Although there was a noticeable improvement in girls' self-esteem and attitudes towards these difficult subjects, findings from more recent research failed to confirm better uptake, performance, or achievement of girls in single-gender environments (Haag, 2000; Koppel et al., 2003). Elwood and Gipps further supported this in their report as it appeared in a publication of Office of Standards in Education in the UK:

> The better performances of girls' schools are not strictly related to single-sexness but to differences in intake that relate to social class and ability, and the histories and traditions of the schools. (Office of Standards in Education, 2003, p. 11)

According to Millar and Toscano (2006), single-gender environments improve girls' achievement when pedagogy and curriculum are effective and teachers are gender sensitive. However, Millar and Toscano failed to confirm increased participation of girls to stereotypically 'male' subjects and have therefore suggested further studies on this issue.

Although reactions of some educationalists appear to be against the anticipated benefits of this strategy in terms of participation and achievement in the challenging sciences such as physics, it has been reported that teachers in single gender classes "were able to address some of the apparent shortcomings of the students' previous education"

(Parker & Rennie, 2002, p. 881), such as the poor written and oral communication of the boys, and the lack of 'hands-on' activities and open-ended problem solving experience of the girls.

In Blickenstaff's (2005) review of various research literature of over 30 years on girls' underrepresentation in the Physical Science and technology, he has come up with a number of suggestions to improve girls' attitudes towards and the uptake of the hard sciences. His suggestions include (p. 384):

- Ensure students have equal access to the teacher and classroom resources.
- Use cooperative groups in class, or at least avoid dividing students by sex for class competitions or in seating arrangements.
- Eliminate sexist language and imagery in printed materials.
- Do not tolerate sexist language or behaviour in the classroom.

Researchers who took interest in effective classroom environment, in both school and university settings, examined the effects of strategies other than gender segregation on keeping students' interest in physics longer. These strategies aim to provide students with a more involved environment. In addition, these strategies allow students to construct their knowledge about physics concepts actively which may give students some first-hand realisation of the importance of physics in everyday life. These classroom environment-modifying schemes were developed to change the negative attitudes of students towards physics. Such strategies include the Learning Cycle developed by Robert Karplus (in Birnie, 1982) based on Piaget's developmental theory, Peer Instruction by Mazur (1997a; 1997b), Physics Projects by Mackin (1996), and Computer technology-based approach (Schecker 1993; Reif & Scott 1994; Anslow 1999; Sillitto & MacKinnon 2000). The following paragraphs briefly describe the strategies mentioned.

The Learning Cycle is a teaching model based on the developmental theory of Jean Piaget (Birnie, 1982). According to Karplus (cited in Birnie, 1982), this is a systematic approach to teaching that advances reasoning by allowing students to construct knowledge actively. It incorporates three phases namely: *Exploration* or *Data Gathering*, *Concept Invention* or *Invention of the Idea* (or *Concept Introduction),* and *Concept Application* or

Invention. These phases bring together the main doctrine of Piaget's theory of intellectual development with a view to encouraging the students to use their mental processes of concept acquisition and problem solving to enhance their effectiveness in learning (Gang, 1995). It was created for relatively small classes (about 30).

Exploration or *Data Gathering* generally involves a hands-on approach that provides the students with opportunity to assimilate. Students learn through direct interaction with materials to arouse curiosity, raise question through conceptual conflict, and identity patterns (St. Paul, 1998). In the *Concept Invention* phase, students discuss the data collected, clarify the pattern(s) observed, and are provided with the appropriate terminology (St. Paul, 1998). It emphasizes the generalisation of concrete experiences to abstract possibilities (Birnie, 1982). The *Concept Application* phase emphasises the use of generalized concepts and/or skills and focuses on directed student activity (Birnie, 1982). Here, students have the opportunity to directly apply and extend the range of concept learned during the invention activity (Birnie, 1982).

A slightly modified version of Karplus' Learning Cycle approach to utilise its benefits in large classes in university-level physics classes was developed by Dean Zollman (1990). Adaptations are needed in the usual format, which centre on an open laboratory environment in which students complete both exploration and application activities (Zollman, 1990; Zollman, 1997). Zollman's course design comprises of 15 activity-based units, each of which is one-week in length. He defined an activity-based unit as a learning experience that focuses on a series of eight to ten short experiments performed by all of the students in the class. Students, therefore, perform a large number of experiments and these activities form the backbone of the course.

Eric Mazur of the Harvard University developed the Peer Instruction approach that aims to actively involve university physics students in lectures. Mazur (1997b) described in his observations using Peer Instruction that discussions among students were always remarkably uninhibited and animated. Thus, discussion periods break the unavoidable monotony of passive lecturing. Furthermore, he adds that students must not merely assimilate; they must think for themselves and put their thoughts into words. Peer Instruction is similar to the 'Students Teaching Students' approach by Yu and Stokes (1998) where students sampled in this study claimed that it is easier for them to ask questions or express their ideas during discussions with their group members. Some researchers call this approach Peer Interaction. Peer Instruction (or Peer Interaction) in physics works under the acknowledgement that group discussion is important in facilitating learning in science (Alexopoulou & Driver, 1996). Yu and Stokes (1998) advocated that with good lesson planning this approach may provide a cheap and effective way of improving students' understanding of physical concepts. But they have also acknowledged the difficulty in implementing this approach especially in the preparation of the test questions that will elicit students' understanding (pre-conceptions or misconceptions) of the physical concept presented. Similar to co-operative learning, Peer Instruction was thought to minimise students' reliance on teachers and induce them to be more reliant on their own ability to think, seek information from other sources, and to learn from other students (Killen, 1998). It can also provide students with opportunities to test their ideas and understandings and to receive feedback in a relatively safe and non-threatening environment (Killen, 1998).

Mackin (1996) had a different approach. She developed and used the Physics Projects approach which can be used as an alternative to lecture and traditional tests. In this approach she envisions that together with students' creativity the projects could become an investigative activity that would be shared with physics classes as well as reaching out to other classes in schools within a certain district and to the community. The goal of the students' project is for them to develop a pretty good understanding of their chosen subject and be able to share it with others. All projects require investigation with actual work to be completed outside of class. Students have the opportunity to choose their subject area depending on their interests. Projects are required to be submitted on a time schedule so that they can be displayed, presented or discussed in class.

Finally, there is the strategy of using computer technology in the classroom. Technological advances led to the increase of the use of computer technology in physics courses (Escalada, Grabhorn & Zollman, 1996) during the past decade or so. In physics classrooms and school laboratories, computer technology is used to create models of physics concepts (Schecker 1993; Reif & Scott 1994; Sillitto & MacKinnon 2000; Anslow 1999) that utilise both audio and video formats. Escalada, Grabhorn & Zollman (1996) pointed out that

> Visualization of phenomena through such techniques as demonstrations, simulations, models, real-time graphs, and video can contribute to students'

> understanding of physics concepts by attaching mental images to these concepts. (p. 73)

They further added

> Computers can introduce and reinforce concepts by various forms of drill, practice, and tutorial work. When connected to various interfacing devices, computers can be used to collect and analyze various types of data in a laboratory situation. Computers can also provide the visualization techniques of simulating and modeling physical phenomena or experiments that would otherwise require expensive equipment (e.g., Millikan oil drop experiment) or would expose students to unnecessary hazards (e.g., radioactive counting experiments). (p. 74)

These are just a few of the growing number of strategies to alter the "traditional" physics classroom environment that aim to change the negative attitudes of students towards physics.

An interesting contrast to these studies on students' high school classroom experiences and their persistence in their uptake of hard sciences was carried out by Tai and Sadler (2001). In their study of university-level students, their results suggest that there is "a striking lack of connectedness between student gender and past pedagogical experiences" (p. 1035), especially in physics (Sadler & Tai, 2001) which was thought to determine students' success in university introductory level physics, and lead to the formation of different attitudes towards the subject. Consistent with other research findings was their observation of the bias towards males of the physics classroom environment in colleges and universities and in work places.

Many studies on classroom environment, as implied above, examined students' preference for, and the effect of, collaborative learning environments. Other researchers, however, have focused on comparing individualised learning environments and those of the more traditional ones. Fraser (1998; 1982) carried out an extensive study on students' perceptions of the actual classroom environment as well as their preferred classroom environment. He, in collaboration with other researchers (such as Walberg, Butts, Sedon and Eagleson in Fisher & Fraser, 1983), have carried out different research on students' perceptions of classroom environment to (a) investigate associations between learning outcomes and classroom environment, (b) determine whether students performed better in their preferred classroom environment, and (c) improve classroom environments based on feedback information based upon students perceptions (see Fisher & Fraser, 1983). According to Fraser (1990), to examine the nature of the learning environment in the classroom, the following dimensions need to be included: personalisation, participation, independence, investigation and differentiation. This distinguishes individualised classrooms from conventional (or traditional) ones.

In this study, Fraser's approach of using the five dimensions mentioned above was employed. This was used to determine whether the attitudes towards physics of students who were currently enrolled in the subject are influenced by their experiences in the physics classroom.

Family environment-related factor

This is another factor that was examined based on its impact on students' attitudes towards a particular subject or course. A number of research studies indicate that parents' aspirations and support for their learning impact their children's future education and career aspirations.

Parents' aspirations

Parents have always been considered the key element in their child's development which has always been emphasized in almost all pedagogical and psychological conceptions (Stanisavljević-Petrović, 2008). Part of the child's development is determined by their parents' aspirations for them when they reach adulthood. Hung and Marjoribanks (2005) defined parents' aspirations as the amount of education, and the kind of occupation, they would like their children to have when they reach adulthood. In their study, the results indicated that children's educational aspirations had large associations with their parents' aspirations, together with family social status. These findings have supported other related studies, such as Hill et al.'s (2004), where parental aspirations and involvement in their child's education have correlations with achievement and aspirations. They have, however, also found that there are some variations in the effect depending on the parents' education levels and ethnicity. In addition, a large number of studies on family influences on children's academic achievement and educational attainment involved parents' aspirations as one of the family variables positively correlated with achievement and attainment (see Marjoribanks, 1972, 1981, 1991; Stage & Hossler, 1989; Teachman & Paasch, 1998).

None of these studies, however, specifically focused on parents' aspirations as an influential factor towards their children's choice of, and attitudes toward, the stereotypically challenging sciences. Nevertheless, based on the literature cited above, this study considered parental aspirations as one of the factors that could have a significant association with students' choice of physics and physics-related courses. This study adapted a part of Marjoribanks' (1999) distal family context model whereby students' educational aspirations have large associations with, and are partly mediated by their parents' aspirations and their support for their children's education. In this model, Marjoribanks (1999, p. 52) highlighted that

> Adolescents in family contexts characterised by high parents' aspirations perceived significantly stronger educational capital in relation to their fathers and mothers than did adolescents in family contexts defined by low parents' aspirations.

For a number of years, Marjoribanks had conducted studies concerning family backgrounds and their relationships with students' school outcomes and consistently found significant relationships.

Individual-level factors

Gender differences and similarities

Student gender effects on attitudes to physics have always been examined. This is due to the observed widening gap in the participation of boys and girls in physics and other challenging sciences. To address issues concerning the existing gender gap in physics, previous researchers in science education initially examined the differences and similarities between male and female students. Of course, there are biological differences between the sexes, but researchers have dispelled these as a possible reason for this disparity (Tai & Sadler, 2001). Furthermore, it has been documented that performance in physics is not gender-dependent, and that intelligence is not correlated with gender (McKenna et al*.,* 2002). Therefore, girls can do physics as well as boys. As shown in several reports (e.g. Ivie & Stowe, 2000; Feder, 2002; Women in Physics, 2002; Women in Physics in South Africa, 2005) women just seem to lack interest in this subject; how and why things move does not seem to excite them. Gender differences are apparent in students' choices and interests – more physics, preference for mechanical topics and more interest in things for males; more biology, preference for physical topics and more interest in people for females (Stokking, 2000). Even when both males and females elect physics, females are much more drawn to physics applications perceived to have high social relevance, and boys towards physics applications perceived to have a high mechanical (e.g. how planes can fly, cars, light and optics, etc.) or practical relevance (e.g. how a nuclear power plant functions) (Jones et al., 2000; Reid & Skryabina, 2002). This is, perhaps, why physics became synonymous with the male gender. Similarities on the other hand, as reviewed by Stokking (2000), are on students' choice predictors. According to Stokking, these choice predictors were "future relevance, competence, interest, achievement, difficulty, and appreciation" (p. 1262), with the first four being relevant to both males and females. Furthermore, similarities between males and females extend to their course selection and the relations between their beliefs and choices (Simpkins & Davis-Kean, 2005).

In Jones' et al. (2000) review of literature on gender differences in students' attitudes towards science and scientists, they cited researchers who found that girls described their science classes as boring and just memorising facts, and they are less likely to be interested to pursue a future career in science compared to the boys. In addition, Jones et al. highlighted in their review that the differences in the attitudes towards science widens as students move from primary to secondary school with girls having less positive attitudes compared to boys.

More recent studies on gender differences in their attitudes towards science re-confirm results from earlier studies. Research such as Miller et al.'s (2006) and Simpkins and Davis-Kean's (2005) provide evidence that girls are more interested in people-oriented aspects of science than males. In addition, Miller et al.'s, and Simpkins and Davis-Kean's findings suggest that females major in science to use it as a pathway to enter the health professions. Simpkins and Davis-Kean's (2005) results also suggest that males take science subjects to become scientists and engineers. These findings are consistent with earlier studies mentioned above. However, the term "scientist" should not be applicable to males only because it covers a broad range of professions related to science.

Attitudes towards physics

For more than forty decades now, the investigation of students' attitudes towards science has been of great interest for science education researchers. In physics particularly, science education researchers have been conducting studies to examine students' attitudes towards physics because of the reported decline in numbers enrolling in physics subjects and courses both at the secondary and at the tertiary levels. This decline in numbers has become an alarming scenario to the science education community because of its impact on a number of aspects, including societal and economic (see above for detailed discussion). Attitudes towards physics and its influence on physics uptake (or intention to enrol in physics) have been found by researchers in science education (e.g., Trumper, 2006; Osborne, 2003; Reid & Skryabina, 2002; Jones et al., 2000; Crawley & Black, 1992) to have strong positive relationship. In other words, students who have positive attitudes towards physics are more likely to choose to study physics.

A variety of studies have been conducted to examine students' attitudes towards physics. Some researchers have focused on factors that might influence attitudes towards physics such as gender (McKenna et al*.,* 2002; Ivie & Stowe, 2000; Feder, 2002; Simpkins & Davis-Kean, 2005; OECD, 2009), motivation (Murphy & Whitelegg, 2006; Angell et al., 2004; Tuan et al., 2005; OECD, 2009), school-related factors such as teachers, curriculum and classroom environment (Labudde et al*.,* 2000; Rodriguez and Zozakiewicz, 2004; Millar & Toscano, 2006; Haag, 2000; Koppel et al., 2003); and family background (OECD, 2009). Results from these studies have all confirmed significant influence of these factors on attitudes towards physics. Other researchers have examined more detailed aspects of school curriculum and its influence on attitudes towards physics. Reid and Skryabina (2002) conducted such a study and found that in order to effectively retain students with positive attitudes towards physics, a school has to have effective physics curriculum structure, attractive syllabus, committed teaching force, and good school experiences. Furthermore, some researchers have examined in detail teachers as a factor with the perception that teachers play a major role in shaping students' attitudes towards physics. Zohar and Bronshtein (2005) examined physics teachers' beliefs on low participation of girls in physics and concluded that teachers were not aware that they were 'creating' gender bias towards males in the physics classroom by unintentionally catering more for males than females. Also, a relatively large-scale study was carried out by Redford (1976) to examine the attitudes of public high school principals, guidance counsellors, and physics teachers towards the need for physics as a course of study. The results of his study indicated that a greater effort should be made to inform principals and guidance counsellors as to the value of physics in the high school curriculum.

This study combined school-, family-, and individual-related factors to examine their effects on attitudes towards physics.

Attitudes towards computers

Student access to personal computers and video games has become much easier in recent years because of their affordability. In fact, these electronic gadgets have become a common sight in homes to provide entertainment for the family, especially for children. So popular are they that researchers have begun to examine their effects on people who use them, especially children. Research results are mixed so far. Some research, such as that reviewed by Subrahmanyam, Kraut, Greenfield, and Gross (2000), suggest that playing specific computer games has been found to have positive effects on specific cognitive skills. Furthermore, they noted that improvement of students' academic performance has been mildly linked with the use of home computers. The TIMSS International Science Report (2003) has shown that personal computer accessibility at home or at school as a study aid relates to higher student achievement, especially in science. Another interesting effect of the increasing popularity of computer technology is the fact that boys and girls reported equal levels of usage and equal levels of confidence in their computer skills (Subrahmanyam et al., 2000).

Researchers have also noted some negative effects resulting from children's use of computers. As a result of the extended hours spent by children using the computer to play games, surf the Web, chat with friends, etc., and the risk of obesity, seizures, and hand injuries have recently been an increasing concern (Subrahmanyam et al., 2000). In addition, spending excessive time playing computer games, especially violent ones, are found to be associated with increased aggression and lower perceived self-concept in a number of areas, including self-esteem for girls (Subrahmanyam et al., 2000; Funk & Buchman, 1996).

Computers and other related electronic equipment have increasingly been adapted in education. The proliferation of computers and associated applications, including the Internet, provided teachers options for different delivery methods of their subjects and courses, and provided students tools for their learning. As a consequence, educational researchers became interested on the impact of computers in education. Educational researchers such as Cradler, McNabb, Freeman, and Burchett (2002); Ben, Alagumalai, and Recker (2007); and Ben and Alagumalai (2009) believe that 21st Century information and communication tools including computer-assisted instructional applications can positively influence student learning processes and outcomes, and dramatically impact educational practice. Alagumalai (2000) pointed out that with careful design, recognising suitability in different contexts, technology-based teaching and learning tools can effectively facilitate learning.

Most of the popular computer games available today show an array of physics concepts. If students could realise the association of these games with physical science concepts, then playing games using computer technology could spark students' interest towards physics and related sciences. However, a study by Escalada and Zollman (1997) was carried out on the use of computers in the physics classroom and their effects on students' with little computer background in terms of their comfort in using technology for learning physics concepts. Even when none of Escalada and Zollman's sample students had used the interactive digital technology prior to the conduct of their study, student comfort in using computer technology was increased. Furthermore, Escalada and Zollman (p. 487) concluded

> …instructional technology can have a positive effect on future teachers even when the technology is beyond their prior experience or knowledge… interactive digital video activities illustrate how technology and scientific inquiry can be integrated into a learning environment where students are given effective methods to visualize, explore, investigate, analyze, and understand physics concepts.

Additionally, a number of researchers explored the use of computer technology-based approaches which are done by making computer models of physics concepts (Schecker 1993; Reif & Scott 1994; Anslow 1999; Sillitto & MacKinnon 2000). Based on Anslow's (1999) and Sillitto and MacKinnon's (2000) review of related research, information technology-based approach may motivate physics students to learn and may therefore change their perception of learning and understanding the concepts in physics as 'dull', 'difficult', and 'boring.'

While the use of computer technology in the classroom to assist in teaching and learning is gaining popularity, some researchers have embarked on studies particularly concerning the attitudes of students towards computers and other technologies in their learning tasks. Studying students' attitudes towards computers was considered important because it formed a basis for both participation and subsequent achievement in information technology activities (Jones & Clarke, 1994). Results of such studies revealed students having generally positive towards computers and are not significantly affected by factors such as educational institution and students' year group, but can be affected by factors such as gender, subject area, and access to a home computer (see e.g., Sanders & Morrison-Shetlar, 2001; Selwyn, 1999).

A number of studies on students' attitudes towards computers were based on Kay's (1993) theoretical framework for assessing attitudes towards computers. This framework covered the cognitive, affective and behavioural domains (adapted by Jones & Clarke, 1994, and Selwyn, 1997).

With a plethora of research on attitudes towards computers, current research in physics education somehow failed to explore (at least explicitly) the possible influence of attitudes towards computers to students' perception of, and interest in, the *hard* sciences. This was explored in this study.

Motivation

Various factors and their inter-relationships can influence motivation. For example, in Zimmerman et al.'s (1992) sociocognitive model of students' self-motivation, several factors influence academic self-motivation and academic achievement. These are: student's prior grades, parents' grade goals, student's grade goals, self-efficacy for self-regulated learning and academic achievement. In physics, researchers have found evidence that motivation contributes to students' academic performance and, hence, attitudes towards the subject. In Angell et al. (2004) for example, based on the results of their analysis of their collected study data, motivation was identified as important in sustaining students' interest and their academic achievement which could also affect their attitudes. Similarly, Reid and Skryabina (2002) also found that motivation plays a key role in making students choose their subjects or courses in school or at the university. Furthermore, Murphy and Whitelegg (2006) have pointed out in their report that motivation has been identified as a significant factor in course choice by students. Teachers also play an important role in the motivation of students to study physics. Many teachers would agree that, regardless of the course/subject they teach, they motivate their students to study the course/subject that they teach by showing them how the course/subject relates to their everyday lives. An example is Weeks' (2005) report about a retired U.S. Air Force personnel who went on to teach physics at a school in Idaho. In this report, Weeks showed how this physics teacher motivated his students, regardless of gender, to study physics by showing them how physics relates to their everyday lives, and by bringing into classroom what's going on outside (school) that they may want to do someday. Furthermore, Weeks also added that this teacher has helped to generate a lot of excitement about science, particularly physics, by turning the 'regular kids' on to physics because he believes that they are the ones who need physics the most.

The previous two paragraphs show how general motivation positively impacts students' choice of a subject or a course to learn. Some researchers studied the more detailed aspects of motivation and how they affect students' interest towards a subject or a course. This is mainly because of the fact that, studies have revealed, motivation is complex and composed of a variety of factors. Researchers such as Duit and Treagust (1998), Lee and Brophy (1996), and Strike and Posner (1992) have stressed the importance of studying students' motivation within its affective components because it affects their critical thinking, learning strategies (Kuyper, van der Werf & Lubbers, 2000), and conceptual change processes (Lee & Brophy, 1996). Others (e.g., Garcia, 1995; Garcia & Pintrich, 1995; Pintrich & Blumenfeld, 1985) have considered self-perceptions of ability, intrinsic motivation, self-efficacy, test anxiety, task value, and learning strategies as important aspects in studying learning motivation. According to Tuan, Chin & Shieh (2005), there is a number of motivational studies carried out in educational psychology. However, Tuan et al. added, these motivational studies carried out by psychologists were interested in pre-determined motivation domains to understand students' general learning motivation rather than motivation to learn a specific subject, like science for instance. Researchers like Blumenfeld, Lee and

Anderson, and Weiner (all in Tuan et al., 2005) have pointed out the importance of examining students' motivation when studying specific subject content areas, such as physics, because they may show different motivational traits in these areas. In response to this, Tuan et al. (2005) carried out a study examining specific motivational domains that may impact students' interest in learning science. They found that students' learning and achievement goals, self-efficacy, learning strategies and science learning values have significant influence on students' motivation to learn science. Since this study specifically focused students' interest in physics, it has been considered appropriate that these same motivational domains be used in this study to examine students' motivation to learn physics.

Self-esteem

In simple terms, Robinson, Shaver, and Wrightsman (1991) defined self-esteem as "the extent to which one prizes, values, approves, or likes oneself" (p. 115). Similar to motivation, an individual's self-esteem is influenced by several external factors. These factors are parents and other family members during early years, and later on by friends, teachers, and schoolmates (Nichols & Utesch, 2001). Since this study partly focuses on the students' perception of physics, the latter two factors can be considered important for this study. Students' negative perception of physics and other challenging sciences including mathematics, especially for girls, has been reported to be the result of their low self-esteem caused by some school-related and external factors. In addition, Benke and Stadler (2003) argued that self-perception and subject interests are correlated. For example, Warrington and Younger (2000) noted that girls' low (academic) self-esteem in physics classes was caused by the laddish and dominant behaviour of the boys. Furthermore, according to Haag's (2000) review of related studies, the level of girls' academic self-esteem may differ between single-sex and mixed-sex environments.

More studies about the influence of self-esteem on attitudes towards physics can be found in Norvilitis, Reid, and Norvilitis (2002), Reid and Skryabina (2002), and Murphy and Whitelegg (2006). Although they have used different terms such self-perception and self-concept in place of self-esteem, their findings share similarities.

It is evident that self-esteem has become an important part in psychological research because of its association with a number of aspects such as, among others, psychological well-being, learning strategies, learning achievement, attitudes and interest (Martin-Albo, Nuñez, Navarro & Grijalvo, 2007). It is therefore imperative that a scale to measure self-esteem has adequate psychometric properties. The majority of researchers who carried out studies on students' self-esteem (including individual attitudes and interests towards a particular subject) relied on face valid self-report scales, which include the Rosenberg Self-Esteem (RSE) scale developed by Morris Rosenberg in 1965 (Robins, Hendin & Trzesniewski, 2001). The RSE scale holds the reputation of being the most tested and used in a wide variety of research contexts with widely varying populations (Gray-Little, Williams & Hancock, 1997). Its popularity is mainly due to its valid and reliable measure of self-worth, and its simpleness. It can be administered in only a few minutes requiring no more than fifth-grade level language for each of the 10 items (Pullmann & Allik, 2000). The RSE scale represents the understanding that self-esteem is a component of self-concept which is defined as an individual's set of thoughts and feelings about his or her own worth and importance, which is a global positive or negative attitude toward oneself (Rosenberg, 1965).

2.4. International studies

Most of the studies mentioned in the previous sections were carried out only in "single" locations (e.g. a university, a group of high schools or elementary schools in an urban or a suburban area). However, a few related international studies have also been carried out in two or more countries seeking answers as to why students move away from physics.

The limited and fragmented nature of the available information is the key driver for conducting this research project. Few studies have sought information in science and physics education by examining (and comparing) at least two countries. For example, in Australia, Lyons (2006) did a comparative study to examine Swedish, English, and Australian high school students' experiences of school science to provide important insights into the decrease in interest and enrolments in high school and university science courses. Lyons' study did not show a strong relationship between attitudes to science and enrolment outcomes, which might suggest that students' experiences are not a compelling influence on students' decisions. However, her study's qualitative approach was able to distinguish students' beliefs about what science courses represent in terms of future aspirations (such as university placement) as one of the factors influencing students' enrolment decisions. This study represents progress in addressing the issue of students' declining interest in the 'hard' sciences. However, in this study the role of cultural and socio-economic aspects could not be investigated effectively since all the countries compared were somewhat similar in these aspects. Another study, of much larger scale, is called the *Relevance of Science Education* (ROSE) international comparative project covering 40 countries. It aimed to explore affective factors of importance to the learning of science and technology of 15-year-old secondary school students (Sjoberg & Schreiner, 2005). Illustrative data in this study showed a clear distinction between developed and developing countries that prompted Sjoberg and Schreiner to conclude that youth orientations towards science and technology are linked to the level of development in a country. Hence, socio-economic factors' affective role. In other words, the less developed the country is, the more positive young people are towards science and technology because of its perceived important progress-improving role in a society. Based on the results of the ROSE project showing that there are more students in developed countries doing courses in medicine, biology and environmental studies, Sjoberg and Schreiner (2005) asserted that this may be an indication that youth in these countries believe that health- and environment-related issues are the most important challenges facing their society, and, consequently, more meaningful jobs can be offered in these fields.

A large scale study carried out every four years since 1995, involving over 60 countries, is the Trends in International Mathematics and Science Study (TIMSS) conducted by the International Association for the Evaluation of Educational Achievement (IEA). This is a large-scale assessment designed to inform educational policy and practice by providing an international perspective on teaching and learning in mathematics and science (TIMSS International Science Report, 2003). This study involves Year 4 and Year 8 students. The results of this study suggest the extent to which students have learned science and mathematics concepts and skills likely to have been taught in school (Gonzales, Williams, Jocelyn, Roey, Kastberg & Brenwald, 2008). According to Thomson and Buckley (2009), the main goal of TIMSS is to assist participating countries to monitor and evaluate their mathematics and science teaching across time and across year levels. Part of this study is a survey of students' attitudes towards science. The results of this study have significant impacts on science pedagogies which could assist educators in developing learning strategies that suit their particular teaching styles and unique educational contexts (Thomson & Buckley, 2009).

A similar large-scale international study which focuses on reading, mathematics and science literacy is the Programme for International Assessment (PISA) conducted by a forum of 30 countries called the Organisation for Economic Co-operation and Development (OECD). Key features of PISA are its: (a) policy orientation, (b) innovative approach to 'literacy', (c) relevance to life-long learning, (d) regularity, (e) consideration of student performance alongside characteristics of students and schools, and (f) breadth of geographical coverage (OECD, 2009). This study, which started in 2000, and repeated every three years, is participated in by 57 countries (in 2006), both OECD member and non-member countries. The main focus of the study each time it was carried out varied: the first time (in 2000) was on reading literacy, the second time (in 2003) was on mathematics literacy, and the third time (in 2006) was on science literacy (Thomson & De Bortoli, 2008). Fifteen-year old school students' performance on reading, mathematics and science were assessed, and data were collected on student, family and institutional factors that can explain performance differences (OECD, 2009). The PISA seeks to measure how well young adults are prepared to use knowledge and skills in particular areas, including science, to meet real-life challenges which address how well students are able to apply what they learn at school (Thomson & De Bortoli, 2008). This study was conceived partly because of the rapidly increasing demand for highly skilled workers that has led to global competition for talent (OECD, 2009). The OECD (2009, p. 3) pointed out

> While basic competencies are important for the absorption of new technologies, high-level skills are critical for the creation of new knowledge, technologies and innovation. For countries near the technology frontier, this implies that the share of highly educated workers in the labour force is an important determinant of economic growth and social development. There is also mounting evidence that individuals with high level skills generate relatively large externalities in knowledge creation and utilisation, compared to an "average" individual, which in turn suggests that investing in excellence may benefit all.

It was mentioned above that in 2006, the focus of the PISA study was on science literacy. Present in the OECD (2009) report are some of the guiding questions of

PISA, which can be considered in parallel with this study's focus. These are: (a) What motivations drive students in their study of science? (b) What are the students' attitudes towards science and what are their intentions regarding science careers? The difference would be that the PISA study focused on all science subject areas while this study focused solely on physics.

2.5. Theoretical framework

The theoretical framework of the present study drew on the tenets of the different theories proposed by a number of researchers on the factors that influence students' attitudes and perceptions of science, and how they do this. The framework thus becomes an integration of constructs from three broad fields namely: school, family, and individual-level characteristics. Many studies have documented the effects of teachers, school environment, parental involvement and gender differences on students' attitudes and perceptions of science, particularly physics, over time. However, only a few have explored the interrelationships of these factors, and how they affect students' attitudes towards physics. Other areas that have been little explored in physics education are the factors that have an effect on adolescent students' self-esteem and motivation to choose physics as a school subject or a course at university. Physics is arguably perceived to be a challenging subject or course by the majority of adolescent students. This is apparently largely because of its mathematical component and its highly theoretical nature (Ogunsola-Bandele, 1996) contributing to students' negative attitudes towards physics and other mathematics-related subjects (Brungardt & Zollman, 1995). However another contributing factor may be of the individual students' perceptions of physics in terms of its social and economic importance. For these reasons a student must have a high self-esteem and motivation, and positive attitudes to do it. Motivation and self-esteem are affected by several factors such as achievement, family, teachers, and school environment.

Other factors, such as media (more specifically computer use), parents' education and parents' aspirations and support for their education and future career choices may also have an effect either directly or indirectly on students' motivation to choose physics.

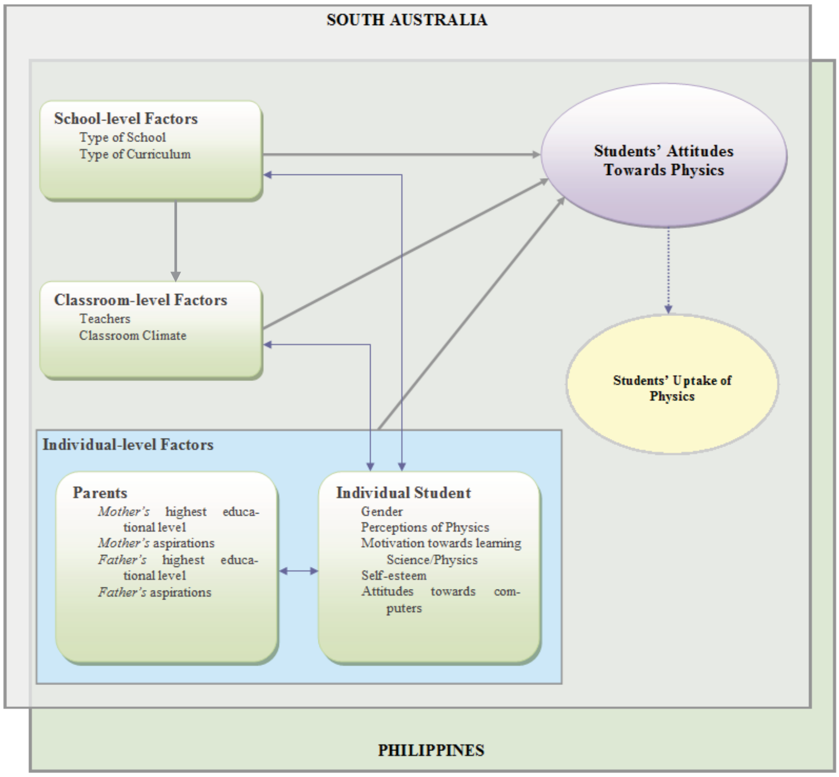


Figure 2.1. General factors influencing students' attitudes towards physics.

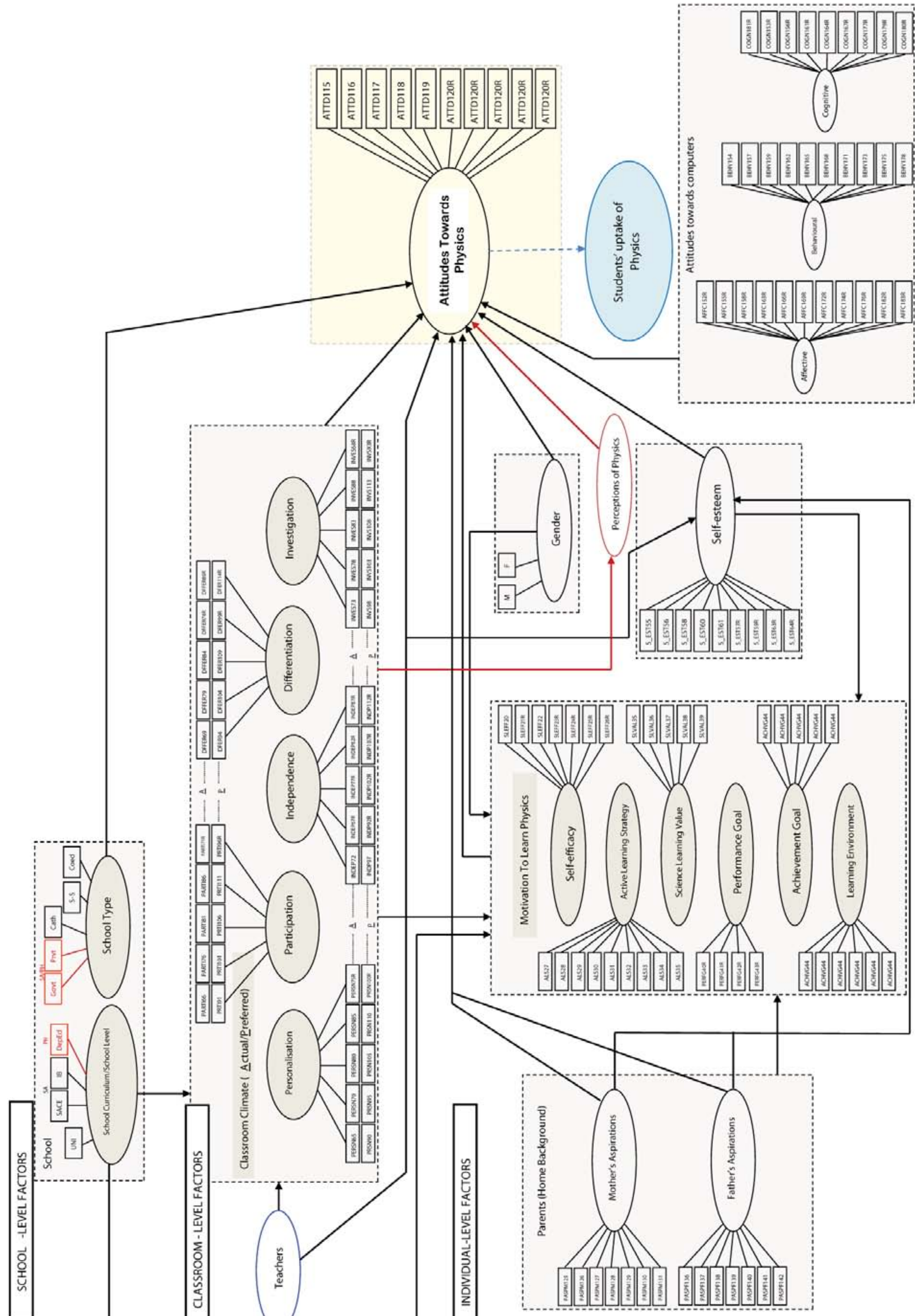


Figure 2.2. Theoretical Model for Analysis.

This study sought to investigate the causal relationships between these factors and how they affect students' attitudes towards, and uptake of, physics. Figures 2.1 and 2.2 illustrate broadly the theoretical model conceived to examine the relationships of students' individual characteristics, family context, and school context to students' uptake of physics. It depicts the interconnections between student's individual-level characteristics, school, and family contexts. Each broad field (defined by a thick broken line) is composed of factors that define it (represented in Figure 2.2).

The theoretical model proposes that school factors (defined by teachers, school curriculum, school environment, and school type) and family factors (defined by parents' aspirations and support for their children's education) have direct impact on a student's individual characteristics (defined by motivation, self-esteem, and attitudes towards physics and computers) that determine their preference to study physics.

The model also implies that students' attitudes affect their uptake of physics. In other words, physics uptake is gauged by positive attitudes (Trumper, 2006; Osborne, 2003; Reid & Skryabina, 2002; Jones et al., 2000; Crawley & Black, 1992). Therefore, 'attitudes towards physics' take centrality in the discussion of the analysis results.

2.6. Summary

Students' attitudes towards the sciences have been examined by science education researchers for over three decades. Of particular interest are students' attitudes towards physics. This is largely due to the declining participation of students in physics which has significant implications on the economic aspect and science literacy of the society.

A number of factors and their influence on students' attitudes towards, and interest in physics have been examined by science education researchers. These factors can be grouped into school- and classroom-related factors, family-related factors and individual-level factors. Among the school and classroom-related factors, studies have found that the curriculum, teachers (their behaviour and teaching strategies), and classroom climate have significant influence on how students perceive physics, hence, consequently affecting their attitudes towards the subject. It has been suggested by a number of research findings that physics curriculum should be context-based or humanistic in order to attract participation of students. Students should be able to see and feel how physics is connected to everyday life.

Consequently, teachers play key roles in implementing a curriculum. It has been found in studies relating to student attitudes that teachers have very significant effect on students' attitudes towards, and perceptions of a subject. In physics, it has been suggested that teachers could use a number of strategies to deliver physics lessons in an interesting and equitable manner (for boys and girls). According to educational researchers, the way teachers teach physics to their students may also have a profound effect on classroom environment which has also been found to affect students' attitudes towards physics.

Parents' education, occupation, and their aspirations and support for their children's learning have also been reviewed for their influence on student attitudes towards school subjects such as the sciences.

Individual level factors also contribute to students' attitudes towards the sciences, particularly physics. Factors such as gender, motivation and self-esteem have all been examined for their relationship with students' attitudes. Researchers who have examined these factors found some significant associations with student attitudes. Attitudes towards computers have also been discussed as contributing although perhaps, no literature has been found about its effects on students' attitudes towards physics.

A few international studies comparing several countries on how students perceive the sciences have also been included in this chapter.

The research methods employed in this study follows this chapter.

Chapter 3

Research Methods

3.1. Introduction

In this study, a range of factors that could affect students' attitude and interest towards taking Physics as a course of study were investigated. These factors, most of which had been proposed at some time in the recent associated literature, were categorised into two broad groups namely: school factors and individual level factors. The factors in each category are as follows:

1. School factors
    a. School curriculum
    b. School type
    c. Teachers
    d. Classroom climate

2. Individual-level factors
    a. Parents' aspirations
    b. Gender
    c. Motivation
    d. Self-esteem
    e. Attitudes towards computers

The overall aim that guided this study was to investigate inter-relationships between the factors mentioned above and how they affect students' attitudes and their interest in taking Physics.

A series of instruments containing scales to measure the factors investigated in this study was developed based on existing instruments previously used to measure each of these factors. This necessitated the need to have systematic methods of data collection and analysis. Even if the scales used in the instrument for this study were identical with existing instruments, it was also necessary to test these scales to confirm their validity, reliability, integrity, and their suitability for use in this study. In addition, this method of data collection using scales required careful consideration of the issues of strength and consistency. Several tests were employed, including Rasch scaling, to address the research items in a valid manner and to establish the strength and consistency of student responses.

Teacher interviews were also conducted to better understand the impact that teachers might have on students' attitudes and interest towards studying Physics.

The study was conducted in senior high schools and universities in the Adelaide metropolitan area in South Australia and in Quezon City in the Philippines. To measure the factors, it was necessary to go through a sequence of carefully considered research methods and materials. This chapter discusses the research methods and materials employed in this study.

3.2. Planning stage

In order for the study to proceed effectively, it was important to complete a number of tasks before collecting data. This section elaborates these required tasks.

Identification of the focus of the study

This section highlights how the study evolved from conceptualisation to forming the proposal for approval.

The focus of this research study developed from an extensive review of literature about problems in Physics education. This was prompted by observations made by the researcher when he taught Physics in the United States for a number of years. For years, based on school records, Physics enrolments at the school where the researcher taught were either low (in the single digits), or none at all.

Initially, problems in Physics education in the European countries and the United States were reviewed, because the bulk of the relevant published articles and books came from these countries. The problems and issues in Physics education addressed in these sources included schools' Physics curricula, students' attitudes towards Physics, the quality of Physics teachers, students' gender, and attitudes to Physics as a profession, among others. Many of these different issues raised, including those mentioned above, fall into the broad category of Physics participation, either by all students, or by women.

Questions about Physics education in Australia and the Philippines then arose as a result of this review. These included questions about trend similarities or differences in students' interest in studying Physics as a subject or a course. The study proposed was thus aimed at contributing to the pool of the still-fragmented knowledge about Physics education in Australia, and to that about the Philippines where there is none. In addition, this study was envisaged to open more research opportunities in the area of Physics education in Asian countries such as the Philippines, where there are few or no publications about students' interest in, or attitudes towards Physics as a school subject or university course. Furthermore, proposing and carrying out this study enabled the examination of the impact of making Physics a compulsory school subject towards subsequent uptake of Physics as a course or subject at university level studies.

Choice of methods

This section describes and justifies the mixed methods (i.e. using both quantitative and qualitative methods) of research and analysis on this research study.

This study employed both quantitative and qualitative methodologies with the belief that although using quantitative measures yield useful information about outcomes, the additional collection of qualitative data develops a more in-depth understanding of the quantitative data obtained (Creswell, 2008). In addition, even if this research in general, falls within the domain of scientific research which tends to be associated with quantitative methods, it is strongly believed that both methods are needed to be able to obtain methodologically sound data. As Mayer (2000, p. 39) argues:

> I disagree with this characterization which equates science with using quantitative data, and non-science with using qualitative data. Scientific research can involve either quantitative or qualitative data; what characterizes research as scientific is the way that data are used to support arguments.

Furthermore, even though quantitative data and qualitative data are inherently different, they are also remarkably the same (Libarkin & Kurdziel, 2002). Libarkin and Kurdziel (2002) pointed out that quantitative data are derived from qualitative decisions and that qualitative data can be transformed into quantitative data. They also added that several methods of quantifying qualitative data have already been developed by social science researchers.

Specifically, this study employed an embedded mixed method design. This means that both quantitative and qualitative data were collected simultaneously, but the qualitative data only acted as an extension support to the quantitative data. This design shows its strength by combining the advantages of both quantitative and qualitative approaches (Creswell, 2008). As Creswell (2008, p. 559) pointed out

> Quantitative data are more effective at recording outcomes of the experiment than identifying through qualitative data how individuals are experiencing that process. It also provides a type of mixed methods design in which the researcher can collect qualitative data, but the overall design still emphasizes quantitative approaches…this role of qualitative data helps to legitimize the use of such forms of data.

In other words, the combination of both quantitative and qualitative methods yields successful and superior research because of the methodological pluralism and eclecticism (Johnson & Onwuegbuzie, 2004).

Ethics approval

Before this study could proceed, it was necessary to seek for ethics approval from the University of Adelaide Human Research and Ethics Committee (UAHREC). Subsequently, approval from the Department of Education and Children's Services (DECS), the Catholic Education Office (CEO), and the Association of Independent Schools in South Australia (AISSA) were sought. Similarly, in the Philippines, approval for participation in the study was also sought from the Department of Education (DepEd) for secondary schools and the Commission on Higher Education (CHEd) for universities. Thus obtaining ethics approval, and approval for participation, involved a considerable amount of paperwork (not to mention time) to inform all of the educational authorities involved about both the rationale and the methodology for the study. In addition, gaining ethics approval also involved the necessity of ensuring that informed consent would be obtained from all participants in the study, and that confidentiality would be maintained at all times. In case of participants who were under 18 years old, their parents'/guardians' consent were obtained.

The UAHREC granted approval for this study to proceed on the 1st of March 2007 (ethics approval number H-135-2006). DECS approved this study on the 20th of April 2007 (approval number DECS CS/07/0108.7). The CEO and the AISSA approved the study to proceed but did not provide a formal certificate of approval. Since this study included students who were under 18 years old, the CEO requested the researcher to obtain a Police Check certificate from the South Australia Police Department before the data collection from the Catholic schools could proceed. The DepEd and CHEd of the Philippines sent their approval through email but did not issue a formal approval certificate. The education authorities both in Adelaide, Australia and Quezon City, Philippines requested for a report of the results of the data analysis as part of their condition for the approval of this study.

3.3. Sampling and data collection

Before data collection commenced, the population considered for the study was defined. In South Australia, the population of this study was defined as students enrolled in Year 11 or Year 12 Physics in schools in the Adelaide Metropolitan area and First Year university-level students in Adelaide undertaking a Science degree or a double degree with Science component.

In the Philippines, a comparable population was defined as students in the 4th Year of high school in the Quezon City School District area and First Year university students undertaking a Physics/Science degree at universities in the Quezon City area. The two groups were seen as reasonably comparable because Fourth Year high school students in the Philippines are comparable to Year 11 students in South Australia in terms of their age. However, Physics in 4th Year high school is compulsory in the Philippines, but an elective in South Australia.

After identifying the target population and all the possible schools that could participate in the study, emails with requests to participate were sent to School Principals and University Physics Department Chairpersons in Quezon City in the Philippines in April 2007. In Adelaide, Australia, emails requesting participation were sent to School Principals, School Science Coordinators, and University Physics Lecturers. Phone calls were also made to discuss the details of the administration of the student questionnaire survey and the teacher interviews in each school or university. It is clearly implied in this paragraph that there were two groups of samples: high school-level students and university-level students. In South Australia, Year 11 and Year 12 Physics students were chosen as samples for the high school level group and First Year University students doing a Science or a double degree with Science component were chosen for the university-level group. In the Philippines, Fourth Year high school students represent the high school group and First Year University students doing a Physics degree or Science degree were chosen for the university-level group. Figure 1.5 in Chapter 1 shows a comparison of the two groups sampled in this study. Students coming from schools and universities who participated in this study were randomly chosen. However, schools and universities who participated were not randomly chosen. This was due to the difficulty encountered by the researcher in getting schools and universities to participate in the study. In other words, the originally planned random sampling of schools and students was not achieved. Opportunity sampling resulted instead. Section 3.5 will provide more details on this.

Two methods for data collection were used in this study. Data were collected through (a) surveys using the instruments that had been developed previously, and (b) teacher interviews. There were two kinds of questionnaires used in the survey; (a) student questionnaire, and (b) teacher questionnaire. The student questionnaire had been developed by using (and slightly modifying) some existing instruments to measure the factors examined in this study. The teacher questionnaire consisted of open-ended questions that focused on their confidence in teaching Physics, their perceptions of the school's Physics curriculum and their promotion of Physics in their classrooms. Teacher interviews were necessary to capture a rich amount of information to enable deeper understanding of what they had written in their answers to the teacher questionnaire items.

Using a survey instrument for data collection yields an advantage for a more efficient collection of large amounts of data from a large number of respondents. A large student sample size, coming from a relatively large number of schools, was considered desirable to reduce error due to sampling.

3.4. Scales used in the study

Several existing scaled instruments that could be used to measure the different factors/latent variables in this study were examined. However, a reasonable time (of within 25 to 35 minutes) for a participant to complete the questionnaire was preferred in order to minimise item processing load and the possibility of boredom on the part of the participant. Thus, only items that would suit the needs of this study were chosen from other instruments to keep the questionnaire within reasonable length. Some items from the different instruments examined were excluded because they addressed an aspect with which this study was not concerned. In addition, for the pilot survey it was decided that a selection of items from the collection of instruments considered in this study needed to be slightly modified suiting the study's needs. This would enable an effective survey of the factors that could affect students' attitudes and interest towards studying Physics. This section describes the different instruments used in the development of the final instrument used in this study. All (except for the self-esteem scale) use a five-point Likert response scale.

Attitude towards physics scale

This was the main focus of this study – to measure students' attitudes towards studying Physics. An instrument developed by Redford (1976) was adapted and used to measure these attitudes. This instrument was originally intended to be used to measure the attitudes of public high school principals, guidance counsellors, and Physics teachers towards the need for Physics as a course of study. However, with some minor modifications, it was believed that this instrument could also be used to measure students' attitudes towards Physics, because each item in the original instrument is straightforward and therefore believed to be easy enough for students to understand. In addition, Redford's instrument focused in the importance and usefulness of Physics in society, and other key areas of focus of this study.

There are 10 statements used in this attitude instrument. The first 5 are positive statements and the other 5 negative. Each statement has five possible responses: strongly agree, agree, neutral, disagree, and strongly disagree. In Redford's (1976) original instrument, he assigned zero as the unfavourable extreme of the attitude continuum and four to the favourable extreme, with two assigned to the neutral position. However, using these assignments would not be consistent with the other scales used; therefore, a small modification was made with one and five being the extremes, and three the neutral position. According to Redford (1976), this instrument yielded a very high correlation of +0.91 using item analysis, and a reliability coefficient of 0.856 using split-half reliability test with the Spearman-Brown formula to obtain an unbiased estimate of the reliability of the total test.

The Colorado Learning Attitudes about Science Survey (CLASS) (Adams, Perkins, Podolefsky, et al., 2006) was also considered for use in this study. This instrument covered areas which could give the researcher a greater insight into students' attitudes towards Physics. These areas include: real world connection, personal interest, conceptual connections, and teaching practices. However, the instrument consists of 42 items and was considered too long to be incorporated into the survey instrument developed for this study. Moreover, some of the items in the CLASS were considered by the authors not to be useful and they noted they were working on improved versions.

The Attitude Toward the Science Subject Scale (ATSSS) (Krynowsky, 1985) was also considered to fit this study, however, the researcher had a difficulty accessing a copy.

Motivation toward learning science/physics scale

A number of motivation scales have been published. Each of these scales have been designed to measure a number of dimensions of motivation. An example is Guay, Vallerand & Blanchard's (2000) Situational Motivation Scale (SIMS). According to the authors, SIMS is a "brief and versatile self-report measure of situational intrinsic motivation, identified regulation, external regulation and amotivation" (p. 175). Another that was considered in this study was Uguroglu, Schiller & Walberg's (1981) multidimensional motivation instrument that included wide range of dimensions including social, emotional and physical self-concepts, locus of control and achievement motivation. However, an instrument used to measure academic motivation was more preferred in this study, and the Uguroglu's instrument was considered too broad and did not really capture what was required in this study – to measure students' motivation to learn Physics. A review of Vallerand, Pelletier, Blais, et al.'s (1992) academic motivation scale to measure intrinsic, extrinsic, and amotivation in education also proved the scale to be too general for use in this study. Thus, a more subject-specific motivational scale provided by Tuan, Chin & Shieh (2005) was preferred here.

Part of the instrument used in this study was adapted from Tuan et al.'s (2005) questionnaire called Students' Motivation Toward Science Learning (SMTSL). This SMTSL questionnaire consists of 35 items measuring 6 scales: self-efficacy, active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation. These scales were defined by the authors (see p. 643 of their paper) in a way that was considered suitable for this study:

1. *Self-efficacy*. Students believe in their own ability to perform well in science learning tasks.
2. *Active learning strategies*. Students take an active role in using a variety of strategies to construct new knowledge based on their previous understanding.
3. *Science learning value*. The value of science learning is to let students acquire problem-solving competency, experience the inquiry activity, stimulate their own thinking, and find the relevance of science with daily life. If they can perceive these important values, they will be motivated to learn science.
4. *Performance goal*. The student's goals in science learning are to compete with other students and get attention from the teacher.
5. *Achievement goal*. Students feel satisfaction as they increase their competence and achievement during science learning.
6. *Learning environment stimulation*. In the class, learning environment surrounding students, such as curriculum, teachers' teaching, and pupil interaction influenced students' motivation in science learning.

Although it was still very much within its testing stage when it was published by its authors, this SMTSL instrument used to measure students' motivation was perceived to fit the needs of this study for two major reasons:

a. Researchers such as Blumenfeld, Lee and Anderson, and Weiner (all in Tuan et al., 2005) have stressed the importance of examining students' motivation when studying specific subject content areas, such as Physics, because they may show different motivational traits in these areas, and

b. SMTSL measures various motivation factors (self-efficacy, active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation) all of which were found to contribute toward students' science learning motivation (Tuan et al., 2005).

In addition, based on the STMSL authors' findings, their instrument yielded a high reliability coefficient of 0.89 with each scale ranging from 0.70 to 0.89.

Self-esteem scale

In this study's attempt to measure Physics students' individual self-esteem, the Rosenberg Self-esteem scale (RSE) (Rosenberg, 1965) and Robins, Hendin, and Trzesniewski's (2001) Single-Item Self Esteem scale (SISE) were compared. Both scales are short but show high correlations with a number of criterion measures including academic outcomes, social desirability, and peer ratings of group behaviour (Robins et al., 2001). However, the RSE scale is by far the most widely used (see e.g Gray-Little, William & Hancock, 1997). The RSE scale has also been used with different groups and in different contexts as well (e.g. Pullmann & Allik, 2000). More recently, the RSE was administered in 53 nations to explore its universal and culture-specific features (Schmitt & Allik, 2005). Thus, it was decided that the Rosenberg Self-Esteem (RSE) scale, aside from its popularity (Hagborg, 1993; Pullmann & Allik, 2000), would suit the requirements of this study in terms of its brevity and thoroughness in measuring global self-worth or general self-esteem (Hagborg, 1993). In addition, the RSE scale has an uncomplicated characteristic with no more than fifth-grade-level language, and it can easily be administered in a few minutes (Pullman & Allik, 2000). The RSE scale also exhibits a considerable evidence of its reliability and validity (see Hagborg, 1993) with some studies reporting reliabilities ranging from 0.72 to 0.88 (Gray-Little et al., 1997), and from 0.88 to 0.90 in others (Robins et al., 2001).

The RSE scale consists of 10 items (five positive and five negative statements) measuring a global, one-dimensional (Hagborg, 1993) construct which is understood to be a person's overall evaluation of his or her worthiness as a human being (Rosenberg, 1979). More specifically, Rosenberg (1979, p. 54) considered a person having a high self-esteem has

> Self-respect, considers himself a person of worth. Appreciating his own merits, he nonetheless recognizes his faults…"Low self-esteem"…means that the individual lacks respect for himself…seriously deficient as a person.

Using the RSE scale addressed this study's requirement to examine Physics students' general level of self-esteem as this study did not necessarily focus on one domain of behaviour.

Computer attitude scale

One of the factors measured in this study was the Physics students' computer access and usage. This does not necessarily mean that this study only measured students' frequency of using a computer; it also measured their attitudes towards computers. This was in connection with this study's aim to examine the general attitudes of Physics students towards computers. In addition, this was particularly interesting for the researcher because of the possibility of attitudinal reaction differences between genders, such as concerns that females may feel less positively than males about computers (Nickel & Pinto, 1986). This may have implications on differences between attitudes of males and females towards Physics.

Three different instruments to measure students' attitudes towards computers were examined for suitability to this study. These were Nickel and Pinto's (1986) Computer Attitude Scale (CAS), Selwyn's (1997) Computer Attitude Scale for 16-19 Education, and Jones and Clarke's (1994) Computer Attitude Scale for Secondary Students (CASS). All of these instruments measured at least three of the following components: affective, perceived usefulness, perceived control, behavioural, and cognitive. Nickel and Pinto's (1986) and Selwyn's (1997) instrument appeared to be reliable and valid research instruments, but both only used a rather limited subject pool. On the other hand Jones and Clarke's (1994) has more items and covered more computer-related behaviours and attitudes. It also used a bigger number of samples for its validation.

For the reasons stated above the instrument developed by Jones and Clarke (1994) was adapted. Jones and Clarke's instrument, like Selwyn's (1997), was based on the theoretical framework developed by Kay (1993) to assess attitudes towards computers covering the cognitive, affective and behavioural domains. The instrument was designed in such a way that it considered the three domains as three distinct but interrelated components of attitudes (Breckler, 1984). Jones and Clarke (1994) believed that the incorporation of these attitudinal components within their computer attitude scale provides a comprehensive measure of attitudes towards computers. The instrument consists of 40 items where 15 assess the cognitive component, 15 assess the affective component and 10 the behavioural component. However, not all 40 items were used in the final instrument used in this study. Some items were omitted because they addressed an aspect with which this study was not concerned, and others were omitted to trim the length of the final questionnaire.

Based on Jones and Clarke's calculations, their computer attitude scale obtained an internal consistency total of 0.95, with each attitude component having a value ranging from 0.71 to 0.88. Their calculations also indicated an adequate test-retest reliability coefficient of 0.84.

Classroom climate scale

In trying to measure Physics students' experiences in a Physics classroom, Barry Fraser's (1990) Individualised Classroom Environment Questionnaire (ICEQ) was used in this study. This instrument was used to address one of the research questions that sought to measure the impact of the students' experiences in their Physics classroom on their attitudes towards Physics and their subsequent uptake of Physics. It was also used to determine teachers' impact on students' attitudes and interest towards Physics based on how teachers interact with their students.

Fraser's ICEQ comes in two forms: the long form and the short form. The long form is generally preferred over the short form for its reliability, as Classical Test Theory recognises that longer tests are more reliable than shorter ones, partly because they more adequately sample the identified construct or behaviour (Alagumalai & Curtis, 2005).

Each form consists of two components: the first, called "actual classroom", consists of items relating to students' perceptions of what is actually happening in their classroom;

and the second part, called "preferred classroom", is concerned with goals and values, measuring what students perceive to be an ideal classroom environment (Fraser, 1990). According to Fraser (1990, p. 1), his ICEQ is different from other classroom environment assessments in a number of aspects:

> First, it assesses those dimensions (namely, *Personalisation*, *Participation*, *Independence*, *Investigation* and *Differentiation*) which distinguish individualised classrooms from conventional ones. Second, in addition to measuring the actual classroom environment, it has a form which assesses the preferred classroom environment. Third, it can be used with either students or teachers. Fourth, the ICEQ has been designed to permit ready hand scoring. Fifth, the instrument has a short form which can be used to provide a rapid, more economical measure of the classroom environment.

The following are Fraser's (1990, p. 5) description for each of the five scales in his ICEQ:

- *Personalisation* – emphasis on opportunities for individual students to interact with the teacher and on concern for the personal welfare and social growth of the individual.
- *Participation* – extent to which students are encouraged to participate rather than be passive listeners.
- *Independence* – extent to which students are allowed to make decisions and have control over their own learning and behaviour.
- *Investigation* – emphasis on the skills and processes of inquiry and their use in problem solving and investigation.
- *Differentiation* – emphasis on the selective treatment of students on the basis of ability, learning style, interests, and rate of working.

Fraser's ICEQ have been used and tested in different countries for a number of years which ensures the instrument has good validity and reliability. In addition, both the long and short forms have the multidimensionality that was needed by this study. However, the short form was the preferred choice for this study, while acknowledging its limitations in terms of its reliability, for the reasons of economy and that only average class perceptions of their experiences in the classroom were measured.

Parents' aspirations scale

This study also measured the impact that parents have towards influencing their children to study Physics. It has been shown in a number of research undertakings about parents and their children (e.g. Darling & Steinberg, 1993; Alexander et al., 1994; Hill et al., 2004) that parents, regardless of their social status, seem to have an influence on what their children would like to do as a future career. Within this study's context, what are the parents' aspirations for their children who are doing Physics in high school? However, there was no direct solicitation of parents' aspirations for their children since parents did not participate in any survey in this study. Information was collected by asking the Physics student participants about their perceptions of their parents' educational and occupational aspirations for them.

Previous research undertakings on parents' influence on their children were mostly completed using either interviews or other qualitative forms, so this was where the researcher had some challenges finding an instrument that would suit this study. During the proposal stage, only Marjoribanks' (2002) Perceived Family Capital Scale (PFCS) was available. However, this instrument was readily adapted because it consisted of items about children's perceptions of their parents' aspirations for their education and future careers. PFCS consists of two factor scales labelled adolescents' perceptions of fathers' and mothers' support for learning. Alpha reliability estimates for these scales were 0.76 and 0.78, respectively. Furthermore, the instrument also contained items about the encouragement children received from their parents with respect to their education, and also their parents' interest in their education (Marjoribanks, 1999). For a number of years, Marjoribanks had tested the PFCS on different cultural groups, a fact that was considered by this author as "beneficial" for this study that used two different groups coming from different cultures.

The pilot study

Before proceeding to the main data collection for the study, it was necessary to trial the final instrument so that the study would proceed smoothly. The following sections give the details of the pilot study.

The student questionnaire

Items coming from 6 different existing instruments (mentioned above) were selected to suite this study's requirements. Items were chosen to reflect Physics students' general perceptions of and their attitudes towards studying Physics based on the following scales:

- Motivation towards learning Physics;
- Attitudes towards learning Physics;
- General self-esteem;
- Parents' aspirations; and
- Attitudes towards computers.

The questionnaire included items about demographic information to obtain personal and general information about each respondent, and it also included some open-ended questions intended to capture in more depth students' views of the importance and the status of Physics in the society. This information was added because it was considered potentially useful in identifying reasons/factors that might influence students to study Physics.

The school chosen for the pilot study was an Independent School in the Adelaide Metropolitan area. This school was chosen because of its convenience, and the fact that it included both genders. In addition, it was also because the author had contacts in the school.

Thirty Year 12 Physics students were randomly chosen by the school's Physics teacher from a pool of over 60 students. An additional 5 students were randomly chosen to serve as replacements in case somebody from the group of 30 students changed his/her mind to participate for personal or parental reasons, or was absent. These chosen students were briefed by the researcher about what the study was all about and why it was important. To comply with ethical requirements, letters with consent forms were sent to parents of the chosen participants and replacements. Before participant students were asked to complete a questionnaire, the consent form signed by their parent or guardian was collected. Fortunately, out of the 33 who were chosen, only two students changed their minds about participating in this pilot study. Each of the 30 students was given a questionnaire to complete. The researcher, with the assistance of the Physics teacher, provided each of the responding students with a set of straightforward instructions for completing the questionnaire.

The pilot study was carried out to determine adequacies/inadequacies in the way certain items in the questionnaire were presented. In addition, the average amount of time consumed by respondents to complete the questionnaire was recorded to determine whether the survey could be carried out within the allotted time of a single Physics class. It was originally planned to have 3 daily 20-minute sessions for the completion of the questionnaire because of its length and, therefore, it was assumed that students would not be able to fill-in the questionnaire within the length of an average lesson. However, the Physics teacher from this school suggested that it would be better if the questionnaire was administered in one session for two reasons: first, it would not cause too much class disruption in schools and universities, and second, it would be difficult to keep students' interest high in completing the questionnaires. On the average, student participants took around 30 to 35 minutes to complete the questionnaire which was well within the allotted time for a Physics class.

After the completed questionnaires were collected, items were scanned to check for errors that would cause coding difficulties such as double responses. Microsoft ® Excel was used to enter and organise the pilot data. The use of this popular spreadsheet software program enabled the easy organisation and classification of data into an appropriate form for entry and processing in the Statistical Package for the Social Sciences (SPSS) (SPSS Inc., 2008) software program. SPSS Version 16.0 was used to analyse the data file created to determine the consistency and the reliability of the items for each scale in the instrument. In addition, results from this analysis also confirmed some of the reliability figures published by the authors for the different instruments compiled used in this study.

Teacher questionnaires

The teacher questionnaire used in this study was specifically written for Physics teachers. It contained open-ended questions that included their perceptions of Physics and the Physics curriculum in their school. It also included questions about how they generally teach Physics in their classroom and how they promote Physics among their students. Five Physics teachers and education experts coming from different schools and a university were approached for their feedback on the questions included in the questionnaire. In addition, suggestions on how to improve the questionnaire were solicited from the teachers and education experts.

Finalisation of the instrument

The instrument used in this study was named the "Students' Uptake of Physics Study Questionnaire" or the SUPSQ. As mentioned earlier in this chapter, it is a collection developed from different instruments that have been trialled and tested by their respective authors. The result was a 183-item questionnaire that was divided into the following sections:

- Section 1: general information about the respondent and the respondent's family, the respondent's school and his/her perceptions of physics.
- Section 2: the respondent's motivation to learn science/physics.
- Section 3: the respondent's general self-esteem.
- Section 4: the respondent's perceptions of his/her actual physics classroom climate (what actually happens in his/her physics classes). This section also includes the respondent's opinion of their preferred physics classroom (how he/she would really like his/her physics classroom to be).
- Section 5: the respondent's attitudes towards the importance and applications of physics.
- Section 6: the respondent's parents' aspirations (strictly what the students perceive to be their parents' educational aspirations for them).
- Section 7: the respondent's access and frequency of computer use. It also included items that measure their attitudes towards computers.

Factor analysis using Varimax rotation from SPSS revealed 7 items that were considered misfits and therefore considered not useful to include in the final SUPSQ instrument. However, it was decided that these items may have been unable to discriminate sufficiently because of the small sample size used in the pilot study. Furthermore, the pilot study was not carried out using Filipino students which may have yielded a different result. Reliability analysis (particularly Cronbach Alpha) using SPSS also showed values that were close to the values published by the authors of the different instruments used in this study. However, the use of SPSS had a number of limitations with regards to its capability of analysing the instrument's reliability and consistency compared to other more sophisticated statistical packages. Nevertheless, it was finally decided to keep these "misbehaving" items in the final instrument since SPSS at least provided an indication of the instrument's overall reliability and consistency. The final instrument therefore is essentially the same instrument used in the pilot study except for the minor changes made in the first section. The finalisation of the SUPSQ instrument was completed in July 2007.

3.5. The survey

The survey phase of the study started in August of 2007 in Quezon City in the Philippines. This phase comprised the administration of the instrument to 307 school and 96 university Filipino students in the selected schools and universities. Nineteen Physics teachers from these selected schools and universities were asked to complete the teacher questionnaire, and to give an interview shortly after completing the questionnaire.

In Adelaide, South Australia, the survey commenced during the early weeks of the start of school year in February of 2008. Administration of the instrument was carried out with this group which comprised 261 school and 45 university level students coming from selected schools and a university. Fifteen Physics teachers from the selected schools were asked to complete the teacher questionnaire and to give an interview after completing the questionnaire.

Interviews were necessary to follow-up the teachers' questionnaire responses to get a more in-depth understanding of their qualifications and their views and ways of teaching and promoting Physics in the classroom. Interviews were structured.

3.6. Selection of schools and universities

Before schools were selected to participate in this study, lists of schools in the focus areas were obtained. Focus areas for this study were Adelaide metropolitan area in South Australia and Quezon City in the Philippines. Information about universities was much easier to obtain since both Adelaide and Quezon City each only have only three universities that offered physics courses.

Within both the Adelaide metropolitan area and Quezon City schools, all types of schools were included in the sample. Statistics for the schools and universities that participated in this study is shown in Table 3.1. Field work for this study comprised of visits to administer the instrument to the selected schools and universities in Adelaide, South Australia, and an overseas trip to the Philippines to visit schools and universities in Quezon City.

Table 3.1. Summary of figures for participating schools in this study.

School Description		Number of Schools	Number of Students
Adelaide, South Australia			
Government Schools		3	63
Independent Schools			
-	Coeducational School	4	93
-	Boys' School	1	39
-	Girls' School	1	25
Catholic Schools			
-	Coeducational School	0	0
-	Boys' School	1	17
-	Girls School	1	24
University			
-	Government	1	45
Quezon City, Philippines			
Government Schools		6	169
Private Schools (Coeducational)		5	138
University			
-	Government	1	32
-	Private	1	64

Procedure for selection of schools and universities

In South Australia, after obtaining general permission from DECS, AISSA, and CEO, the governing bodies representing the government, independent, and catholic schools, respectively, schools in the Adelaide Metropolitan area were identified through the DECS, AISSA, and CEO websites. The next step was to call or send an email to the principal or science coordinator of each school to identify the number of students enrolled in Year 11 and Year 12. Here it was surprising to find out that some schools had small Physics classes (fewer than 10 students per year level) and others had none. Among the 68 schools contacted, only 46 responded with their Physics enrolment numbers, as some of them would not disclose their enrolment numbers in any subject. Out of the three universities in Adelaide, only one agreed to participate in the study.

In the Philippines, the 142 government- and 269 privately-owned high schools in the Quezon City School District area were identified through the Philippines' Department of Education (DepEd) website. Because of time and financial constraints, the researcher contacted the Department of Education's District Office in Quezon City for the statistics of students enrolled in 4th Year high school. The DepEd District Office replied via email with the statistics (an average of about 80 per school), and with the suggestion that feeder schools to the two universities considered to be among the Centre of Excellence for Physics should be contacted to participate in the study. The educational department took an interest in the study because it was considered to be the first research endeavour of its kind in the country.

To be able to make valid inferences based on a subgroup about a larger group, the subgroup needs to be randomly selected. This was the original plan for this study so as to minimise bias or sampling error, with the aim being to undertake a two-stage stratified probability design (Ross & Rosier, 1992). According to Ross and Rosier, this sampling design is to select schools within strata with a probability proportional to the size of the target population within the school. The next stage is to select students randomly from these schools. However, a number of problems were encountered in getting schools to agree to participate; then some of them took a long time to give approval for the visit and a good number of the schools which agreed to participate earlier pulled out. Hence, the original plan of having completely randomly sampled students and schools failed and, instead, opportunity or non-probability sampling resulted. Nevertheless, the sample still represented the characteristics of the population considered for this study although the type of sampling used limits the generalisability of the results of this study.

Administration of the instrument

A total of eleven schools and two universities which are government- and privately-owned from Quezon City, Philippines agreed to participate in this study. Coincidentally, a total of 11 (same as in the Philippines) schools from government, independent and catholic sectors, and one university in the Adelaide Metropolitan area agreed to participate in the study. Table 3.1 shows a summary of the number of schools and student participants. Principals and/or science coordinators in schools and Physics department course coordinators or department heads at universities were contacted to arrange a suitable time to conduct the survey. Scheduling of visits to schools was systematically organised to avoid conflicts – one school per day and up to 2 schools per week. However, this was not always the case as some of the schools would re-schedule the survey a few times. This significantly prolonged the data collection.

Participant information sheets, complaint forms, and consent forms were distributed to all Physics students from the participating schools and universities. The same set of papers was given to the Physics teachers who agreed to be involved in the study. Both physics students and teachers who agreed to participate were given the questionnaires to complete, and teachers allowed the researcher conduct the survey within their Physics class times. On the average, students took about 40 minutes to complete the questionnaire and teachers about 15 minutes. In a few cases, some of the students, who were not able to finish the questionnaires in the time available, were allowed to take it home. Unfortunately, some of these students did not return the questionnaire back to school. As a follow up to their questionnaire responses, Physics teachers were individually interviewed for approximately 10 minutes.

3.7. Statistical procedures employed in the study

A number of statistical procedures were employed in this study. These statistical procedures were carried out using different software packages specifically designed for each of these procedures. This study aimed to identify a causal model of factors that might have an effect on high school and university students' choice to do Physics. Therefore, it was extremely important for this study to employ these statistical procedures in order to ascertain the validity of the results.

Confirmatory factor analysis

This study focused on constructs that represent the factors that were examined for their effects on students' uptake of Physics. These constructs are considered latent (or unobserved). They are: attitudes, motivation, self-esteem, classroom climate, and parents' aspirations. These latent variables may be defined by a number of observed or manifest indicators. The latent structures of these sets of observed variables can be tested or uncovered with the use of a statistical technique called factor analysis. Factor analysis can either be *exploratory factor analysis* (EFA) or *confirmatory factor analysis* (CFA). EFA is a type of factor analysis that is used to identify underlying factor structure of a set of measures (Stewart, 2001). CFA on the other hand assumes that the researcher has some knowledge of the underlying factor structure of a set of measures (Byrne, 2001) and therefore it is used as "a test whether an a priori dimensional structure is consistent with the structure obtained in a particular set of measures" (Stewart, 2001, p. 76). In other words, CFA is used to test whether a hypothesised relationship between the observed variables and their underlying latent constructs exists. Similarly, CFA is a theory-testing model in which a researcher begins with a hypothesis before proceeding to analyse (Stapleton, 1997). According to Thompson (2004), CFA is more useful over EFA in the presence of theory because (a) the analysis directly tests the theory, and (b) the degree of model fit can be quantified in a number of ways.

Since this study used an instrument derived from existing ones, the researcher had already hypothesised that the observed variables have links to their underlying latent constructs. Therefore, CFA was the method used in this study. In addition, CFA allows specification of a more complete measurement model (Perry, 1996). CFA was carried out using Structural Equation Modeling (SEM).

Structural equation modeling

As mentioned earlier this study used Structural Equation Modeling (SEM) to carry out Confirmatory Factor Analysis (CFA) of the structures of observed and unobserved measures. SEM is a comprehensive statistical approach that is a multiparameter system used to test hypotheses about the relationships among observed variables and their latent constructs (Hoyle, 1995). According to Byrne (2001), what sets SEM apart from its older multivariate procedure counterparts is its ability to explicitly provide estimates of error variance parameters. SEMs also allow multiple indicators of latent constructs and estimation of reliability and validity in factor analysis (Bollen & Long, 1993). Furthermore, Byrne (2001) pointed out that SEM also incorporates both latent (unobserved) variables and observed variables in showing structural relations that can also be pictorially modelled.

To reinforce why SEM was used to carry out CFA in this study, SEM is essentially confirmatory in nature which means that "it seeks to confirm that the relationships hypothesised among the latent variables and the manifest indicators are indeed consistent with empirical data at hand" (Diamantopoulos & Siguaw, 2000, p. 4). In addition, SEMs can be subdivided into two sub-models. These are *measurement model* (which defines the relationship between observed and unobserved variables), and *structural model* (which defines relationship among unobserved variables) (Byrne, 2001). The latter sub-model is another feature of the SEM that was considered useful in this study.

A number of authors of books about SEM (e.g. Bollen & Long, 1993; Diamantopoulos & Siguaw, 2000) provide sequential steps in characterising applications of SEM. Figure 3.1 shows the steps generally used in SEM. *Model specification* is the first step in SEM where the researcher states the theoretical model either in equation form or graphical form. The second step, *identification*, aims to determine whether it is possible to estimate the model with the observed data. In other words, is it possible to find unique values for the parameters of the model specified (Bollen & Long, 2003)? After identifying the model, *estimation* is carried out. There are several methods of estimating such as multiple regression but more complicated methods are often used depending on the distributional properties of the analysed variables (Bollen & Long, 2003). The fourth step is *testing* the model's consistency with the data. This is where a number of indices that indicate good model fit are checked. *Re-specification* of the model is needed when the researcher prefers to improve model fit.

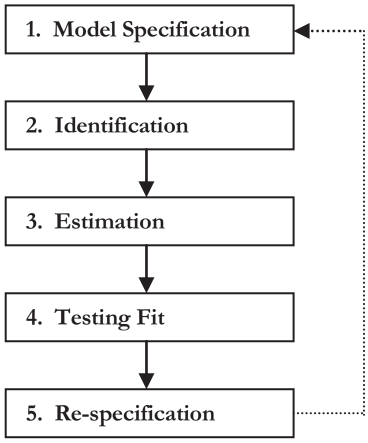


Figure 3.1. Steps in Structural Equation Modeling (Bollen & Long, 2003)

Other SEM book authors such as Diamantopoulos and Siguaw (2000) have additional steps before model specification. These are: model conceptualisation and path diagram construction. These steps are particularly useful when using specialised SEM software such as LISREL (Jöreskog & Sörbom, 2006) and AMOS (Arbuckle, 2007) (which will be discussed in more detail in the later chapters). In this study, however, some of the steps were skipped since only CFA was used.

In more simple terms, CFA was used to test the factorial structures of each scale model used in this study. It was also used to test the postulated relationships between variables in each of the models. In other words, CFA was used to examine the fit (or consistency) of data to the measurement model of each scale.

The Rasch Model for scaling items

Some of the tests employed in this study can be found within the confines of the Classical Test Theory (CTT) model. However, CTT is considered to have limited effectiveness in educational measurement (Alagumalai & Curtis, 2005). According to Alagumalai and Curtis (p. 10):

> When different tests that seek to measure the same content are administered to different cohorts of students, comparisons of test items and examinees are not sound. Various equating processes have been implemented, but there is little theoretical justification for them.

This is not only true with test items but also with attitudinal survey items. This study used attitudinal survey items and different cohorts of students coming from different countries making it not immune from the shortcomings of the procedures under CTT. To solve this issue, the attitudinal data collected in this study was subjected to one of the methods used in Item Response Theory (IRT). IRT, as described by Alagumalai and Curtis (2005, p. 2), "is a complex body of methods used in the analysis of test and attitudinal data." IRT is a collection of methods used for scale validation that uses models that focus on the interaction between the respondents and the survey items (Piquero, MacIntosh & Hickman, 2000). Piquero, MacIntosh and Hickman also added that the IRT models assess the extent to which cumulative scales fail to provide fundamental measurement. The instrument used in this study is designed to measure attitudinal traits; therefore, one of the various methods in IRT was required.

Questionnaires that use Likert-type items are often scored by assigning low values (such as "0" or "1") to the least valued response, e.g. "strongly disagree" and highest value (such as "4", or more) to the most favourable response, e.g. "strongly agree". It is also common to report a mean or average response score to summarise responses. This implies that if a mean score is taken from the scored responses, then the scores assigned to the responses form an interval scale. This is not the case, however. This is because the difference between the judgments "strongly disagree" and "disagree" and "agree" and "strongly agree" (in the case of a 4-point Likert scale) can hardly be assumed equal and the interpretation of the scale may be different from one person to another (Burke, Solomon & Seelig, 2007). The difference does not represent a constant increase in the judgment of quality, and the average taken from the scores provides a value that is not interpretable (Burke, Solomon & Seelig, 2007). Therefore, the options presented to survey questionnaire respondents do not lie on an interval – they are ordinal. This is where Rasch modeling (one of the various methods in IRT) becomes useful because it recognises the ordinal character of a set of data (Harwell & Gatti, 2001).

For many decades, educational and social science researchers had been subject to the challenges of scoring survey responses and test items. To counter this problem Rasch (1980) proposed a simple formulation that fits item difficulty and person ability parameters to a measurement model for responses to dichotomous items (items with two possible answers) to test questions. This method models the difference of the ability of the test-taker (or survey respondents) and the difficulty of the test items (or survey items). In addition, Rasch model is not only confined to dichotomous items because it can also handle polytomously-scored responses (Masters, 1982).

The Rasch model aims to scale subjects (or persons) and scale items (in a test or a survey instrument, for instance) on the same continuum (Van Alphen et al., 1994). In a more mathematical way of describing it, the Rasch model "permits persons…and items…to be located on the same number scale with…values $-\infty$ to $+\infty$ assigned in such a way that an interval scale ranging from large negative values to large positive values is formed" (Keeves & Alagumalai, 1999, p. 27). According to Keeves and Alagumalai, the values assigned to persons and items must be related by the expression using the equation

$$p_{ni} = \frac{\exp(\beta_n - \delta_i)}{1 + \exp(\beta_n - \delta_i)}$$

where p_{ni} is the probability of a correct response given by the person *n* to item *i*. β_n is the person ability and δ_i is the item difficulty. In scaling using the Rasch model the scale is independent of both the items in the test and the sample of persons employed in the calibration (Keeves & Masters, 1999).

The Rasch model is a broad classification of a family of different measurement models. Two of these models are the rating scale model (Andrich, 1978) and the partial credit model (Masters, 1982). In this study, the rating scale model was used. The rating scale model can be used for the analysis of questionnaires that use a fixed set of response alternatives with every item like "strongly disagree", "disagree", "agree", and "strongly agree" (Masters, 1999). Although questionnaires of this type can also be analysed using the partial credit model, Masters (1999, p. 103) pointed out that:

> …the fact that the response alternatives are defined in the same way for all items introduces the possibility of simplifying the partial credit model by assuming that, in questionnaires of this type, the pattern…will be the same for all items on the questionnaire and that the only difference between items will be a difference in location on the measurement variable (e.g., difficulty of endorsement).

This was the main reason why the rating scale model was chosen over the partial credit model.

Validity and reliability

A pre-requisite of a successful research study, especially a quantitative one, is a valid and reliable measurement using a valid and reliable instrument. In the broader concept of research, validity refers to whether a method to examine a phenomenon really examines what is really intended to examine (Kvale, 1995). This stemmed out of what Kvale would call a definition coming from a narrow positivist approach, where validity came to mean that a method measures what is supposed to measure. Although issues surrounding the concept of validity may be seen as complex, Keeves and Masters (1999) consider two important aspects of it: meaningfulness and usefulness. Therefore, in the context of this study, validity means that the respondents' individual scores from the instrument that they filled out make sense, are meaningful, and enable the researcher to draw good conclusions from the sample being studied to the population (Creswell, 2005).

Reliability is a necessary – although not a sufficient (Thompson, 2004) – condition for validity (Knight, 1997). As Moss (1994, p. 6) puts it, "Without reliability, there is no validity." In Thorndike's (1988, p. 330) own words, reliability "relates to the question of how accurately the test sample represents the broader universe of responses from which it is drawn." The concept of reliability in quantitative studies presupposes the consistency and stability of an instrument to measure what is supposed to measure with only minimal errors in the scores.

Validity and reliability may be considered complementary in research. In this study, as Creswell (2005, p. 162) pointed out, "the more reliable the scores from an instrument, the more valid the scores will be." This relates to what Cronbach et al. (1972) spoke of about validity and reliability as collectively the generalisability, or the range of inferences that can be derived out, of a test score. However, within the confines of the Classical Test Theory (CTT), the reliability of the scores is affected by a number of factors: measurement precision, group heterogeneity, length and time limit given to the respondents (Alagumalai & Curtis, 2005). Therefore, these factors were also taken into consideration when designing the instrument used in this study.

Validation of the scales

In this study that involved two different countries, it was important to validate the scales to measure the factors in focus that were considered to have an effect on students' uptake of Physics. The instrument used in this study was the result of the review of different existing published instruments designed to measure the different factors examined in this study. It is implicit that these instruments have already been validated by their respective authors. A more detailed description of the scales used in this study was provided earlier in this chapter which also include indices that indicate their respective reliabilities. A further method of validation was to test each scale and each item within a scale in the instrument for their consistency and coherence by calculating different model fit indices and comparing them with established values for model fit. Moreover, since this study used samples from two different countries, therefore considered as two different groups, test of instrument invariance was also carried out. This test enabled the researcher to determine whether the items in the instrument "behaved" in the same manner for each group. This was carried out using SEM and Rasch Modeling which were discussed in the previous sections of this chapter. Figure 3.2 shows a graphical representation of how the scales used in this study were validated. It also shows how reliability forms an integral part of validity.

3.8. Analysis of data

Data have been organised for both student and teacher respondents. Student data were entered and organised using Microsoft ® Excel spreadsheet software. Teacher interviews were transcribed and typed as a Microsoft ® Word document. After all the data from both student groups (South Australians and Filipinos) had been entered and cleaned, analysis of the data proceeded.

Preparation of data

Entry and processing of data from the Philippines commenced shortly after collecting all the questionnaires and compiling all the teacher interview audio files towards the end of September 2007. As mentioned earlier, Microsoft ® Excel was used to organise and enter the student data in its most raw form. Teacher interviews were manually transcribed and processed in text form using Microsoft ® Word. Raw data in Excel file format were then converted to SPSS file format for data processing. Parts of the student data were then classified into an appropriate numerical form for use in the SPSS program. This involved assigning numbers to items such as gender (e.g., 0 for females and 1 for males) and schooling levels. The number "9" was assigned for all missing numerical data in all the scales. School sectors were also assigned a numerical code. Items in the instrument that need reverse scoring were also recoded. Recoded items were renamed into the same item name with the addition of a suffix "R". As early as February 2008, data from the South Australian group was prepared in a similar way. For the full details of all the codes used in this study please refer to the Codebook in the Appendix.

The instrument used in this study was considered long. In order to deal with the analysis of the prepared data more effectively, it was necessary to break it down into parts. Each part consisted of a scale used in this study. Each part was then saved as a separate SPSS file. Furthermore, each part was broken down into two groups representing the high school students' group and the university students' group. However, a bigger SPSS data file containing all the scales and both high school and university students' group was also prepared. This process undertaken was the same for both Filipino and South Australian groups. Breaking down the SPSS data files by scale was considered necessary to facilitate easier and more precise handling of the data. SPSS files were used to calculate the means, standard deviations, frequency distributions and other descriptive statistics necessary to analyse the data.

Analysis techniques

Instrument level analysis

Data analysis involved Confirmatory Factor Analysis (CFA) using Structural Equation Modeling (SEM). This was carried out using two highly specialised software packages called Linear Structural Relations (LISREL) Version 8.8 (Jöreskog & Sörbom, 2006) and Analysis of Moment Structures (AMOS) Version 16.0 (Arbuckle, 2007). These two SEM statistical packages read data in SPSS format so there was no necessity to convert the SPSS files into something else. It was not necessary to use two different applications for SEM but the researcher was also keen on looking at the output differences from these softwares. It was found later that the outputs were almost exactly the same in only some of the models tested. However, since the analysis of data heavily involved CFA, the LISREL software was preferred over AMOS mainly for two reasons: it works most effectively in a confirmatory context (Diamantopoulos & Siguaw, 2000), and it recognises, among other forms, ordinal data. AMOS was used mainly to generate SEM figures because of the ease of use of its graphical user interface.

Each item was also subjected to analysis using the Rasch model. This was carried out using a computer program called ConQUEST Version 2.0 (Wu, Adams, Wilson & Haldane, 2007) intended for this type of analysis. This was where it was necessary to convert the SPSS files into tab-delimited data files in ASCII format. Only data files in ASCII format can be recognised by ConQUEST. Details about the testing of scales are described in Chapters 4 to 9.

Single Level and multi-level Analysis

Single (or student level) path analysis was carried out to obtain an overview of the interaction of the different variables considered in this study and how they might influence students' attitudes towards Physics. This data analysis technique is described and discussed (including the issues associated with it) in Chapters 10 and 11. However, single level analysis technique was not considered to be sufficient in analysing the data because the data collected from the two sample groups contain two distinct levels – student and school levels, thus issues arise with using this data analysis technique. The nested nature of the data collected for this study is similar to most of the data sets collected for social science research. Therefore, it was necessary to employ a multilevel data analysis technique. Snijders and Bosker (1999, p. 1) define multilevel analysis as "a methodology for the analysis of data with complex patterns of variability, with a focus on nested sources of variability: e.g., pupils in classes, employees in firms …", etc. They further added that if the sources of variability are ignored, one may draw wrong conclusions. This multilevel analysis technique is further elaborated in much more detail in Chapter 12.

Qualitative data

Teacher interview transcriptions, in addition to some data obtained with the questionnaire, form part of the qualitative data. This data was used to support/complement quantitative data findings on the effect of teachers on students' uptake of Physics. Furthermore, the qualitative interviews were used to better understand how teachers contribute to the classroom climate and how they affect students' attitudes. Interview transcriptions were analysed using the SPSS Text Analysis software.

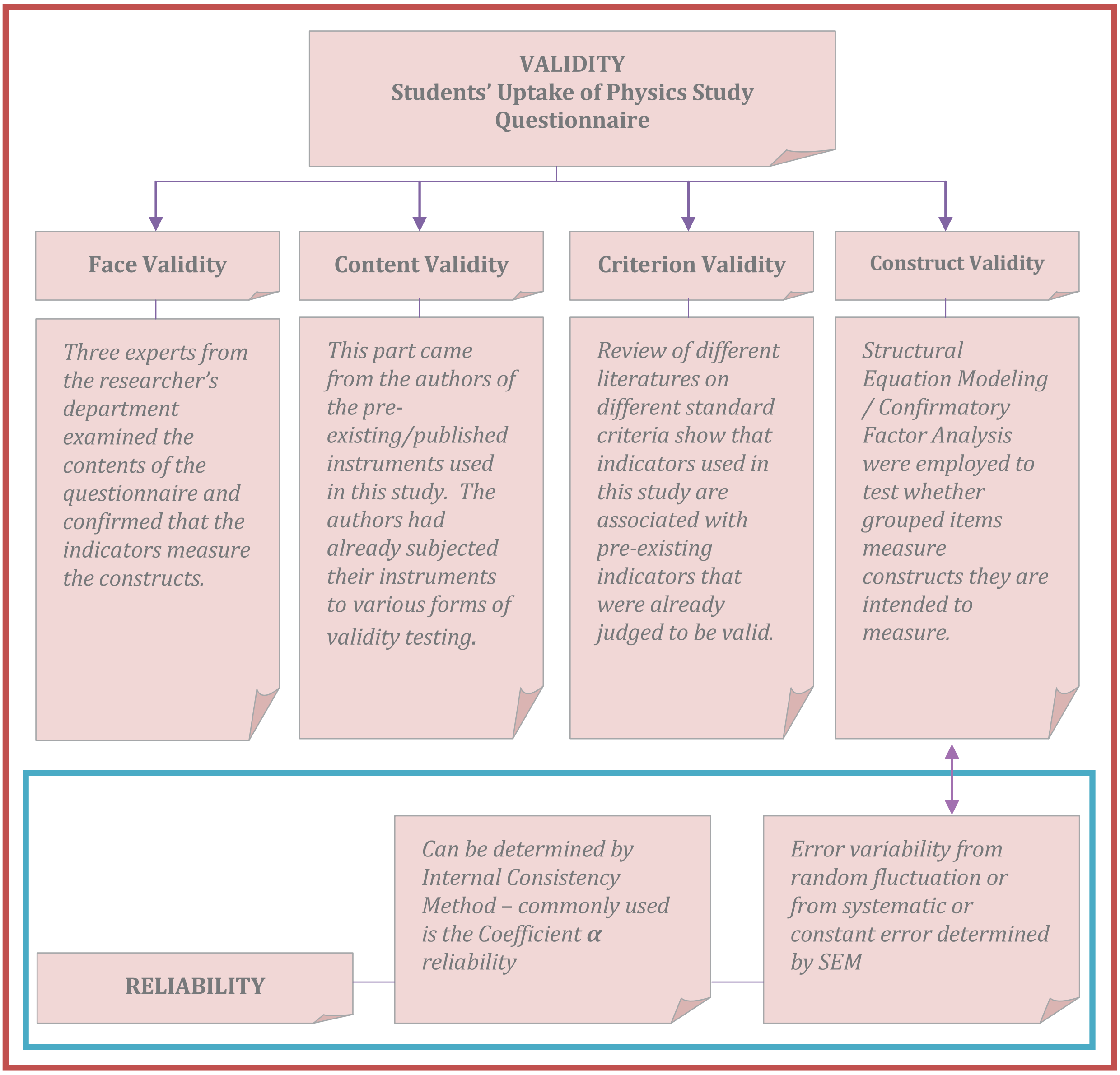


Figure 3.2. Validation of the scales used in the study.

3.9. Summary

The focus of this study was identified through the researcher's observation teaching Physics in the United States that prompted him to carry out review of literature on the declining participation of students in Physics. This study focused on how several factors affect students' decision to study Physics in senior secondary school or university level. This study consisted of two groups coming from two different countries: Australia and the Philippines. More specifically, samples came from Years 11 and 12 and First Year university Physics students from the Adelaide metropolitan area in South Australia. Samples from the Philippines came from Fourth Year high school and First Year university Physics students from the Quezon City area. Ethics approval was obtained from the University of Adelaide and from DECS. Permission was also sought from the AISSA and the CEO. Similarly permission was obtained from the Philippines' DepEd and the CHEd. The instrument used in this study was the result of compiling different pre-existing instruments developed by their respective authors to measure factors considered in this study. This instrument was trialled during the pilot study to enable the researcher to confirm the scales' reliability based on their authors' claim and to enable the researcher to make necessary adjustments in the final instrument.

Schools and universities for the main study came from the metropolitan area of Adelaide, South Australia and the Quezon City area in the Philippines. List of schools were obtained from the DECS, AISSA, and the CEO websites for South Australian group and from the DepEd website for the Filipino group. Universities were easily identified since there are only three major Australian universities in South Australia and two universities in the Quezon City area in the Philippines that offer Physics courses. Enrolment figures for Year 11 and 12 Physics South Australian students were obtained by making phone calls to the principals or science coordinators of the schools identified. Approximate numbers of Filipino 4th Year students were obtained from the DepEd District Office in Quezon City. Sampling employing stratified random sampling and sampling proportional to size was planned for this study to minimise bias. School principals and science coordinators and university head of Physics departments were contacted either by email or by phone to seek their participation in the study. However, a considerable number of the schools withdrew due to technical and practical constraints which led to the use of opportunity or non-probability sampling.

Participating schools and universities were sent forms that included information sheets about the study, and consent forms student and teacher participants had to sign to be involved in the study.

In South Australia, the instrument was administered to 261 Year 11 and 12 Physics students and 45 First Year university students doing either a degree or a double degree in Science. School students were from 11 metropolitan schools from the government, independent and catholic sectors. University students were from a university in Adelaide. Fifteen Physics teachers from different schools participated in the study.

In the Philippines, 307 Fourth Year high school students from 11 schools from both government and private sectors completed the instrument. There were 96 First Year university students doing a degree in Physics who participated in the study. A government-owned university and a privately-owned one agreed to participate in this study. Nineteen Physics teachers completed the teacher questionnaire and were interviewed.

A number of statistical techniques were employed in this study. SPSS was used to handle large amounts of data in this study and was also used to determine necessary "descriptives" for data analysis. It was necessary for this study to use valid and reliable instrument, and since the scales used were from pre-existing ones developed by their respective authors, CFA through SEM was used to confirm their latent structures and their reliability. SEM was carried out using LISREL and AMOS. This study also employed the use of Rasch modeling to perform item analysis which required the use of a highly specialised computer software called ConQUEST. Single or student level path analysis was carried out to get an overview, based on the data gathered, of how the factors 'interact' and how they might affect students' attitudes towards Physics which may influence their uptake of Physics. Furthermore, since the data were nested at different levels, HLM was employed to examine the effects at different levels and the interaction between the effects at different levels.

Raw student data were prepared using the Microsoft ® Excel spreadsheet software then converted to the SPSS file format. SPSS files were also converted to the ASCII format for use in some of the more specialised software applications used in the study. Teacher interviews were transcribed and analysed using SPSS Text Analysis software. Chapters 4, 5, 6, 7, 8, and 9 detail the validation of each scale used in this study. Because this study used different scales developed by different researchers, variation in the statistical procedures in validation could easily be inferred. Therefore, it was considered necessary to show and discuss the different procedures followed to highlight the consistency and the rigour taken to validate each scale.

Chapter 4

Attitudes Towards Physics Scale

4.1. Introduction

This study examined individual-level, school, and family factors and their impact on students' decision to study physics. One aspect of the individual-level factors is the student's attitudes towards studying physics, and this chapter provides a description of the technique and analysis carried out for the validation of the instrument used to measure students' attitudes towards physics in the South Australian and Philippine contexts. Since students' attitudes towards physics was a major focus of this study, it was necessary to carefully validate the instrument to measure this factor in order to get results that can be meaningfully interpreted to partly address a number of research questions (RQ), particularly RQ1a, RQ2a, RQ2c, RQ3a, RQ3c, RQ3f, and RQ3g advanced in Chapter 1. In addition, by carefully validating the instrument, results from the analysis of data using the attitudes instrument may be used for comparison with the findings presented in the literature review on attitudes towards physics presented in Chapter 2.

The instrument used was first developed by Redford (1976), and the structure of the instrument was confirmed in two phases by contemporary approaches (Curtis, 2004) to instrument measure and scoring at a macro-level (or instrument level) using confirmatory factor analysis (CFA) through structural equation modeling (SEM), and at a micro-level (or item level) through Rasch analysis. CFA was undertaken to determine or verify the factor structure of the set of observed variables used in the instrument. It was also used to confirm the relationship between the observed variables and their underlying latent trait as established by the author of the instrument and other researchers who have used it for similar research. Furthermore, CFA through the use of SEM was used to make sense of how the instrument behaved in two different groups. Item-level analysis was carried out employing the use of Rasch modeling to test for the uni-dimensionality of the scale. In this study, the terms 'latent factor' and 'latent variable' are used interchangeably to mean unobserved variable, trait or construct (Andrich, 2004).

This chapter begins with a section briefly describing the instrument and its items that represent the observed variables, then the chapter moves on to the description of how the structure of the instrument was investigated using structural equation modeling (SEM), which included CFA of the measurement model and alternative models. For each model, a set of goodness-of-fit indexes are reported and examined to determine how a set of data fitted a particular model. This section is followed by an item-level analysis using Rasch modeling. An earlier section in Chapter 3 provided details for carrying out CFA and Rasch Modeling. The chapter concludes with a summary.

4.2. The Attitudes Towards Physics scale

Redford's (1976) Attitudes Towards Physics scale was used in this study. It consists of 10 items, five of which are positively-worded and the other five negatively worded. The instrument uses five-point Likert-type scale: strongly agree, agree, neutral, disagree, and strongly disagree. The focus of the 10 items is on the usefulness and importance of Physics in the society. These items are item 115 through to item 124 in the Students' Uptake of Physics Study Questionnaire (SUPSQ), and for the purposes of data analysis, these items were labelled ATTD115, ATTD116, ATTD117, ATTD118, ATTD119, ATTD120, ATTD121, ATTD122, ATTD123, and ATTD124. Items ATTD115 to ATTD119 are positive statements and items ATTD120 to ATTD124 are negatively-worded statements. Item responses were coded 1, 2, 3, 4, and 5 corresponding to the categories 'strongly disagree', 'disagree', 'neutral', 'agree', and 'strongly agree'. An item not responded to was coded '9'. This was an arbitrary value designated to be recognized by statistical software as a non-response. Negatively-worded statements were reverse-scored to keep the scale's scoring consistency. Table 4.1 shows the summary of the items in this scale, their nature (e.g., positive statement or negative statement), their item code equivalent to indicate reverse scoring, and item texts. Redford originally developed and used this instrument to measure school administrators' and science teachers' attitudes towards physics in terms of its practicability and importance of physics in the school curriculum. However, Redford developed this instrument with the belief that the negative attitudes of students towards physics are at least influenced by teachers and school personnel who help them choose their course of study. He further added that, "If these people do not consider physics an important course in their overall educational process, they will do little to encourage students to include physics in their studies" (Redford, 1976, p. 337). Therefore, students might be expected to carry the same attitudes as their teachers and other school personnel such as their guidance counsellors, and these were all once students who may have held negative attitudes towards physics. This is one of the underlying reasons why Redford's attitude instrument was adapted for use with senior high school and university students. In addition, items in the instrument are straightforward, and easily understood by students at the levels mentioned. The other is that this study focused on students' attitudes towards physics in terms of its importance and practicability.

Table 4.1. Summary of items in the Attitude Towards Physics scale used in the SUPSQ instrument.

Item Code	Nature of statement	Item Code to indicate reverse scoring	Item text
ATTD115	Positive	*none*	There should be more effort made to educate the general public in physics.
ATTD116	Positive	*none*	To have a good understanding of the world in which we live one needs to study physics.
ATTD117	Positive	*none*	All high school students should be encouraged to take a course at some level in physics.
ATTD118	Positive	*none*	To not have taken a course in physics leaves a student unprepared for his/her place in the society.
ATTD119	Positive	*none*	Physics should be considered an essential element in the general education of any high school student.
ATTD120	Negative	ATTD120R	Physics is too materialistic and is opposed to humanism.
ATTD121	Negative	ATTD121R	The effort to understand some physics is too great for the benefits obtained from it.
ATTD122	Negative	ATTD122R	The amount of money being spent to teach physics could better be spent in other areas of our curriculum.
ATTD123	Negative	ATTD123R	Only high school students who are college bound should take courses in physics.
ATTD124	Negative	ATTD124R	Physics is too complicated for the average high school student.

4.3. Previous analytic practices

In the analysis of the attitudes towards physics in the high school curriculum, data collected by Redford (1976) for the Wisconsin State Department of Public Instruction, the item responses were coded, 0, 1, 2, 3, and 4, corresponding to the Likert-type categories "strongly disagree", "disagree", "neutral", "agree", and "strongly agree". This was done for the purposes of tabulation and scoring. This means that if a respondent had a favourable attitude towards physics, then he or she could have a maximum score of 40. For extremely unfavourable response, the score could be 0. In this study, the least favourable response was coded 1 to be consistent with the codes of the other scales in this study, and therefore the most favourable was 5 (with a maximum score of 50). In Redford's study, item analysis using the criterion of internal consistency was used to determine how differentiating the statements were in the instrument. Split-half reliability test was used to determine the reliability of the instrument. With a decent sample size (n = 969), Cronbach alpha (indicating internal reliability) was found to be 0.856.

Based on the number of cases used in Redford's study, it appears that the analytic practices used had been adequate to validate the hypothesized structure of the instrument. However, there have been no additional attempts to further validate the hypothesized structure of the instrument. In addition, the instrument has not been exposed to different samples coming from different groups (e.g. countries, cultures, etc.). As highlighted by Rowe (2005), the structural and measurement properties of a scale have to be ascertained before any inferential decision can be made, so it was deemed necessary to do this for the new groups studied here.

4.4. Instrument structure analysis

The section of this study's data set concerned with students' attitudes towards physics has been subjected to detailed structural analysis. The technique used to examine to examine the structure does not belong to the confines of the classical test theory (CTT), due to the limitations of the CTT in terms of its effectiveness in educational measurement (Alagumalai & Curtis, 2005) (see Chapter 3 for details).

This section describes and discusses results from data collected from two main sample groups: South Australian Physics students and Filipino Physics students. Each group of sample consists of two subgroups: high school Physics students and university Physics students. The main methods used to examine the structure of the instrument used to measure attitudes toward physics were CFA using SEM, and Rasch measurement modeling.

Byrne (2001) described SEM as a statistical methodology that takes a confirmatory (i.e.,hypothesis-testing) approach to the analysis of a structural theory on some underlying phenomenon. In the context of this study, SEM was used to check or verify the structure or relationship between the observed and latent variables based on existing theory. SEM provided the base for confirmatory factor analysis of the structures of the observed variables and their latent structures. Three different statistical software applications were used namely: SPSS Version 16 (SPSS Inc., 2008), LISREL Version 8.8 ((Jöreskog & Sörbom, 2006), and AMOS Version 16 (Arbuckle, 2007). SPSS was used for the descriptive analyses of the data and LISREL for the CFA and SEM. Because of the ease of use of its graphical user interface, AMOS was used for drawing figures that represent the models' structures.

Factor analysis using EFA was not carried out with this scale. This is under the premise that the author who developed this instrument has already subjected it in such exploratory analysis. In addition, in Social Science research constructs of interest are often complex, multivariate, multi-faceted and multi-level (Keeves & Masters, 1999), thus CFA is favoured over EFA for the analysis of the structures of these constructs. Curtis (2004, p. 187) pointed out that:

> Tools such as exploratory factor analysis are limited in the extent to which they are able to probe these structures. Further, for a construct to be compatible with simple measurement – that is, to be able to report a single quantitative score that truly reflects a level of particular construct – the structure of the construct must reflect ultimately a single underlying factor.

Furthermore, depending on estimation and extraction methods, the number of 'solutions' for a given set of data through EFA is infinite which, according to Rowe (2005, p. 40),

> …constitutes a major weakness of EFA methods and a key reason why such methods are often regarded more as an 'art form' than as 'science' and are not used by reputable statisticians."

The hypothesized relationships were then subjected to tests using confirmatory factor analysis starting with the measurement model, then proceeding to the analysis of alternative models. Specialised statistical software were used to carry out CFA to obtain reliable results. The following sections report on the results of the CFA tests carried out for each group of students at each level of schooling for each country. Each group were analysed separately to examine if there is measurement invariance between levels (high school and university) within a country or between groups (countries), or both.

Confirmatory factor analysis of the measurement model

The 10 items of the attitudes towards science/physics scale were subjected to CFA using the LISREL software. LISREL is a highly specialised statistical software that works most effectively in a confirmatory context (Diamantopoulos & Siguaw, 2000) which makes it more advantageous compared to other similar applications. In addition, LISREL recognises, among other forms, ordinal data.

Because it is feasible that these items are undifferentiated, and that all load directly onto the latent variable called 'Attitudes towards Physics', the first model tested for model fit to the data was a single factor model based on Redford's proposition. A single factor model is otherwise known as a measurement model which shows how a latent variable is represented by a number of observable (or observed) variables (Diamantopoulos & Siguaw, 2000). In this model the 10 items loaded directly onto the latent variable called 'attitudes towards physics' shortened as "ATTD" (see Figure 4.1). Error or item residuals are also represented in the model (shown as "e" in the diagram). The CFA results presented in the following sections drew from the data collected from samples of South Australian high school and university Physics students, and Filipino high school and university Physics students. These results provided information about the hypothesized measurement model.

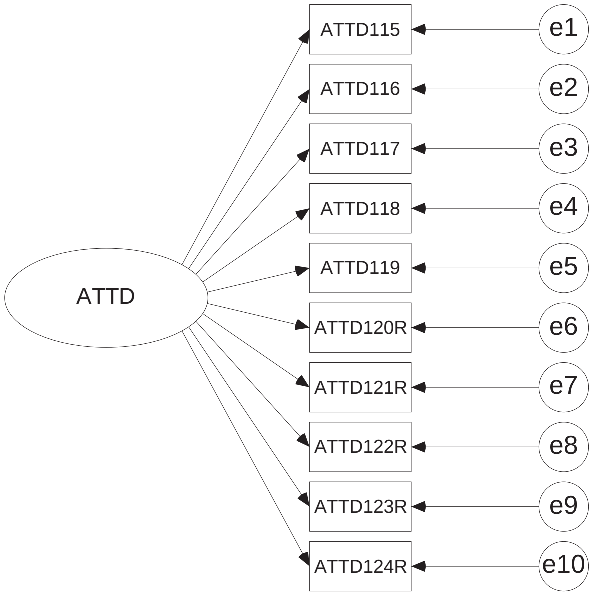


Figure 4.1. Structure of the single factor model for the Attitudes Towards Physics Scale.

The minimum factor loading (or regression weight) value used in all factor analyses in this study was 0.40. This 'cut-off' value has been used by a number of researchers (e.g. Raubenheimer, 2004; Hair, Anderson, Tatham & Black, 1998). Factor loadings of observed variables greater than this minimum value are considered meaningful indicators of a latent variable. A low (below 0.40) observed variable factor loading may suggest an indication of a factor other than the one it intends to reflect.

Model Fit Indexes

Included in the results of the analysis using CFA are the commonly used different model fit indexes. They are sometimes termed as the 'absolute fit indices' (Diamantopoulos & Siguaw, 2000, p. 87). These indexes assess how well the sample covariances were reproduced by the covariances predicted from the parameter estimates. These indexes are the Root Mean Square Error of Approximation (RMSEA) (Steiger & Lind, 1980), Goodness-of –fit Index (GFI), Adjusted Goodness-of-fit Index (AGFI) and the Root Mean Square Residual (RMR). The Parsimony Goodness-of-fit Index (PGFI) which indicates model complexity (the number of estimated parameters) is also included. The RMSEA represents the error of approximation in the population and is considered to be the most informative of all the indexes in CFA (Diamantopoulos & Siguaw, 2000). Byrne (2001, p. 82) added that it takes into account the question, "How well would the model, with unknown but optimally chosen parameter values, fit the population covariance matrix if it were available?" The GFI and the AGFI are measures of the relative amount of variance and covariance of the sample data that is jointly explained by the population covariance matrix (Byrne, 2001). They estimate the extent to which the sample variances and covariances are reproduced by the hypothesised model (Bollen & Long, 1993). The only difference between the GFI and the AGFI is that the latter adjusts for the number of degrees of freedom in the specified model. However, Byrne (2001), citing Fan, Thompson and Wang (1999), advised against the use of these indexes because they can be overly influenced by sample size. The RMR is a summary measure of fitted residuals. Threshold value for GFI, AGFI and PGFI is 0.90. Values at or above 0.90 are indicative of good fit. For the RMSEA, values less than the critical value of 0.05 indicate good fit, between "0.08 and more indicate a reasonable error of approximation" (Schulz, 2004, p. 94). RMSEA values more than 0.10 indicate poor fit (Diamantopoulos & Siguaw, 2000). For some researchers such as Hu and Bentler (1999) 0.06 is considered as the critical value for the RMSEA. This critical value was used in this study. RMR values of less than 0.05 indicate a close fit.

Table 4.2. Summary of fit indexes used in the validation of the scales used in the study.

Fit Index	Values to indicate Good Fit
Root Mean Square Error of Approximation (RMSEA)	≤ 0.05
Root Mean Square Residual (RMR)	≤ 0.05
Goodness-of-fit Index (GFI)	≥ 0.90
Adjusted Goodness-of-fit Index (AGFI)	≥ 0.90
Parsimony Goodness-of-fit Index (PGFI)	≥ 0.90

A summary of all the fit indexes used in the validation of all the scales used in this study is provided in Table 4.2.

The South Australian Sample

This section presents the results of fitting the single factor model into the data collected from the South Australian sample. Three separate CFA runs using the single factor model were carried out: first using the set of data from a sample of high school physics students, then from a sample of university students, and finally, combining both sets of data.

Sample of South Australian High School Physics Students

This data was collected from a sample of 261 high school physics students coming from 11 schools in the Adelaide metropolitan area. The schools came from the Government, the Independent, and Catholic education sectors. The results of fitting the single factor model to the high school data set are shown in Table 4.3. The table includes the factor loadings of the observed variables including their respective standard error. The standard error indicates the variability of the estimates (factor loadings). The value of the estimate divided by the standard error is used to calculate an index called the 'critical ratio' to determine statistical significance. According to Arbuckle and Wothke (1999), at the 0.05 significance level, a critical ratio exceeding 1.96 is considered significant. This means that value of the standard error becomes problematic when it becomes more than half of the estimate. Tabulated summary of the fit indexes for each group of sample can be found later in the section (see Table 4.4). The summary also contains chi-square and degrees of freedom values. The chi-square value is affected by a number of values that have to be estimated in the model (more values = bigger chi-square) and is more likely to be statistically significant the larger the sample is (Cramer, 2003).

All of the 10 items which loaded onto a single latent variable (ATTD) show reasonable figures above the minimum accepted value of 0.40 to indicate adequate fit. Looking at the structure of the model from the high school sample, items ATTD118 (0.65), ATTD123R (0.62) and ATTD124R (0.67) show moderate fit and the rest of the items are showing strong fit.

Using SPSS, the Cronbach alpha (for internal reliability) of the scale for the South Australian high school sample was found to be 0.73. Values above 0.70 are generally acceptable (Nunnally, 1978). However, this does not mean that values below 0.70 indicate unreliability. This may provide an indication of several latent attributes, therefore deflating the value of the Cronbach alpha (Yu, n.d.).

Table 4.3. Factor loadings of items in the single factor model (South Australia high school sample and university sample and combined high school and university samples).

Variable	*Loadings (se)* † *ATTD (High School)*	*Loadings (se)* †† *ATTD (University)*	*Loadings (se)* ††† *ATTD (Combined)*
ATTD115	0.76(0.05)	0.80(0.13)	0.77(0.05)
ATTD116	0.80(0.05)	0.70(0.14)	0.79(0.05)
ATTD117	0.85(0.05)	0.73(0.13)	0.85(0.05)
ATTD118	0.65(0.06)	0.79(0.13)	0.65(0.05)
ATTD119	0.80(0.05)	0.86(0.12)	0.81(0.05)
ATTD120R	0.72(0.05)	0.66(0.14)	0.73(0.05)
ATTD121R	0.71(0.06)	0.41(0.15)	0.69(0.05)
ATTD122R	0.74(0.05)	0.59(0.14)	0.74(0.05)
ATTD123R	0.62(0.06)	0.12(0.16)	0.58(0.05)
ATTD124R	0.67(0.06)	0.26(0.16)	0.65(0.05)

†*n=261* ††*n=45* ††† *n=306*

Sample of South Australian University Physics Students

This set of data was collected from a sample of 45 first year university Physics students. They came from one of the three universities in South Australia located in the Adelaide Metropolitan area. The results of fitting the single factor model to this set of data are shown in Table 4.3. All of the items except for ATTD123R (0.12) and ATTD124R (0.26) loaded above 0.40. This is the threshold value for the factor loading or regression weight as discussed above. Items loading at or above the threshold value are considered to represent the latent variable they intend to measure.

Comparing the single factor model fitted separately to the high school and the university data, the first eight items (looking from top to bottom of the table) loaded onto the single latent factor with closely similar values and fitting the model well but differed significantly in the last two items. Items ATTD123R and ATTD124R moderately fitted the model using the high school data, but poorly fitted the model using the university data. This difference could be a result of the large difference in the sample sizes of the two groups. Although running LISREL using this data set did not issue any warnings about the number of parameters to be estimated and the number of samples, a strong caution was taken in the interpretation of the results as the sample size was too small relative to what researchers (e.g. Ding, Velicer & Harlow, 1995; Lomax, 1989;

Boomsma, 1987) consider as a minimum (ranging from 100 to 400), thus making CFA not suitable for use (Thompson, 2000). The Cronbach alpha to indicate internal reliability was also used with caution as it is dependent on a number of factors including sample size.

Using SPSS, the Cronbach alpha of the scale indicating its internal reliability for the South Australian university sample was found to be 0.65.

Combined Samples of South Australian High School and University Physics Students

It was feasible for the author of this study to combine the sets of high school and university data for a number of reasons. The average age difference between the high school and university student samples is around one year. In addition, the first year university student samples were just into their second week of university classes when they filled out the survey questionnaire. It was therefore assumed that student samples from both groups (high school and university) were likely to hold similar attitudes and perceptions towards things – like school subjects, for instance. In addition, combining the two sets of data significantly increases the sample size which makes SEM more fit for use (Thompson, 2000 in Phakiti, 2007).

Subjecting the single factor model to a CFA test combining the two data sets yielded a result similar to that of the model using the high school data (see Table 4.3) with all items loading onto their latent variable, with the lowest being 0.58. However, this result does not warrant a good fitting model. The model's goodness-of-fit statistics have to be examined before conclusions can be made about the model's fit.

Cronbach alpha indicating the internal consistency of the scale for the South Australian university sample was found to be 0.73.

Fit Indexes of the Single Factor Model (South Australian Sample)

The fit index values that warrant a good fitting model were given above. In this section, a summary of the models' fit indexes are presented in Table 4.4. Of particular importance is the value of the RMSEA which is considered to be the most informative of the fit indices. All the single factor models show an almost consistent but very high RMSEA values that show poor fit. This conclusion is supported by the low GFI and

AGFI and high RMR values. The PGFI values which account for the models' complexity are showing significantly lower values than what is accepted. This means that the models are rather more complex than what appear in the figures.

The model fitted to the high school data and the combined sets of data show very closely similar fit indexes. These indexes are better than those resulting from fitting the model to the university data. However, overall, none of them exhibited a highly acceptable solution.

Table 4.4. Goodness of fit index summary for the single factor model (South Australian Sample).

	High School data *n=261*	University data *n=45*	Combined data *n=306*
Chi-Square	403.13	221.05	477.48
df	35	35	35
GFI	0.68	0.64	0.68
AGFI	0.49	0.43	0.50
PGFI	0.43	0.41	0.44
RMR	0.10	0.15	0.10
RMSEA	0.25	0.24	0.25

Thus, alternative models needed to be explored in order to fit the data more closely. These include hierarchical structures in which a number of distinct factors are shown to reflect a higher order factor (Curtis, 2004), and correlated structures in which a number of distinct factors are correlated, or it could involve just removing some item(s).

The Filipino sample

This section presents the results of fitting the single factor model into the data collected from samples of high school and university Physics students from the Philippines. Three CFA runs using the single factor model similar to that fitted to the South Australian sample were carried out: first using the set of data from a sample of high school Physics students, then from a sample of university Physics students, and finally, combining both sets of data. The same sets of fit indexes and statistics are reported.

Filipino High School Physics Students Sample

This data was collected from a sample of 307 high school physics students coming from 11 schools in the Quezon City School District area in the Philippines. The schools came from the Government and Private Education sectors. The results of fitting the single factor model to the high school data are shown in Table 4.5. It includes factor loadings of the observed variables and their corresponding standard error. To be able to identify whether or not the model fits the data, a set of goodness-of-fit indexes usually used in CFA are also included (see Table 4.6). These fit indexes include the GFI, AGFI, PGFI, RMR and RMSEA.

The internal consistency (Cronbach alpha) of the scale for the Filipino high school sample was found to be 0.66.

Table 4.5. Factor loadings of items in the single factor model (Philippine high school sample and university sample and combined high school and university samples).

Variable	*Loadings (se)*† *ATTD (High School)*	*Loadings (se)* †† *ATTD (University)*	*Loadings (se)* ††† *ATTD (Combined)*
ATTD115	0.16(0.05)	0.66(0.10)	0.45(0.05)
ATTD116	0.22(0.05)	0.75(0.09)	0.54(0.05)
ATTD117	0.24(0.07)	0.51(0.10)	0.46(0.05)
ATTD118	0.13(0.06)	0.39(0.11)	0.30(0.06)
ATTD119	0.24(0.06)	0.76(0.09)	0.57(0.05)
ATTD120R	0.47(0.06)	0.36(0.11)	0.50(0.05)
ATTD121R	0.20(0.06)	0.50(0.10)	0.30(0.06)
ATTD122R	0.59(0.05)	0.65(0.10)	0.63(0.05)
ATTD123R	0.52(0.06)	0.53(0.10)	0.57(0.05)
ATTD124R	0.68(0.06)	0.54(0.10)	0.63(0.05)
	†*n=305*	†† *n=95*	††† *n=400*

The single factor model that represents the Filipino high school groups shows 6 items that loaded poorly onto the latent variable. These are ATTD115 (0.16), ATTD116 (0.22), ATTD117 (0.24), ATTD118 (0.13), ATTD119 (0.24) and ATTD121R (0.20). In this model, it appears that the items with poor loadings do not have much commonality with the latent variable. In other words, these items are not reflective of the model's latent variable. Using this data set, it is believed that these factors measure an important but unique factor, thus, testing the two correlated factors model discussed later in this chapter.

Filipino University Physics Students Sample

There was a total sample of 96 Filipino first year university Physics students who responded to the survey that formed this set of data. They came from one government-owned and one privately-owned university in Quezon City in the Philippines. The results of the single-factor test using this set of data are shown in Table 4.5. All of the items except for ATTD118 (0.39) and ATTD120R (0.36) loaded above 0.40. However, the loadings ranging from 0.50 to 0.76 cannot be considered strong but rather modest. Overall, the items in this model loaded onto the single latent variable better than the items in the model using the high school data albeit showing somewhat high residual values.

Cronbach's Alpha indicating the scale's internal consistency in the Filipino university sample was found to be 0.78.

Combined Filipino High School and University Physics Students Samples

Combining the two sets of data was considered feasible for similar reasons mentioned above that apply to the South Australian sample. The average age difference between the high school student samples and the university student samples is about a year. In addition, the first year university student samples were only into their second month of university classes when they filled out a survey questionnaire for this study. Thus, it was assumed that their attitudes towards and perceptions of a subject were similar. Furthermore, combining the two sets of data significantly increases the sample size which makes SEM more fit for use (Thompson, 2000 in Phakiti, 2007).

Testing the single factor model using the combined data from the high school and university groups yields modest results. Except for items ATTD118 and ATTD121R which both loaded poorly onto the latent factor, the rest of the items loaded modestly. The different fit indexes of the model also have to be examined to determine whether or not the model provides a good solution.

Cronbach's Alpha of the scale for the combined Filipino high school and university sample was 0.72.

Fit Indexes of the Single Factor Models (Filipino Sample)

Threshold values that warrant a good fitting model were given above. In this section, a summary of the models' fit indexes are presented in Table 4.6. Of particular importance is the value of the RMSEA which is considered to be the most informative of the fit indices. The single factor model fitted to the different sets of data show an almost consistent but very high RMSEA values that show poor fit. This conclusion is supported by the values GFI and AGFI which are lower than the threshold value of 0.90 and much higher than 0.05 RMR values. The PGFI values which account for the models' complexity are showing significantly lower values than what is accepted. This means that the models are rather complex than what appear in the figures. Thus, the single factor model needs to be modified in order to fit the data. This can be done using alternative models. These include hierarchical structures in which a number of distinct factors are shown to reflect a higher order factor (Curtis, 2004), and correlated structures in which a number of distinct factors are correlated.

Table 4.6. Goodness of fit index summary for the Single-Factor model (Filipino sample).

	High School data *n=305*	University data *n=95*	Combined data *n=400*
Chi-Square	256.40	152.98	424.44
df	35	35	35
GFI	0.82	0.76	0.78
AGFI	0.72	0.63	0.65
PGFI	0.52	0.49	0.50
RMR	0.11	0.11	0.12
RMSEA	0.16	0.18	0.20

The single factor model using the high school data appears to show the best solution. Interestingly, however, this is contrary to the fact that in this model more than half of the items loaded poorly onto the common factor. Nevertheless, this was accepted as the best solution among the three sets of data fitted to the model as indicated by its set of goodness-of-fit indexes.

Confirmatory factor analysis of the alternative models

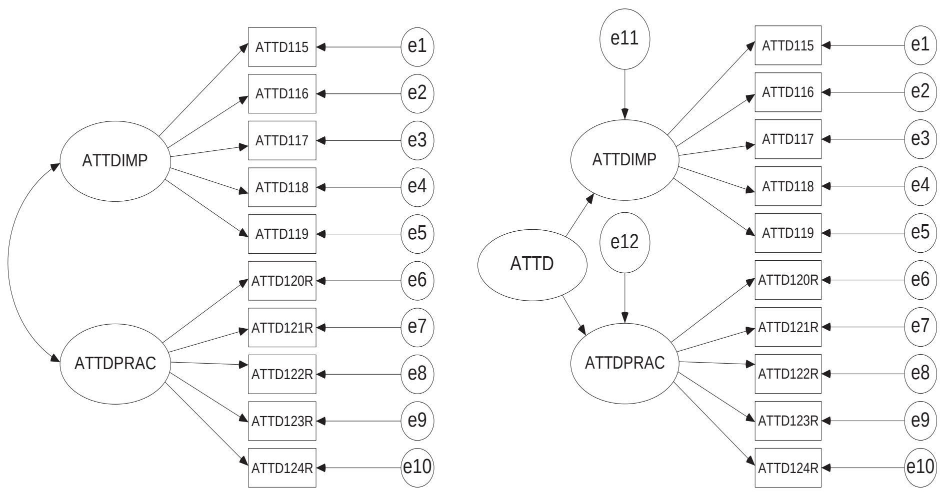
Alternative models were advanced and tested for fit against the sample data. Two correlated factors model and hierarchical model were proposed based on Redford's (1976) focus when he developed the 'Attitudes towards Physics' scale highlighting the importance and practicability of physics in the society. The two correlated factors model (Figure 4.2a) hypothesizes that the 10 items reflect two first-order factors that are correlated. And, if the first-order factors are correlated, it is possible that the correlation between the first-order factors is due to a single second-order factor (Jöreskog & Sörbom, 1993). This model is called the hierarchical factors model (Figure 4.2b).

To extract possible alternative models, the items in the scale were subjected to factor analysis with varimax rotation. Examining closely the item loadings in the attitudes instrument revealed two distinct clusters or groups that defined two latent attitudinal traits. One cluster defined an attitude towards the importance of Physics in the society and the other towards the usefulness of Physics in the society. These became the two distinct factors that were subjected to the CFA tests using the alternative models mentioned above. The first latent variable focused on the importance was designated as "ATTDIMP" and the second which focused on the usefulness as "ATTDPRAC". This formed an alternative model called the two correlated factors model. The second alternative model consisted of a second-order latent variable. In this model, the proposed two component constructs were first order factors, which loaded onto a single second-order latent variable called 'Attitudes towards Physics'.

CFA is not only used in hypothesis testing but also in comparing alternative models (Byrne, 1998). In this study, the purpose of carrying out testing for the alternative models was to determine whether they are more consistent with the data compared to the single factor model. Figure 4.2 shows the structures of the alternative models.

In the two correlated factors model, the items grouped as loading onto the latent variable ATTDIMP were ATTD115, ATTD116, ATTD117, ATTD118 and ATTD119. These items form a common theme that defines the importance of studying Physics.

The latent variable ATTDPRAC was defined by items ATTD120R, ATTD121R, ATTD122R, ATTD123R and ATTD124R that focus on the usefulness of studying physics.



(a)Two correlated factors model *(b) Hierarchical factor*

Figure 4.2. Structures of the Correlated Factors and Hierarchical Factors Model for the Attitudes Towards Physics Scale.

Each of these alternative models was constructed and investigated by CFA using the South Australian high school, university and the combination of high school and university data.

The South Australian sample

South Australian High School Physics Students Sample

Based on the two correlated factors model for the high school group in Table 4.7 items in each cluster loaded strongly onto their latent variables. This indicates results that are overall better than the single factor model. All items have loads significantly higher than the generally accepted minimum of 0.40 with a lowest value equal to 0.72. The two latent variables appear to have a moderate to high correlation (Hair, Anderson, Tatham, & Black, 1998).

Table 4.7. Factor loadings of the two-correlated factors model (South Australia high school sample).

Variable	*Loadings (se)* † *ATTDIMP*	*Loadings (se)* † *ATTDPRAC*	*Correlation between ATTDIMP and ATTDPRAC*
ATTD115	0.77(0.05)		0.71(0.04) †
ATTD116	0.82(0.05)		
ATTD117	0.89(0.05)		
ATTD118	0.72(0.05)		
ATTD119	0.86(0.05)		
ATTD120R		0.84(0.05)	
ATTD121R		0.83(0.05)	
ATTD122R		0.80(0.05)	
ATTD123R		0.76(0.05)	
ATTD124R		0.75(0.05)	

†*n=261*

South Australian University Physics Students Sample

The two correlated factors model for the university group (see Table 4.8) shows a similar pattern of loadings to the single factor model; the last two items loading poorly (Hair et al., 1998) onto their latent variable. A slight difference of the two correlated factors model from the single factor model is its stronger and more consistent loading of the first 8 items onto their respective latent variable. Items ATTD123R and ATTD124R in the two correlated factors model still loaded poorly although they have higher values compared to the single factor model. Again, sample size may account for in this result.

The correlation between the two latent variables is slightly higher for the high school sample than the university school sample. Perhaps this is indicative of the high school sample's perception that if Physics is useful then it should be of significant importance in the society. In other words, the high school students sampled in this study consider the attributes 'usefulness' and 'importance' almost always go hand-in-hand.

Table 4.8. Factor loadings of the two-correlated factors model (South Australia university sample).

Variable	*Loadings (se)* † *ATTDIMP*	*Loadings (se)* † *ATTDPRAC*	*Correlation between ATTDIMP and ATTDPRAC*
ATTD115	0.79(0.13)		0.59(0.12) †
ATTD116	0.71(0.14)		
ATTD117	0.76(0.13)		
ATTD118	0.81(0.13)		
ATTD119	0.86(0.12)		
ATTD120R		0.89(0.13)	
ATTD121R		0.73(0.14)	
ATTD122R		0.82(0.13)	
ATTD123R		0.29(0.16)	
ATTD124R		0.33(0.16)	

†*n=45*

Combined South Australian High School and University Physics Students Samples

A similar argument can be advanced when combining the South Australian high school and university data sets. The average age difference between the high school and university student samples is around one year. In addition, the first year university student samples were just into their second week of university classes when they filled out the survey questionnaire. It was therefore assumed that student samples from both groups (high school and university) were likely to hold similar attitudes and perceptions towards things – like school subjects, for instance. In addition, combining the two sets of data significantly increases the sample size which makes SEM more fit for use especially with models with more parameters to be estimated (Thompson, 2000 in Phakiti, 2007).

Table 4.9 shows the results of fitting the two correlated factors model to the combined sets of data. It shares a similar trend with the single factor model where all the items show loadings greater than 0.40. However, the items in the two correlated factors model show generally stronger loadings compared to the single factor model. The correlation between the two latent factors is strongest in the model that used the high school, and the combined high school and university data.

Table 4.9. Factor loadings of the two-correlated factors model (combined South Australia high school and university samples).

Variable	*Loadings (se)* † *ATTDIMP*	*Loadings (se)* † *ATTDPRAC*	*Correlation between ATTDIMP and ATTDPRAC*
ATTD115	0.78(0.05)		0.71(0.03) †
ATTD116	0.82(0.05)		
ATTD117	0.88(0.05)		
ATTD118	0.72(0.05)		
ATTD119	0.86(0.05)		
ATTD120R		0.85(0.05)	
ATTD121R		0.82(0.05)	
ATTD122R		0.81(0.05)	
ATTD123R		0.71(0.05)	
ATTD124R		0.73(0.05)	

†*n=306*

Fit Indexes of the Two Correlated Factors Model (South Australian sample)

Significant differences can be observed between how the two correlated factors model and the single factor model fit the study data. This is based on the comparison of the fit indexes of the models. Although the RMSEA of the two correlated factors model still shows values indicative of poor fit, the GFI and the AGFI values show that the models offer better solution (see Table 4.10). The models also show less complexity as indicated by the higher values of the PGFI. The PGFI, as described above, indicates how complex the model is (i.e., the less numbers of parameters a model has the less complex it is). The smallest number of parameters in the model is generally more preferred because each parameter added into the model adds some uncertainty to it (Diamantopoulos & Siguaw, 2000). The two correlated factors model using the high school data shows the best solution among all the models tested.

Table 4.10. Goodness of fit index summary for the Two Correlated Factors model (South Australian sample).

	High School data *n=261*	University data *n=45*	Combined data *n=306*
Chi-Square	114.08	177.56	152.11
df	34	34	34
GFI	0.91	0.73	0.91
AGFI	0.86	0.57	0.85
PGFI	0.57	0.45	0.56
RMR	0.05	0.11	0.05
RMSEA	0.10	0.18	0.11

Hierarchical Factor Models

A hierarchical model was used as one other alternative model because it is feasible that the proposed two latent variables reflect a single second-order latent variable which may be labelled as 'Attitudes towards Physics'.

The consistency of the hierarchical factor model to the data from the South Australian sample was also examined. Figure 4.2 (b) shows the structure of this model. The results of the tests using the hierarchical factor (or second-order factor) model are not included due to problems encountered including model convergence and identification. This was expected because in a model with one second-order factor and with two first-order factors, there are more parameters to be estimated than information available from the data. Therefore, the model cannot be extracted. This provided the basis of the conclusion that among the three models tested, the two correlated factors model best fits the South Australian data.

The Filipino sample

Filipino High School Physics Students Sample

Based on the two correlated factors model for the high school sample in Table 4.11 items in each cluster loaded from modestly to moderately onto their respective latent variable. This indicates an improvement over the results of the item loadings in the single factor model. It appears that the model fits the data better. In addition, it appears that the improvement is a result of the separation of the two distinct latent variables reflective of 'attitudes'. The two latent variables show a modest correlation.

Filipino University Physics Students Sample

The results of the test of the two correlated factors model using the university data shows similarity with the results of the test using the high school data (see Table 4.12). All items except one item (ATTD120R=0.35) loaded onto their latent variable from 0.45 to 0.85 indicating acceptable values which indicate good evidence of construct validity. In other words, the items are generally reflective of the latent variable they intent to measure.

Table 4.11. Factor loadings of the two-correlated factors model (Philippine high school sample).

Variable	*Loadings (se)* † *ATTDIMP*	*Loadings (se)* † *ATTDPRAC*	*Correlation between ATTDIMP and ATTDPRAC*
ATTD115	0.56(0.05)		0.41(0.06) †
ATTD116	0.74(0.05)		
ATTD117	0.60(0.05)		
ATTD118	0.46(0.05)		
ATTD119	0.70(0.05)		
ATTD120R		0.54(0.05)	
ATTD121R		0.40(0.05)	
ATTD122R		0.78(0.05)	
ATTD123R		0.63(0.05)	
ATTD124R		0.70(0.05)	

†*n=305*

The correlation between ATTDIMP and ATTDPRAC (see Table 4.12) is slightly higher in the university group than the high school group. This shows an opposite trend to the South Australian high school and university cohorts. This is clearly an indication that as far as this study is concerned, the attitudes instrument did not behave the same way for different groups. In other words, the instrument exhibited measurement variance when used in different groups of samples. This conclusion can be confirmed using Rasch analysis which will be discussed in the next sections of this chapter.

Table 4.12. Factor loadings of the two-correlated factors model (Philippine university sample).

Variable	*Loadings (se)* † *ATTDIMP*	*Loadings (se)* † *ATTDPRAC*	*Correlation between ATTDIMP and ATTDPRAC*
ATTD115	0.68(0.10)		0.61(0.09) ††
ATTD116	0.83(0.09)		
ATTD117	0.61(0.10)		
ATTD118	0.45(0.11)		
ATTD119	0.73(0.10)		
ATTD120R		0.35(0.11)	
ATTD121R		0.69(0.10)	
ATTD122R		0.85(0.09)	
ATTD123R		0.57(0.10)	
ATTD124R		0.60(0.10)	

†*n=95*

Combined Filipino High School and University Physics Students Sample

The same argument noted for combining the Filipino high school and university data sets presented above was applied to this particular test. Combining both Filipino Physics students' data sets yields results that show similarity with the results fitting the South Australian sample. Table 4.13 shows this. All items loaded onto their latent factors at least 0.40 although lower than that of the model using the university group. This can be considered better considering the number of misfitting items in the models represented in Tables 4.10 and 4.11 where some items loaded below 0.40. Again, sample size may be accounted for this. However, this conclusion may have little grounds for support as a robust model. Further tests were carried out to verify this.

Table 4.13. Factor loadings of the two-correlated factors model (combined Philippine high school and university samples).

Variable	*Loadings (se)* † *ATTDIMP*	*Loadings (se)* † *ATTDPRAC*	*Correlation between ATTDIMP and ATTDPRAC*
ATTD115	0.56(0.05)		0.41(0.06) †
ATTD116	0.74(0.05)		
ATTD117	0.60(0.05)		
ATTD118	0.46(0.05)		
ATTD119	0.70(0.05)		
ATTD120R		0.54(0.05)	
ATTD121R		0.40(0.05)	
ATTD122R		0.78(0.05)	
ATTD123R		0.63(0.05)	
ATTD124R		0.70(0.05)	

†*n=400*

Fit Indexes of the Two Correlated Factors Models (Filipino sample)

Improvement in model fit can be observed between in the two correlated factors model over the single factor model. This is based on the comparison of the fit indices of the two models. The RMSEA values for the model that used the high school and the combined high school and university data show mediocre fit. However, their high GFI and AGFI values suggest good model fit (see Table 4.14). Compared to the single factor model, the two correlated factors model complexity indicated by the PGFI has improved but not much. The two correlated factors model using the high school data shows the best solution among the data sets subjected to the test.

Table 4.14. Goodness of fit index summary for the Two Correlated Factors model (Filipino sample).

	High School data *n=305*	University data *n=95*	Combined data *n=400*
Chi-Square	83.48	107.20	145.34
df	34	34	34
GFI	0.95	0.83	0.93
AGFI	0.91	0.72	0.89
PGFI	0.58	0.51	0.58
RMR	0.05	0.09	0.06
RMSEA	0.07	0.14	0.09

Hierarchical Factor Model

The consistency of the hierarchical factor model to the data from the Filipino sample was also examined. The structure of this model is shown in Figure 4.2 (b). The results of the tests using the hierarchical factors (or second-order factor) model are not included due to problems encountered including model convergence and identification. This was expected because of the explanation mentioned earlier about second-order factor with two first-order factors (Joreskog & Sorbom, 1993). This provided the basis of the conclusion that among the models tested the two correlated factors model best fits the Filipino data. A solution to the hierarchical factor models could have been found if additional parameters were constrained and error terms correlated. However, this was not carried out to keep analysis uniformity and comparability across all the models tested.

4.5. Rasch analysis

The series of confirmatory factor analyses undertaken above examined the of the hypothesised structures of the scale. CFA also allowed for the assessment of the overall statistical significance and model fit. Rasch analysis enables for a more detailed (item-level) examination of the structure and operation of the attitudes scale.

In this study the data collected from the two groups of samples were subjected to Rasch analysis using the ConQuest 2.0 software (Wu, Adams, Wilson & Haldane, 2007). Both the rating scale and the partial credit model could be employed because all items in this scale used the same five response categories. The rating scale model was chosen for subsequent analyses for the reasons pointed out in Chapter 3. All 10 items in the scale were included in the initial analysis.

Item analysis with the Rating Scale Model

The 10 items in the Attitude Towards Physics scale was subjected to item analysis using the rating scale model. This was carried out to test the unidimensionality of the ten items to measure a construct called 'Attitudes towards Physics'. This involved examining each item's fit statistics. More specifically, the infit mean square (INFIT MNSQ) statistic was used as a basis for model fitting or non-fitting items. According to Tilahun (2004, p. 69), the INFIT MNSQ "measures the consistency of fit of the students to the item characteristic curve for each item with weighted consideration given to those persons close to the 0.5 probability level." In this study, the range of values of this statistic was taken to be from 0.72 to 1.30 (Linacre, Wright, Gustafsson & Martin-Lof, 1994). There was a degree of leniency in the chosen range because of the low stakes nature of the survey instrument used in this study. Items whose infit mean square values fall above 1.30 are generally considered misfitting and do not discriminate well, while below 0.72 are overfitting and provide redundant information (Tilahun, 2004). Items with infit mean square values outside the accepted range, and therefore not fitting the model, were deleted from the analysis. However, care was taken in removing items. Items with infit mean square values outside the accepted range whose item deltas (indicator of the location of the response choices on a scale) exhibit order swapping were readily removed. When items have an infit mean square values outside the range but exhibit item deltas in order, item statements were examined carefully as to whether or not they appeared to measure what was needed in this study. If deemed not to measure what was required in the study, then they were removed. In other words caution was strongly exercised in removing misfitting items as they may be valuable in providing other important information, or findings, that might arise from the study.

The combined data sets from high school and university samples (for both South Australia and the Philippines) were used in the Rasch analysis using the rating scale model. This is to minimise the effects of sample size on the resulting *t*-statistics (but not so much on the mean square statistics) (Smith, Rush, Fallowfield, Velikova & Sharpe, 2008) considering the small sizes of the university samples.

The analyses were carried out and results are presented in the following order:

- combined samples of South Australian high school and university Physics students
- combined samples of Filipino high school and university Physics students

The refinement process included subsequent runs after items that indicated misfit to the model were carefully considered to determine if they should remain a part of the model. Once decided, misfitting items were removed one at a time. If and when an item is removed, the analysis was re-run to check whether there exist 'masking' effects between items (i.e., items affecting other items by making them appear to be 'not functioning').

Tabulated results include item estimate, error and the unweighted fit statistics. The unweighted fit statistics include the infit mean square and the *t* value. The separation reliability index, chi-square test of parameter equality, degrees of freedom and significance level are also included. The separation reliability index indicates the proportion of the observed variance that is considered true (Adams and Khoo, 1993). High separation reliability index is preferred because this means that measurement error is smaller, and, therefore, the discrimination power of the scale/test is high, indicating that the items discriminate between the high ability respondents and low ability respondents (Alagumalai & Curtis, 2005).

Combined Samples of South Australian high school and university students

This set of data consists of a sample of 261 high school Physics students from schools across all education sectors within the Adelaide Metropolitan area and a sample of 45 university Physics students from a government-owned university in Adelaide, South Australia. The data were fitted to the rating scale model where all the 10 items of the Attitude Towards Physics scale were included in the analysis. Although this study based item fit on the infit statistics in the Rasch analysis due to its robustness against fluctuations caused by sample size (Adams & Khoo, 1993), data for the high school and university samples were combined using the same argument advanced in the CFA to keep consistency in the analysis. The results of the initial run are shown in Table 4.15.

All of the items' infit mean square values fall within the acceptable range (0.70 to 1.30) except for item ATTD123R (INFIT MNSQ=1.45) which appears to be misfitting. Removal of this item was suggested. However, examination of the item deltas shows that they are in order of increasing value, which indicates that the response choices on a scale are also in order. Furthermore, this item loaded well in a number of CFA models fitted to the different sets of data. Therefore, this item was not removed.

Table 4.15. Table of response model parameter estimates of the Attitude Towards Physics scale for the South Australian sample (no items removed).

Variables	*Estimates*	*Error*	*Unweighted Fit*		
			INFIT MNSQ	*CI*	*t*
ATTD115	0.065	0.052	0.79	(0.83, 1.17)	-2.7
ATTD116	0.122	0.052	0.96	(0.83, 1.17)	-0.5
ATTD117	0.099	0.052	0.79	(0.83, 1.17)	-2.7
ATTD118	-1.609	0.052	1.03	(0.83, 1.17)	0.4
ATTD119	-0.473	0.051	0.95	(0.83, 1.17)	-0.6
ATTD120R	0.556	0.054	0.87	(0.83, 1.17)	-1.6
ATTD121R	-0.036	0.052	1.08	(0.83, 1.17)	0.9
ATTD122R	0.507	0.053	1.13	(0.83, 1.17)	1.5
ATTD123R	0.299	0.053	1.45	(0.83, 1.17)	4.7
ATTD124R	0.470*	0.157	1.29	(0.83, 1.17)	3.2

Separation Reliability = 0.994
Chi-square test of parameter equality = 1284.32
df = 9
Significance Level = 0.000

Rasch analysis with the rating scale model was also carried out separately for each of the latent variables in the proposed two correlated factors model. The results (not shown) of fitting the rating scale model are very similar to the one presented above.

Combined samples of Filipino high school and university students

Respondents consisting of a sample of 307 Physics students from 11 high schools and a sample of 96 first year Physics students from two universities in Quezon City, Philippines, compose these data sets. All 10 items in the scale were subjected to the analysis using the rating scale model. The results are shown in Table 4.16. It appears that all of the items fit the model well as their infit mean squares are within the accepted range. Therefore no items were removed from the scale. This is not consistent with the results of the CFA using the one-factor model where a number of items appeared not to fit the model.

The reason for this result may be elaborated in a detailed, mathematical way. However, this is not the concern of this study; thus, a more general descriptive explanation is provided. CFA uses a multi-parameter logistic model approach while Rasch modeling uses a unidimensional or 1-parameter approach (for more detailed explanation, see Hill, Edwards, Thissen, Langer, Wirth, Burwinkle & Varni, 2007). These two different approaches use different methods of estimation. Hill et al. (2007, p. S46) pointed out that

> Different estimation methods and even different software packages may produce different results…It is possible that a scale could be unidimensional in 1 sample and multidimensional in another, as well as for 2 items to be locally dependent in some but not all samples.

Table 4.16. Table of response model parameter estimates of the Attitude Towards Physics scale for the Filipino sample (no items removed).

Variables	*Estimates*	*Error*	*Unweighted Fit*		
			INFIT MNSQ	*CI*	*t*
ATTD115	0.777	0.044	1.04	(0.86, 1.14)	0.6
ATTD116	0.577	0.043	0.89	(0.86, 1.14)	-1.6
ATTD117	-0.176	0.042	1.24	(0.86, 1.14)	3.2
ATTD118	-0.898	0.041	1.15	(0.86, 1.14)	2.1
ATTD119	0.517	0.043	0.93	(0.86, 1.14)	-0.9
ATTD120R	-0.015	0.042	0.92	(0.86, 1.14)	-1.1
ATTD121R	-0.954	0.041	1.08	(0.86, 1.14)	1.1
ATTD122R	-0.064	0.042	0.76	(0.86, 1.14)	-3.7
ATTD123R	0.270	0.043	0.99	(0.86, 1.14)	-0.1
ATTD124R	-0.035*	0.127	1.10	(0.86, 1.14)	1.4

Separation Reliability = 0.995
Chi-square test of parameter equality = 1694.17
df = 9
Significance Level = 0.000

This is clearly demonstrated by the results of using CFA and Rasch modeling when the Filipino data was used. In contrast, the South Australian data exhibited similar results when CFA and Rasch modeling were used.

Fitting the Filipino data to the rating scale model was also carried out separately for each of the latent variables in the proposed two correlated factors model. The results (not shown) are very similar to the one presented above where there were no misfitting items.

4.6. Model for the study

After examining and comparing the results of the CFA and Rasch analysis tests, it was decided that the single factor model, which retained all the items would be used in the subsequent analyses. The reasons for this decision was that the results of the Rasch analysis has demonstrated the unidimensionality of all the items to measure a common construct, and thus resulting in a fitting parsimonious model, which is more preferred (Thompson, 2000).

Although the model used is the same for both groups of samples (South Australians and Filipinos), the results provide clear evidence of measurement variance between them. This is in part exhibited by misfitting items when the model was fitted to different data sets for two different groups of samples. Therefore, the results of analysing the South Australian sample and the Filipino sample cannot be directly compared.

4.7. Summary

The Attitudes Towards Physics scale developed by Redford (1976) was adapted for use as part of the SUPSQ instrument to measure Physics students' attitudes towards choosing and studying Physics in high school and university levels. This scale consists of 10 items using 5-point response choices ranging from 'strongly disagree' (1) to 'strongly agree' (5). The middle point was labelled 'neutral' (3). Items which were not responded to were designated an arbitrary value '9'.

Data were collected from a sample of 261 South Australian Years 11 and 12 Physics high school students and a sample of 45 first year university Physics students. Data were also collected from a sample of 307 Fourth Year high school students and a sample of 96 first year university Physics students from the Philippines. Data from the South Australian and Filipino samples were analysed separately. CFA using LISREL 8.80 software package was employed to examine the structure of the scale, and Rasch Modeling with ConQuest 2.0 (using the rating scale model) was used for item-level analysis to test for the unidimensionality of the instrument items to measure a common latent factor – Attitudes towards Physics.

The CFA component of instrument validation involved fitting the measurement and alternative models into the South Australian and Filipino data sets. The measurement model consisted of 10 items loading onto a common latent variable called 'Attitudes towards Physics'. Two alternative models were tested; the two-correlated factors model and the hierarchical model. There were no results obtained for the hierarchical model due to problems with model identification. This was a warning issued by LISREL during CFA runs fitting the model to the data sets. For the two-correlated factors model, item loadings were examined to determine whether items are reflective of the latent variable they are representing. Fit indexes were also examined to identify whether the model shows good fit or poor fit to the data. Between the measurement and the two-correlated factors models, the latter showed better fit to the data. No items were removed when CFA was carried out.

To test the unidimensionality of the items to measure a common factor in the motivation instrument, the rating scale model was fitted into the data. Using the unweighted fit statistics, items were examined for their fit in the model. Items with infit mean square values that fall outside the accepted range of 0.72 to 1.30 became candidates for removal. However, removal of items was carried out carefully considering not only the item's infit mean square but also the item deltas (indicating the location of the item choices on a scale) and the item statement. No item was removed when the rating scale model was fitted to the South Australian and Filipino data sets. Fitting the South Australian data to the rating scale model using Rasch analysis and fitting the structural model using CFA to the South Australian data exhibited similar results. However, interestingly, the Filipino data showed different results where several items showed poor fit in the CFA approach while in the Rasch modeling approach all the items showed good fit. The possible reason for this difference could be that different approaches use different estimation methods. However, the CFA and Rasch analysis methods are similar in a number of ways in that they both: (a) examine the relationship between an underlying construct and a set of measured variables, (b) examine the degree to which item/subscale level true scores are similar for persons in the two different populations with the same level of satisfaction/attitude/ability score on the latent construct, and (c) can be used to identify the extent and the source of the problem when there is measurement variance (Raju, Laffitte & Byrne, 2002).

Based on the results of the different validation techniques carried out, it was decided that the single factor (or measurement) model keeping all the items would be used in the subsequent analyses due to its simplicity which is generally better preferred. Although the two-correlated factors model showed better fit to the data sets, the measurement model could not be rejected either.

All scales and instruments used in this study were examined using the same steps and techniques. The next chapter discusses how the scale Motivation Towards Learning Science/Physics was validated.

Chapter 5

Motivation Towards Learning Science/Physics Scale

5.1. Introduction

Student's motivation to learn physics was measured as part of the individual level factors that were examined in this study. It was believed that it is important to study student's motivation to learn specific subject areas (such as physics) because students may show different motivational traits (Lee & Brophy, 1996; Lee and Anderson, 1993), and, in effect could affect their attitudes towards a specific subject area. Motivation factors such as self-efficacy, active learning strategies, Science learning value, performance goal, achievement goal and learning environment stimulation were found to contribute in a student's Science learning motivation (Tuan et al., 2005). These motivation factors could apply to learning Physics. Tuan et al.'s (2005) Students' Motivation Toward Science Learning (SMTL) instrument was adapted for this study.

This chapter provides a detailed discussion of the quantitative analyses carried out to validate this instrument used to measure students' motivation to learn physics. To address the research questions (RQ) advanced in Chapter 1 with meaningful answers, the motivation instrument needs to be carefully and thoroughly validated. RQs partly concerning student motivation are RQ1c, RQ2b, RQ3b, and RQ3c. In addition, by validating thoroughly the SMTL instrument, the results of the analysis using this instrument may be used to complement existing literature on students' motivation towards learning physics described in Chapter 2.

Broadly, the structure of the instrument was confirmed using the contemporary approaches (Curtis, 2004) including confirmatory factor analysis (CFA) and Rasch measurement modeling used in Chapter 4. In this study, the terms 'latent factor' and 'latent variable' are used interchangeably to mean unobserved variable, trait or construct (Andrich, 2004).

This chapter is presented starting with a section briefly describing the SMTL instrument and its items that represent the observed variables. This is followed by the description of how the structure of the instrument was investigated using structural equation modeling (SEM) which includes confirmatory factor analysis of the six-factor correlated model and an alternative model. Each of these models' fit indexes was examined to determine which data fits a model best. This section is followed by an item-level analysis using Rasch modeling. The chapter concludes with a summary.

5.2. The Motivation Toward Learning Science/Physics instrument

To measure students' motivation to learn physics, Tuan et al.'s (2005) Students' Motivation Toward Science Learning (SMTSL) questionnaire was adapted. The questionnaire consists of 35 covering 6 factors of motivation: self-efficacy (7 items), active learning strategies (8 items), science learning value (5 items), performance goal (4 items), achievement goal (5 items) and learning environment stimulation (6 items). Each item consists of Five-point Likert-type response options. These options were coded 1 for 'strongly disagree', 2 for 'disagree', 3 for 'no opinion', 4 for 'agree', and 5 for 'strongly agree'. Non-response items were coded '9'. This was an arbitrary value designated to be recognized by statistical software as a non-response. In the Students' Uptake of Physics Study Questionnaire (SUPSQ) used in this study, the items pertaining to motivation towards learning Physics were numbers 20 through 54. For the purposes of data analysis, items were designated prefixes to represent the latent variable or factor they measure: SLEFF for self-efficacy, ALS for active learning strategies, SLVAL for Science learning value, PERFG for performance goal, ACHVG for achievement goal, and LERNV for learning environment stimulation. Table 5.1 shows the summary of the items in the SMTSL adapted, their nature (e.g., positively-worded or negative-worded statement), their item code to indicate reverse scoring for the negatively-worded statements, and each item's text. Negatively-worded statements were reverse-scored to keep scoring consistency (see for details Tuan et al., 2005).

Table 5.1. Summary of items in the SMTSL questionnaire used in the SUPSQ instrument.

Item	Nature of statement	Item Code to indicate reverse scoring	Item text
SLEFF20	Positive	*none*	Whether the science content is difficult or easy, I am sure that I can understand it
SLEFF21	Negative	SLEFF21R	I am not confident about understanding difficult science concepts
SLEFF22	Positive	*none*	I am sure that I can do well on science tests
SLEFF23	Negative	SLEFF23R	No matter how much effort I put in, I cannot learn science
SLEFF24	Negative	SLEFF24R	When science activities are too difficult, I give up or only do the easy parts
SLEFF25	Negative	SLEFF25R	During science activities, I prefer to ask other people for the answer rather than think for myself
SLEFF26	Negative	SLEFF26R	When I find the science content difficult, I do not try to learn it
ALS27	Positive	*none*	When learning new science concepts, I attempt to understand them
ALS28	Positive	*none*	When learning new science concepts, I connect them to my previous experiences
ALS29	Positive	*none*	When I do not understand a science concept, I find relevant resources that will help me
ALS30	Positive	*none*	When I do not understand a science concept, I would discuss with the teacher or other students to clarify my understanding
ALS31	Positive	*none*	During the learning processes, I attempt to make connections between the concepts that I learn
ALS32	Positive	*none*	When I make a mistake, I try to find out why
ALS33	Positive	*none*	When I meet science concepts that I do not understand, I still try to learn them
ALS34	Positive	*none*	When new science concepts that I have learned conflict with my previous understanding, I try to understand why
SLVAL35	Positive	*none*	I think that learning science is important because I can use it in my daily life
SLVAL36	Positive	*none*	I think that learning science is important because it stimulates my thinking
SLVAL37	Positive	*none*	In science, I think that it is important to learn to solve problems
SLVAL38	Positive	*none*	In science, I think it is important to participate in inquiry activities
SLVAL39	Positive	*none*	It is important to have the opportunity to satisfy my own curiosity when

			learning science
PERFG40	Negative	PERFG40R	I participate in science courses to get a good grade
PERFG41	Negative	PERFG41R	I participate in science courses to perform better than other students
PERFG42	Negative	PERFG42R	I participate in science courses so that other students think that I'm smart
PERFG43	Negative	PERFG43R	I participate in science courses so that the teacher pays attention to me
ACHVG44	Positive	*none*	During a science course, I feel most fulfilled when I attain a good score in a test
ACHVG45	Positive	*none*	I feel most fulfilled when I feel confident about the content in a science course
ACHVG46	Positive	*none*	During a science course, I feel most fulfilled when I am able to solve a difficult problem
ACHVG47	Positive	*none*	During a science course, I feel most fulfilled when the teacher accepts my ideas
ACHVG48	Positive	*none*	During a science course, I feel most fulfilled when other students accept my ideas
LERNV49	Positive	*none*	I am willing to participate in this science course because the content is exciting and changeable
LERNV50	Positive	*none*	I am willing to participate in this science course because the teacher uses a variety of teaching methods
LERNV51	Positive	*none*	I am willing to participate in this science course because the teacher does not put a lot of pressure on me
LERNV52	Positive	*none*	I am willing to participate in this science course because the teacher pays attention to me
LERNV53	Positive	*none*	I am willing to participate in this science course because it is challenging
LERNV54	Positive	*none*	I am willing to participate in this science course because the students are involved in discussions

5.3. Previous analytic practices

Tuan et al. (2005) established 6 scales based on existing relevant motivation questionnaires including Motivated Strategies for Learning Questionnaire by Pintrich, Multidimensional Motivation Instrument by Uguroglu, and Patterns of Adaptive Learning Survey by Midgley coded item response . Each item in all 6 scales were anchored at 1, 2, 3, 4 and 5 for "strongly disagree", "disagree", "no opinion", "agree" and "strongly agree", respectively. Tuan et al. did not directly use existing scales from other instruments because they did not address science learning and were not designed for high school students.

The authors of the SMTSL satisfied the three validity requirements (content, construct, and criterion-related) when they developed the SMTSL questionnaire. Construct validity of the instrument was investigated using factor analysis, presumably exploratory. The authors also used one-way analysis of variance to analyse whether students with high, moderate and low motivation showed significant difference on SMTSL scores. Internal consistency was examined using the Cronbach Alpha coefficient. Using a sample of 1407 junior high school students from central Taiwan, internal consistency (Cronbach alpha) for the entire instrument was found by Tuan et al. to be 0.89, and for each scale ranged from 0.70 to 0.89. Independence of each scale was determined using the discriminative validity value. Discriminative validity refers to the extent in which a scale measured a dimension different from that measured by any other scale. They found that the discriminative validity of each scale ranged from 0.09 to 0.51 which suggests that there is scale independence and also some overlap with other scales.

It is recognised that Tuan et al.'s instrument is still in its development stages. It is implicit that more thorough validation of the hypothesized structure using different methods is needed using a wide variety of samples (i.e. from different cultural groups, countries, etc.). This study did just that! Samples came from different groups of different cultural backgrounds and educational settings. This study examined the structure of the SMTSL using CFA (through SEM) for the overall instrument structure and fit, and Rasch modeling for the item-level analysis. As highlighted by Rowe (2005), the structural and measurement properties of a scale have to be ascertained before any inferential decision can be made. The following sections describe in more detail the methods (including the results) used to validate the SMTSL.

5.4. Instrument structure analysis

The section of this study's data set concerned with students' motivation towards learning physics has been subjected to detailed structural analysis. This section describes and discusses results from using data from two main groups of samples: South

Australian physics students and Filipino physics students. Each group consists of two subgroups: high school physics students and university physics students. The main methods used to examine the structure of the instrument used to measure attitudes toward physics were CFA and Rasch measurement modeling. These are the same methods used in the examination of the attitude scale discussed in Chapter 4.

Factor analysis using EFA was not carried out with this scale. This is under the premise that the authors who developed this instrument have already subjected it in such analysis. Therefore, CFA was utilised to confirm factor structures as advanced by the authors.

The hypothesized relationships were then subjected to tests using confirmatory factor analysis starting with the authors' original (or baseline) model then followed by the analysis of alternative models. Special-purpose statistical software applications were used to carry out CFA to obtain more reliable results. In this study, LISREL and AMOS were used. LISREL was used mainly for undertaking CFA and AMOS was used mainly to draw structural figures (a section in Chapter 3 details the reasons for this). The following sections report on the results of the CFA tests carried out for each group of sampled students level-wise and country-wise. Each group of sample were analysed separately to examine for measurement invariance between levels (high school and university) within a country or between main groups (countries), or both.

Confirmatory factor analysis of the authors' model

This section reports the fit of the authors' model (or baseline model) to the data for the six latent variables identified by Tuan et al. (2005). These are: self-efficacy (SLEFF), active learning strategies (ALS), Science learning value (SLVAL), performance goal (PERFG), achievement goal (ACHVG), and learning environment stimulation (LERNV). The structure of this model is shown in Figure 5.1. The results presented in the following sections drew from this study's data sets collected from a sample of South Australian high school and university physics students, and from a sample of Filipino high school and university physics students. A six-correlated factors model was fitted to different data sets in the following order.

- South Australian high school physics students
- South Australian university physics students

- Combined South Australian high school and university physics students
- Filipino high school physics students
- Filipino university physics students
- Combined Filipino high school and university physics students.

Results of the CFA runs are presented in table form showing the loading value (together with the standard error) of each observed variable onto its latent variable. For an observed variable to provide an adequate and meaningful indication of the latent variable, a minimum factor loading (or regression weight estimates) value of 0.40 was used. Model fit indexes for each model are also presented for comparison to determine which set of data best fits the six-correlated factors model.

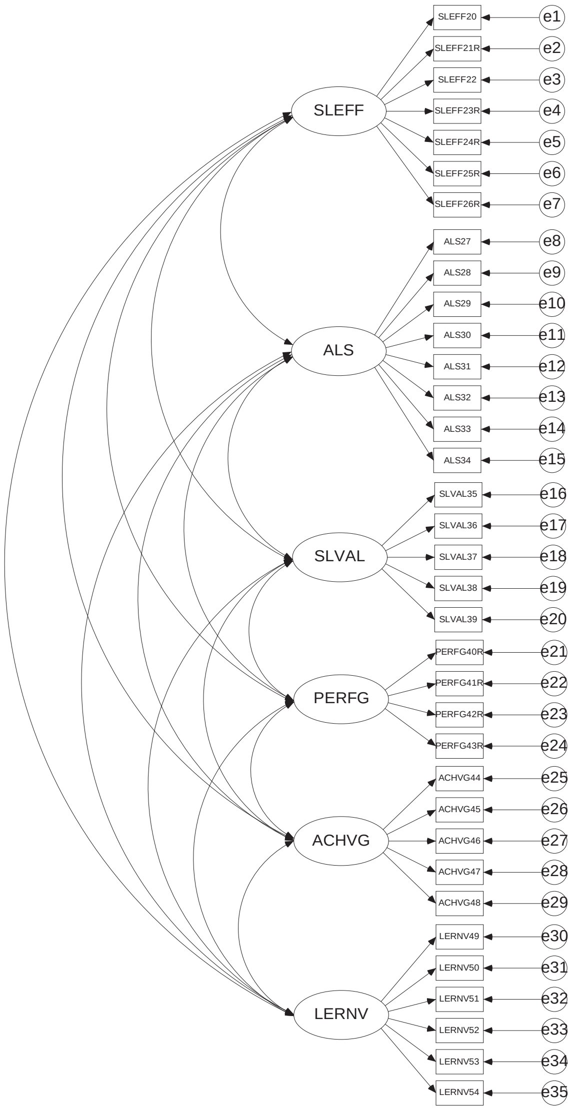


Figure 5.1. Structure of the 6-correlated factors Model for the Motivation Towards Learning Science/Physics Scale.

Model Fit Indexes

The different model fit indexes from a CFA run using LISREL are the same as the ones presented in Chapter 4: GFI, AGFI, PGFI, RMR and RMSEA. A model shows good fit when their minimum GFI, AGFI and PGFI value equals at least 0.90. RMSEA and RMR values should be below 0.05 to indicate good fit. Table 4.2 in Chapter 4 summarizes these indexes.

The South Australian Sample

The following sections present results of the CFA tests of the six-correlated factors model (see Figure 1) using the data set from the South Australian sample. Three CFA tests were carried out fitting the model to the data sets from the South Australian high school sample, university sample, and a data set combining the two.

South Australian High School Physics Students Sample

This set of data was collected from a sample 261 high school physics students coming from 11 schools in the Adelaide metropolitan area. However, the number of sample that appears at the bottom of tables showing factor loadings may be different. This is due to the fact that missing data were omitted. The schools were from the Government, the Independent, and Catholic education sectors. This data set was fitted to the six-correlated factors model. The results are shown in Table 5.2. Out of the 35 items loaded onto their respective latent variables, five items were identified as not reflective of the latent variable they try to measure. For the items that fit the model, they load onto their respective latent variable ranging from modestly fitting (ACHVG47=0.43) to strongly fitting (PERFG42R=0.93) with small standard errors. Overall, the result shows that the model reasonably fits the South Australian high school sample data.

Table 5.2. Factor loadings of the six-correlated factors model fitted to the South Australian high school data.

Variable	*Loadings (se)* † *SLEFF*	*ALS*	*SLVAL*	*PERFG*	*ACHVG*	*LERNV*
SLEFF20	0.63(0.06)					
SLEFF21R	0.63(0.06)					
SLEFF22	0.69(0.06)					
SLEFF23R	0.80(0.05)					
SLEFF24R	0.65(0.06)					
SLEFF25R	0.62(0.06)					
SLEFF26R	0.80(0.05)					
ALS27		0.76(0.05)				
ALS28		0.39(0.06)				
ALS29		0.54(0.06)				
ALS30		0.44(0.06)				
ALS31		0.66(0.06)				
ALS32		0.67(0.06)				
ALS33		0.78(0.05)				
ALS34		0.68(0.06)				
SLVAL35			0.61(0.06)			
SLVAL36			0.69(0.06)			
SLVAL37			0.76(0.06)			
SLVAL38			0.61(0.06)			
SLVAL39			0.65(0.06)			
PERFG40R				0.33(0.06)		
PERFG41R				0.63(0.06)		
PERFG42R				0.93(0.05)		
PERFG43R				0.83(0.06)		
ACHVG44					0.52(0.06)	
ACHVG45					0.85(0.05)	
ACHVG46					0.90(0.05)	
ACHVG47					0.43(0.06)	
ACHVG48					0.36(0.06)	
LERNV49						0.72(0.06)
LERNV50						0.52(0.06)
LERNV51						0.20(0.07)
LERNV52						0.20(0.07)
LERNV53						0.76(0.06)
LERNV54						0.45(0.07)

†*n=257*

The set of this model's goodness-of-fit indexes were also examined, however, to provide a more sound evidence of its fit to the data.

South Australian University Physics Students Sample

This set of data was collected from a sample of 45 first year university physics students. They came from one of the three universities in South Australia which is located in the Adelaide Metropolitan area.

Table 5.3. Factor loadings of the six-correlated factors model fitted to the South Australian university data.

Variable	*Loadings (se)* † *SLEFF*	*ALS*	*SLVAL*	*PERFG*	*ACHVG*	*LERNV*
SLEFF20	0.92(0.22)					
SLEFF21R	0.73(0.23)					
SLEFF22	0.39(0.24)					
SLEFF23R	0.52(0.23)					
SLEFF24R	0.52(0.23)					
SLEFF25R	0.73(0.23)					
SLEFF26R	0.70(0.23)					
ALS27		0.87(0.23)				
ALS28		-0.11(0.24				
ALS29		0.38(0.24)				
ALS30		-0.03(0.24)				
ALS31		0.56(0.24)				
ALS32		0.46(0.24)				
ALS33		0.67(0.23)				
ALS34		0.66(0.23)				
SLVAL35			0.21(0.25)			
SLVAL36			0.78(0.24)			
SLVAL37			0.52(0.25)			
SLVAL38			0.52(0.25)			
SLVAL39			0.69(0.24)			
PERFG40R				0.57(0.26)		
PERFG41R				0.79(0.25)		
PERFG42R				0.82(0.25)		
PERFG43R				0.65(0.25)		
ACHVG44					0.65(0.27)	
ACHVG45					0.14(0.27)	
ACHVG46					0.45(0.27)	
ACHVG47					0.50(0.27)	
ACHVG48					0.73(0.27)	
LERNV49						0.57(0.25)
LERNV50						0.79(0.26)
LERNV51						0.03(0.26)
LERNV52						0.23(0.26)
LERNV53						0.28(0.26)
LERNV54						0.66(0.25)

†*n*=45

The results of fitting the six-correlated factors model to this data set are shown in Table 5.3. However, a strong caution was taken in the interpretation of the results due the issue of sample size (Thompson, 2000; Lomax, 1989; Ding et al., 1995). This was confirmed by a warning message prompted by the LISREL program during the CFA run fitting the model to this set of data. The warning message reads "Total sample size is smaller than the number of parameters. Parameter estimates are unreliable."

Therefore, the results presented were not used for comparison purposes but only for information.

Combined Samples of South Australian High School and University Students

The students in the high school and the university samples have age differences that are roughly a year apart. In addition, the first year university student samples were just into their second week of university classes when they filled out the survey questionnaire. Thus, it was assumed that student samples from both groups (high school and university) were likely to hold attitudes and perceptions towards things that may not be very different from one another. Therefore, the author of this study considered combining the two sets of data feasible. In addition, since there was only little information that can be extracted from the university data alone, it was considered to be useful for this set of data to be combined with the high school data to increase the sample size to make CFA usable.

Combining the two sets of data and fitting the six-correlated factors to it yields similar results as the test using the high school data (see Table 5.4). Out of 35 items, five items were identified to not fit the model. Four of these five items also did not fit the model using the high school data. These items are ALS28, PERFG40R, LERNV51 and LERNV52. Factor loadings of three items out of the four have lower values in this CFA run. Factor loadings of the items that fit the model are on the average the same as those in the model that used the high school data. Similarities between these two models compared can be confirmed by looking at their respective fit indexes which are almost exactly the same.

Table 5.4. Factor loadings of the six-correlated factors model fitted to the combined South Australian high school and university data sets.

	Loadings (se)†					
Variable	*SLEFF*	*ALS*	*SLVAL*	*PERFG*	*ACHVG*	*LERNV*
SLEFF20	0.66(0.05)					
SLEFF21R	0.65(0.05)					
SLEFF22	0.66(0.05)					
SLEFF23R	0.76(0.05)					
SLEFF24R	0.63(0.06)					
SLEFF25R	0.63(0.05)					
SLEFF26R	0.76(0.05)					
ALS27		0.75(0.05)				
ALS28		0.33(0.06)				
ALS29		0.51(0.06)				
ALS30		0.32(0.06)				
ALS31		0.66(0.05)				
ALS32		0.64(0.05)				
ALS33		0.77(0.05)				
ALS34		0.69(0.05)				
SLVAL35			0.54(0.06)			
SLVAL36			0.70(0.06)			
SLVAL37			0.73(0.05)			
SLVAL38			0.59(0.06)			
SLVAL39			0.65(0.06)			
PERFG40R				0.35(0.06)		
PERFG41R				0.64(0.06)		
PERFG42R				0.93(0.05)		
PERFG43R				0.82(0.05)		
ACHVG44					0.52(0.06)	
ACHVG45					0.77(0.05)	
ACHVG46					0.84(0.05)	
ACHVG47					0.44(0.06)	
ACHVG48					0.41(0.06)	
LERNV49						0.75(0.06)
LERNV50						0.46(0.06)
LERNV51						0.16(0.07)
LERNV52						0.11(0.07)
LERNV53						0.73(0.06)
LERNV54						0.40(0.06)

†*n=302*

Fit Indexes of the Six-Correlated Factors Models (South Australian sample)

Summarized above are the cut-off values for the fit indexes to indicate good model fit. Table 5.5 shows the summary of the resulting fit indexes of the six-correlated factors model fitted to the South Australian data sets. It should be noted that the goodness-of-fit indexes presented for the set of data collected from the sample of university Physics students could not be used for comparison with the other two models due to the errors cited above as a result of the limited sample size.

Table 5.5. Goodness-of-fit index summary for the six-correlated factors model fitted to the South Australian data sets.

	High School data *n=257*	University data* *n=45*	Combined data *n=302*
Chi-Square	2461.11	215.94	2514.40
df	545	545	545
GFI	0.67	0.76	0.67
AGFI	0.61	0.73	0.62
PGFI	0.58	0.66	0.58
RMR	0.11	0.19	0.11
RMSEA	0.11	0.00	0.11

**cannot be used for comparison*

There is not much that can be said about the models fitted into the high school data and the combined high school and university data except for the fact that almost the entire model fit indexes are exactly the same. Both models have RMSEA and RMR values that indicate poor fit. Both GFI and AGFI values are below 0.90 which is the accepted value to indicate good fit. Considering the values of GFI and the AGFI to evaluate individual models, these fit indexes suggest poor-fitting models. Both have PGFI indicating that there is a moderate amount of complexity within the models. A variety of modification indexes, a majority of them for error correlations, suggested that the model could be improved. However, these modifications were not undertaken because of the limited grounding on theories guiding specification of error correlations. Instead, an examination of alternative models which will be discussed in the later sections of this chapter was carried out.

The Filipino sample

This section presents the results of fitting the six-correlated factors model to the data collected from samples of high school and university physics students in the Philippines. Three CFA runs fitting the six-correlated factors model were carried out: first to the high school data set, then to the university data set, and finally, combining both sets of data. The same set of fit indexes is reported.

Filipino High School Physics Students Sample

This set of data was collected from a sample of 307 high school physics students coming from 11 schools in the Quezon City School District area in the Philippines. Results of the CFA fitting a six-correlated factors model into this set of data are shown in Table 5.6. Three out of 35 observed variables did not fit the model. In other words, these items were not reflective of the latent variables they intend to measure (as far as this set of data is concerned). These non-fitting items include PERFG40R, LERNV51 and LERNV52. These items also did not fit the model using the South Australian data. Factor loadings of the fitting items range from a modest 0.40 to a strong 0.86.

Filipino University Physics Students Sample

This data set was collected from a sample of 96 Filipino first year university physics students from one government-owned and one privately-owned university in Quezon City, Philippines. Using LISREL, a six-correlated factors model was fitted into this data and the results are shown in Table 5.7. However, a strong caution was taken in interpreting the results of this particular CFA because of the issue of sample size. Although bigger than the South Australian university sample, it is still considered small relative to the figures provided by researchers cited in Chapter 4. The sample size (n=96) may be close to the minimum suggested by Ding, Velicer and Harlow (1995) but in terms of the ratio of the number of respondents to the number of observed variables, it is still small compared to the 10:1 suggested by Mueller (1997). Therefore the results in this test were used cautiously for comparison with the other CFA results.

Table 5.6. Factor loadings of the six-correlated factors model fitted to the Filipino high school data.

	Loadings (se)†					
Variable	*SLEFF*	*ALS*	*SLVAL*	*PERFG*	*ACHVG*	*LERNV*
SLEFF20	0.47(0.06)					
SLEFF21R	0.63(0.06)					
SLEFF22	0.62(0.06)					
SLEFF23R	0.73(0.05)					
SLEFF24R	0.60(0.06)					
SLEFF25R	0.63(0.06)					
SLEFF26R	0.74(0.05)					
ALS27		0.72(0.05)				
ALS28		0.40(0.06)				
ALS29		0.55(0.06)				
ALS30		0.56(0.06)				
ALS31		0.64(0.05)				
ALS32		0.60(0.06)				
ALS33		0.71(0.05)				
ALS34		0.77(0.05)				
SLVAL35			0.69(0.05)			
SLVAL36			0.86(0.05)			
SLVAL37			0.69(0.05)			
SLVAL38			0.66(0.05)			
SLVAL39			0.67(0.05)			
PERFG40R				0.30(0.06)		
PERFG41R				0.67(0.06)		
PERFG42R				0.85(0.05)		
PERFG43R				0.80(0.05)		
ACHVG44					0.84(0.05)	
ACHVG45					0.65(0.05)	
ACHVG46					0.79(0.05)	
ACHVG47					0.68(0.05)	
ACHVG48					0.63(0.05)	
LERNV49						0.79(0.05)
LERNV50						0.67(0.05)
LERNV51						0.37(0.06)
LERNV52						0.26(0.06)
LERNV53						0.78(0.05)
LERNV54						0.66(0.05)

†n=301

Table 5.7. Factor loadings of the six-correlated factors model fitted to the Filipino university data set.

Variable	*Loadings (se)†* *SLEFF*	*ALS*	*SLVAL*	*PERFG*	*ACHVG*	*LERNV*
SLEFF20	0.58(0.11)					
SLEFF21R	0.65(0.10)					
SLEFF22	0.63(0.11)					
SLEFF23R	0.82(0.10)					
SLEFF24R	0.70(0.10)					
SLEFF25R	0.66(0.10)					
SLEFF26R	0.61(0.11)					
ALS27		0.83(0.09)				
ALS28		0.48(0.11)				
ALS29		0.47(0.11)				
ALS30		0.54(0.11)				
ALS31		0.70(0.10)				
ALS32		0.73(0.10)				
ALS33		0.86(0.09)				
ALS34		0.84(0.09)				
SLVAL35			0.58(0.11)			
SLVAL36			0.75(0.10)			
SLVAL37			0.71(0.10)			
SLVAL38			0.66(0.11)			
SLVAL39			0.64(0.11)			
PERFG40R				0.46(0.11)		
PERFG41R				0.81(0.10)		
PERFG42R				0.88(0.09)		
PERFG43R				0.87(0.10)		
ACHVG44					0.43(0.11)	
ACHVG45					0.51(0.11)	
ACHVG46					0.47(0.11)	
ACHVG47					0.97(0.09)	
ACHVG48					0.83(0.10)	
LERNV49						0.90(0.09)
LERNV50						0.64(0.10)
LERNV51						0.38(0.11)
LERNV52						0.35(0.11)
LERNV53						0.82(0.10)
LERNV54						0.64(0.10)

n=94

Combined Samples of High School and University Students

The Filipino high school and university data sets were combined following the same rationale presented earlier in this chapter.

Fitting the six-correlated factors model into the combined sets of high school and university data yields results that are shown in Table 5.8. Factor loadings of the items are about the same as the model using the high school data. Only two items did not fit the model: PERFG40R and LERNV51. The model fit using the combined sets of data has generally improved. This is based on the fewer non-fitting items and better goodness-of-fit indexes which will be discussed more in detail in the following section.

Table 5.8. Factor loadings of the six-correlated factors model fitted to the combined Filipino data sets.

	Loadings (se)†					
Variable	*SLEFF*	*ALS*	*SLVAL*	*PERFG*	*ACHVG*	*LERNV*
SLEFF20	0.50(0.05)					
SLEFF21R	0.64(0.05)					
SLEFF22	0.63(0.05)					
SLEFF23R	0.75(0.05)					
SLEFF24R	0.63(0.05)					
SLEFF25R	0.63(0.05)					
SLEFF26R	0.70(0.05)					
ALS27		0.75(0.04)				
ALS28		0.42(0.05)				
ALS29		0.54(0.05)				
ALS30		0.56(0.05)				
ALS31		0.66(0.05)				
ALS32		0.63(0.05)				
ALS33		0.74(0.05)				
ALS34		0.78(0.05)				
SLVAL35			0.65(0.05)			
SLVAL36			0.83(0.04)			
SLVAL37			0.68(0.05)			
SLVAL38			0.66(0.05)			
SLVAL39			0.65(0.05)			
PERFG40R				0.35(0.05)		
PERFG41R				0.71(0.05)		
PERFG42R				0.86(0.04)		
PERFG43R				0.82(0.05)		
ACHVG44					0.74(0.05)	
ACHVG45					0.62(0.05)	
ACHVG46					0.72(0.05)	
ACHVG47					0.74(0.05)	
ACHVG48					0.68(0.05)	
LERNV49						0.81(0.04)
LERNV50						0.66(0.05)
LERNV51						0.36(0.05)
LERNV52						0.28(0.05)
LERNV53						0.79(0.04)
LERNV54						0.65(0.05)

n=395

Fit Indexes of the Six-Correlated Factors Model (Filipino Sample)

Table 5.9 shows the summary of the goodness-of-fit indexes of the six-correlated factors model fitted to the Filipino data sets. As indicated by the higher values of GFI, AGFI and PGFI, and lower values of RMR and RMSEA, the 6-correlated factors model appears to be most fit to the combined high school and university data. However, these values do not signify good fit; the GFI, AGFI and PGFI values are below the accepted value of 0.90 and the RMR and RMSEA values are way above the accepted value of 0.05.

Table 5.9. Goodness-of-fit index summary for the six-correlated factors model fitted to the Filipino data sets.

	High School data *n=301*	University data *n=94*	Combined data *n=395*
Chi-Square	2425.78	1642.02	2682.33
df	545	545	545
GFI	0.71	0.62	0.74
AGFI	0.67	0.56	0.69
PGFI	0.62	0.54	0.64
RMR	0.10	0.11	0.09
RMSEA	0.10	0.10	0.10

As suggested in the CFA results based on a variety of modification indexes, the model could be improved by correlating the item errors. However, this was not carried out to keep analysis uniformity and comparability across all the models tested. Examination of alternative models was carried out instead.

Confirmatory factor analysis of an alternative model

It was originally planned by the author of this study to examine a single factor model with all the 35 items of the motivation instrument loading onto a single factor. However, this was not undertaken because Tuan et al. (2005) have already examined the discriminative validity of their motivation instrument and found that there is significant scale independence. However, even when there is significant scale independence, they are not totally independent which means that they are somehow correlated. If the first-order factors are correlated, it is possible that the correlation between the first-order factors is due to a single second-order factor (Jöreskog & Sörbom, 1993). Therefore, testing a second-order factor (or hierarchical) model (Figure 5.2) as an alternative was considered more appropriate. In this test, seven latent variables were identified, including six latent factors that were used in the baseline model, and the overall latent variable (reflected by the six latent factors). The six latent factors were loaded onto the overall latent factor called 'motivation'. This factor was labelled MOTIVATN. The structure of the second-order factor model is shown in Figure 5.2. The aim of this examination was to determine whether the model fit could be improved by introducing a second-order factor that can be measured by the six latent factors identified in the measurement model. In addition, model parsimony can also be tested. In research studies such as this, parsimonious models are more preferred (Thompson, 2000).

The results presented in the following sections drew from this study's data sets collected from South Australian high school and university Physics students, and from Filipino high school and university Physics students. A second-order factor model was tested in the order of the following data sets:

- South Australian high school Physics students
- South Australian university Physics students
- Combined South Australian high school and university Physics students
- Filipino high school Physics students
- Filipino university Physics students
- Combined Filipino high school and university Physics students.

Results of the CFA runs are presented in table form showing the loading value of each observed variable onto its latent factor. The loadings of the first-order factors to the second-order factors are also presented. For an observed variable to fit the latent factor, it should have a minimum loading of 0.40. Model fit indexes for each model are also presented for comparison to determine which second-order factor model fits best which cohort of Physics students.

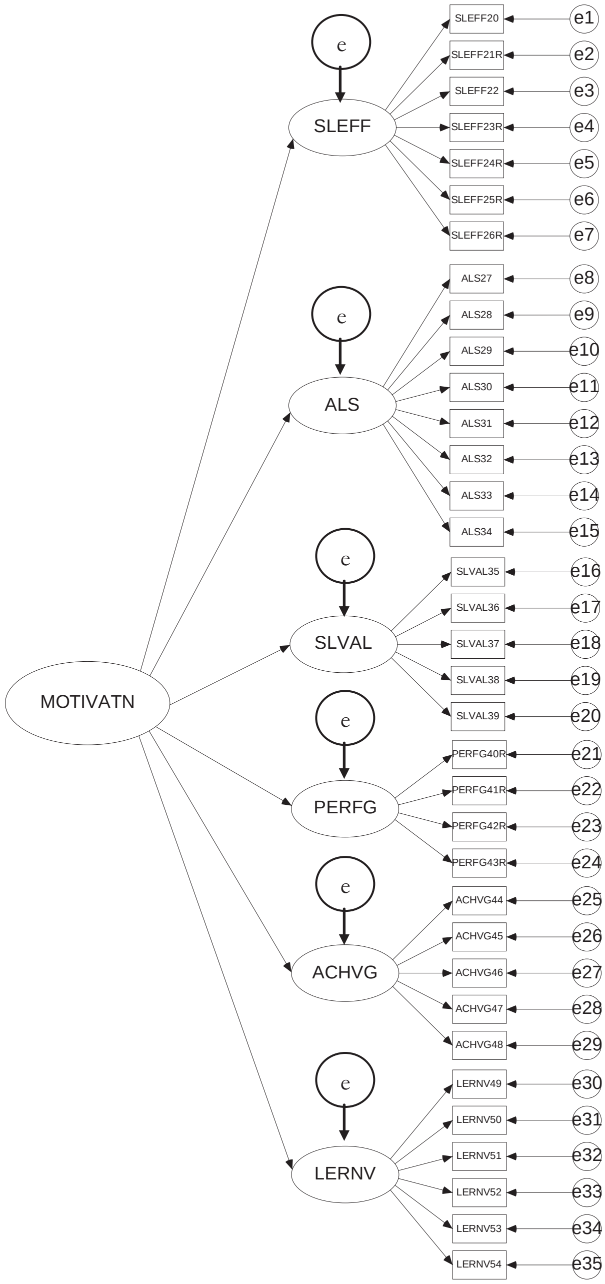


Figure 5.2. Structure of the Second-order Factor Model for the Motivation Towards Learning Science/Physics Scale.

The South Australian sample

The following sections present the results of fitting the South Australian data sets into the second-order factor model. CFA through structural equation modeling (SEM) was carried out fitting the high school data into the second-order factor model first, succeeded by the university data, and finally the combined sets of data.

South Australian High School Physics Students Sample

Table 5.10 shows the results of the CFA run using a second-order factor model. The loadings of the 35 items were examined and found that four of them did not fit the model. The items include PERFG40R (0.33), ACHVG48 (0.35), LERNV51 (0.21) and LERNV52 (0.19). These items are the same with the items that did not fit the 6-correlated factors model using the high school data. With regards to the first-order factors loading onto the second-order factor, five out of six fitted the model. PERFG is the only first-order factor that loaded poorly onto the second-order factor. The result suggests that PERFG has very little coherence with the second-order factor. This means that performance goal appears to have little to do with motivation.

For the overall fit of the model, goodness-of-fit statistics were examined. The summary and discussion of these fit indexes appears later in the chapter.

South Australian University Physics Students Sample

A second-order factor model was fitted into the university data. The loadings of the 35 items onto the first order factor and the loadings of the first-order factor onto the second-order factor are shown in Table 5.11. Similar to the six-correlated factors model fitted to this set of data, however, a strong caution was taken in the interpretation of the data because of the issue of sample size. This was confirmed by a warning message prompted by the LISREL program during the CFA run fitting the model to this set of data. The warning message reads "Total sample size is smaller than the number of parameters. Parameter estimates are unreliable."

Therefore, the results presented here were not used for comparison with the results of fitting the second-order factor model fitted to the other data sets.

Table 5.10. Factor loadings of the second-order factor model fitted to the South Australian high school data.

Variable	*Loadings*						
	SLEFF	*ALS*	*SLVAL*	*PERFG*	*ACHVG*	*LERNV*	*MOTIVATN*
<u>SLEFF</u>							0.85
SLEFF20	0.62						
SLEFF21R	0.64						
SLEFF22	0.68						
SLEFF23R	0.80						
SLEFF24R	0.64						
SLEFF25R	0.61						
SLEFF26R	0.80						
<u>ALS</u>							0.99
ALS27		0.75					
ALS28		0.41					
ALS29		0.55					
ALS30		0.44					
ALS31		0.67					
ALS32		0.66					
ALS33		0.77					
ALS34		0.69					
<u>SLVAL</u>							0.76
SLVAL35			0.60				
SLVAL36			0.67				
SLVAL37			0.77				
SLVAL38			0.61				
SLVAL39			0.63				
<u>PERFG</u>							0.15
PERFG40R				0.33			
PERFG41R				0.63			
PERFG42R				0.94			
PERFG43R				0.82			
<u>ACHVG</u>							0.55
ACHVG44					0.52		
ACHVG45					0.85		
ACHVG46					0.89		
ACHVG47					0.42		
ACHVG48					0.35		
<u>LERNV</u>							0.57
LERNV49						0.72	
LERNV50						0.55	
LERNV51						0.21	
LERNV52						0.19	
LERNV53						0.75	
LERNV54						0.46	

n=248

Table 5.11. Factor loadings of the second-order factor model fitted to the South Australian university data.

Variable	*Loadings*						
	SLEFF	*ALS*	*SLVAL*	*PERFG*	*ACHVG*	*LERNV*	*MOTIVATN*
SLEFF							0.95
SLEFF20	0.95						
SLEFF21R	0.70						
SLEFF22	0.41						
SLEFF23R	0.52						
SLEFF24R	0.51						
SLEFF25R	0.71						
SLEFF26R	0.69						
ALS							0.87
ALS27		0.85					
ALS28		-0.06					
ALS29		0.41					
ALS30		0.04					
ALS31		0.57					
ALS32		0.46					
ALS33		0.71					
ALS34		0.64					
SLVAL							0.78
SLVAL35			0.24				
SLVAL36			0.60				
SLVAL37			0.65				
SLVAL38			0.47				
SLVAL39			0.78				
PERFG							-0.05
PERFG40R				0.60			
PERFG41R				0.92			
PERFG42R				0.72			
PERFG43R				0.58			
ACHVG							0.59
ACHVG44					0.62		
ACHVG45					0.16		
ACHVG46					0.48		
ACHVG47					0.51		
ACHVG48					0.70		
LERNV							0.45
LERNV49						0.55	
LERNV50						0.09	
LERNV51						0.09	
LERNV52						-0.41	
LERNV53						1.02	
LERNV54						0.13	

n=45

Combined Samples of South Australian High School and University Students

The South Australian high school and university data sets were combined following the same reasons presented above.

Table 5.12 shows the loadings of the items and factors resulting from a CFA run fitting a second-order factor model into a combined high school and university data. Six items were found to have loadings below 0.40 therefore not fitting the model. The non-fitting items include ALS28 (0.37), ALS30 (0.32), PERFG40R (0.35), ACHVG48 (0.39), LERNV51 (0.17) and LERNV52 (0.10). This is two more non-fitting items compared to the model fitted into the high school data. Only one first-order factor (PERFG) loaded poorly onto the second-order factor consistent with the model that was fitted into the high school data. Generally, item loadings are a little lower than the item loadings from the CFA run using the high school data. The results suggest that combining the two sets of data to increase the sample size and fitting a second-order factor model does not necessarily yield model improvement.

Fit Indexes of the Second-Order Factor Models (South Australian Sample)

The goodness-of-fit statistics shown in Table 5.13 indicate whether the second-order factor models fitted well into the different sets of data used. The fit indexes of the model fitted to the high school and the combined high school and university data sets show exactly the same figures. These figures suggest that the model does not fit well into the data. The model fitted to the university data cannot be used due for the reasons mentioned above. Compared to the fit indexes of the 6-correlated factors model, the second-order factor model shows values a little lower if not the same. Therefore, the model fit has not improved after using the second-order factor model. The model fit could be improved, as suggested by the CFA results, by correlating the residual (or error) terms. However, for reasons of uniformity and comparability across all models tested, this was not carried out. Item-level analysis using Rasch modeling was used instead. This will be discussed in the later sections of this chapter.

Table 5.12. Factor loadings of the second-order factor model fitted to the combined South Australian high school and university data sets.

Variable	*Loadings*						
	SLEFF	*ALS*	*SLVAL*	*PERFG*	*ACHVG*	*LERNV*	*MOTIVATN*
SLEFF							0.85
SLEFF20	0.67						
SLEFF21R	0.66						
SLEFF22	0.66						
SLEFF23R	0.77						
SLEFF24R	0.62						
SLEFF25R	0.63						
SLEFF26R	0.76						
ALS							0.96
ALS27		0.74					
ALS28		0.37					
ALS29		0.53					
ALS30		0.32					
ALS31		0.67					
ALS32		0.64					
ALS33		0.76					
ALS34		0.69					
SLVAL							0.78
SLVAL35			0.52				
SLVAL36			0.67				
SLVAL37			0.76				
SLVAL38			0.59				
SLVAL39			0.66				
PERFG							0.16
PERFG40R				0.35			
PERFG41R				0.64			
PERFG42R				0.93			
PERFG43R				0.81			
ACHVG							0.55
ACHVG44					0.51		
ACHVG45					0.78		
ACHVG46					0.85		
ACHVG47					0.41		
ACHVG48					0.39		
LERNV							0.58
LERNV49						0.74	
LERNV50						0.48	
LERNV51						0.17	
LERNV52						0.10	
LERNV53						0.73	
LERNV54						0.42	

n=293

Table 5.13. Goodness-of-fit index summary for the second-order factor model fitted to the South Australian data sets.

	High School data	University data*	Combined data
Chi-Square	2442.84	229.39	2597.18
df	554	554	554
GFI	0.66	0.75	0.66
AGFI	0.61	0.71	0.61
PGFI	0.58	0.66	0.58
RMR	0.12	0.19	0.12
RMSEA	0.11	0.00	0.11

**cannot be used for comparison*

The Filipino sample

The following sections present the results of fitting a second-order factor model into the Filipino data. CFA through SEM were carried out fitting the second-order factor model to the high school data, then into the university data, and finally into the combined sets of data.

Filipino High School Physics Students Sample

Table 5.14 shows the results of the CFA run fitting a second-order factor model to the high school data set. The loadings of the 35 items were examined and three were found to misfit the model. The items include PERFG40R (0.29), LERNV51 (0.37) and LERNV52 (0.27). These items are the same with the items that did not fit the 6-correlated factors model using the Filipino high school data. In addition, these three items consistently loaded poorly onto their latent factors in both the 6-correlated factors model and the second-order factor model fitted into the South Australian data. With regards to the first-order factors loading onto the second-order factor, five out of six fitted the model. Similar to the model that was fitted into the South Australian data, PERFG is the only first-order factor that loaded poorly (less than 0.40) onto the second-order factor. The result suggests that PERFG little reflects the second-order factor. More interesting is the negative sign of the loading of PERFG onto the second-order factor. This may suggest that the second-order factor actually defines the first-order factor meaning that motivation may have an effect on performance goal and not otherwise.

Table 5.14. Factor loadings of the second-order factor model fitted to the Filipino high school data.

Variable	*Loadings*						
	SLEFF	*ALS*	*SLVAL*	*PERFG*	*ACHVG*	*LERNV*	*MOTIVATN*
SLEFF							0.71
SLEFF20	0.47						
SLEFF21R	0.64						
SLEFF22	0.62						
SLEFF23R	0.74						
SLEFF24R	0.60						
SLEFF25R	0.63						
SLEFF26R	0.74						
ALS							0.84
ALS27		0.72					
ALS28		0.41					
ALS29		0.56					
ALS30		0.56					
ALS31		0.64					
ALS32		0.60					
ALS33		0.70					
ALS34		0.76					
SLVAL							0.91
SLVAL35			0.68				
SLVAL36			0.86				
SLVAL37			0.69				
SLVAL38			0.66				
SLVAL39			0.67				
PERFG							-0.17
PERFG40R				0.29			
PERFG41R				0.66			
PERFG42R				0.86			
PERFG43R				0.81			
ACHVG							0.72
ACHVG44					0.82		
ACHVG45					0.65		
ACHVG46					0.77		
ACHVG47					0.70		
ACHVG48					0.66		
LERNV							0.77
LERNV49						0.78	
LERNV50						0.68	
LERNV51						0.37	
LERNV52						0.27	
LERNV53						0.77	
LERNV54						0.66	

n=301

Filipino University Physics Students Sample

The Filipino university data was fitted into second-order factor model. The loadings of the 35 items onto the first order factor and the loadings of the first-order factor onto the second-order factor are shown in Table 5.15. Three items did not fit the model. These are: PERFG40R (0.29), LERNV51 (0.37) and LERNV52 (0.27). These are the same items that did not fit the second-order factor model using the high school data. Interestingly, no warnings about model identification were issued by LISREL when the CFA test was run. In addition, the loading values of these non-fitting items in both models are exactly the same. One first-order latent factor poorly loaded onto the second-order latent factor. This is the latent factor 'performance goal' (PERFG) which loaded onto the second-order factor MOTIVATN with a value of -0.17. The negative sign suggests that motivation may have an effect on performance goal instead of the other way around. However, with a numerical value that is significantly smaller than the accepted value of 0.40, it appears that PERFG has very little commonality with the latent factor MOTIVATN.

Combined Samples of Filipino High School and University Students

The Filipino high school and university data sets were combined following the same reasons presented above.

Table 5.16 shows the loadings of the items and factors resulting from a CFA run fitting the combined Filipino high school and university data into a second-order factor model. Three items were found to have loadings below 0.40 and, therefore, not fitting the model. The non-fitting items include PERFG40R (0.34), LERNV51 (0.36) and LERNV52 (0.29). The non-fitting items are consistent with the model fitted into the high school data. Only one first-order factor (PERFG) loaded poorly onto the second-order factor consistent with the model that was fitted into the high school data. Similar to the models fitted into the high school and university data, the resulting test shows that PERFG loaded onto the second-order latent factor MOTIVATN with a value that is both negative and below the acceptable value of 0.40.

Table 5.15. Factor loadings of the second-order factor model fitted to the Filipino university data.

Variable	*Loadings*						
	SLEFF	*ALS*	*SLVAL*	*PERFG*	*ACHVG*	*LERNV*	*MOTIVATN*
<u>SLEFF</u>							0.71
SLEFF20	0.47						
SLEFF21R	0.64						
SLEFF22	0.62						
SLEFF23R	0.74						
SLEFF24R	0.60						
SLEFF25R	0.63						
SLEFF26R	0.74						
<u>ALS</u>							0.84
ALS27		0.72					
ALS28		0.41					
ALS29		0.56					
ALS30		0.56					
ALS31		0.64					
ALS32		0.60					
ALS33		0.70					
ALS34		0.76					
<u>SLVAL</u>							0.91
SLVAL35			0.68				
SLVAL36			0.86				
SLVAL37			0.69				
SLVAL38			0.66				
SLVAL39			0.67				
<u>PERFG</u>							-0.17
PERFG40R				0.29			
PERFG41R				0.66			
PERFG42R				0.86			
PERFG43R				0.81			
<u>ACHVG</u>							0.72
ACHVG44					0.82		
ACHVG45					0.65		
ACHVG46					0.77		
ACHVG47					0.70		
ACHVG48					0.66		
<u>LERNV</u>							0.77
LERNV49						0.78	
LERNV50						0.68	
LERNV51						0.37	
LERNV52						0.27	
LERNV53						0.77	
LERNV54						0.66	

n=94

Table 5.16. Factor loadings of the second-order factor model fitted to the combined Filipino high school and university data sets.

Variable	*Loadings*						
	SLEFF	*ALS*	*SLVAL*	*PERFG*	*ACHVG*	*LERNV*	*MOTIVATN*
SLEFF							0.71
SLEFF20	0.50						
SLEFF21R	0.65						
SLEFF22	0.63						
SLEFF23R	0.75						
SLEFF24R	0.62						
SLEFF25R	0.63						
SLEFF26R	0.71						
ALS							0.82
ALS27		0.74					
ALS28		0.43					
ALS29		0.54					
ALS30		0.56					
ALS31		0.66					
ALS32		0.63					
ALS33		0.73					
ALS34		0.78					
SLVAL							0.90
SLVAL35			0.64				
SLVAL36			0.83				
SLVAL37			0.68				
SLVAL38			0.66				
SLVAL39			0.66				
PERFG							-0.17
PERFG40R				0.34			
PERFG41R				0.71			
PERFG42R				0.86			
PERFG43R				0.82			
ACHVG							0.67
ACHVG44					0.71		
ACHVG45					0.60		
ACHVG46					0.68		
ACHVG47					0.79		
ACHVG48					0.73		
LERNV							0.78
LERNV49						0.82	
LERNV50						0.66	
LERNV51						0.36	
LERNV52						0.29	
LERNV53						0.79	
LERNV54						0.65	

n=395

Fit Indexes of the Second-Order Factor Models (Filipino Sample)

To identify model fit to the different data sets from the Filipino sample, a set of goodness-of-fit indexes needed to be examined. A summary of the different fit indexes resulting from the different CFA runs of the second-order factor models is presented in Table 5.17. The second-order factor model fitted to the university data shows the best fit based on the RMSEA value (0.05) which is better than the 0.06 threshold suggested by Hu and Bentler (1999). However, considering the values of the GFI, AGFI, PGFI and RMR, it appears that the model fitted to the combined groups has the best fit although the RMSEA value do not really indicate such conclusion. This is an interesting result considering that it was expected that the model fitted into the combined groups would show a good RMSEA as well. However, it should also be considered that the scale could be affected by the difference in sample sizes as explained by Hill et al. (2007).

Table 5.17. Goodness-of-fit index summary for the second-order factor model fitted to the Filipino data sets.

	High School data	University data	Combined data
Chi-Square	2476.44	767.70	2742.89
df	554	554	554
GFI	0.71	0.71	0.73
AGFI	0.67	0.67	0.69
PGFI	0.62	0.62	0.64
RMR	0.10	0.10	0.09
RMSEA	0.10	0.05	0.10

Model fit was also tested and verified at the item-level by using Rasch modeling.

5.5. Rasch analysis

The series of confirmatory factor analyses (CFA) undertaken above examined statistically the hypothesised structures of the scale. CFA also allowed for the assessment of the overall model fit. Rasch analysis enables for a more detailed (item-level) examination of the structure and operation of the SMTL. Moreover, Rasch analysis is also used to test the fit of data to the Rasch model. In this study, Rasch analysis was used to test the unidimensionality of the items to measure a common latent variable. In the SMTL instrument, there were six scales tested.

The data collected in this study were fitted to the Rasch rating scale model using the ConQuest 2.0 statistical package software (Wu, Adams, Wilson & Haldane, 2007). The rating scale model was chosen for subsequent analyses because of the reasons cited in Chapter 3. All 35 items in the SMTL were included in the analysis.

Item analysis with the rating scale model

Drawing from Tuan et al.'s (2005) finding of the independence of the six scales in their SMTL instrument, it was no longer necessary to fit the data to the Rasch model with all the 35 items included. In other words, the multidimensionality of the SMTL instrument was tested. This was carried out by fitting the data to each of the six scales independently to confirm the multidimensionality of the SMTL instrument.

Testing involved the examination of each item's fit statistics and item threshold values. To assess each item's fit, the infit mean square (INFIT MNSQ) statistic was used as a basis for model fitting or non-fitting items. In this study, the range of values of this statistic was taken to be from 0.72 to 1.30 (Linacre, Wright, Gustafsson & Martin-Lof, 1994). There was a degree of leniency in the chosen range because of the low stakes nature of the survey instrument (where students do not really get anything out of the survey) used in this study. Items whose infit mean square values fall above 1.30 are considered misfitting and do not discriminate well while below 0.72 are overfitting and they provide redundant information. Items found to be misfitting were subsequently deleted. However, misfitting items based on the infit mean square values were not immediately removed. Items with infit mean square values outside the accepted range whose item deltas (indicator of the location of the response choices on a scale) exhibit order swapping were readily removed. For items having an infit mean square values outside the range but exhibit item deltas in order, item statements were examined carefully as to whether or not they measure what was needed in this study. If deemed not to measure what was required in the study, then they were removed.

The combined high school and university data (for both South Australia and the Philippines) were used in the Rasch analysis using the rating scale model. This is to minimise the effects of sample size on the resulting *t*-statistics (but not so much on the mean square statistics) (Smith, Rush, Fallowfield, Velikova & Sharpe, 2008) considering the small sizes of the university groups. Further, although this study based item fit on the infit statistics (or mean square statistics) in the Rasch analysis due to its robustness against fluctuations caused by sample size (Adams & Khoo, 1993), data for the high school and university samples were combined using the same argument advanced in the CFA to keep consistency in the analysis.

The different sets of data were fitted to the Rasch Model in the following order:

- Combined samples of South Australian high school and university physics students (The six scales were analysed independently and no items removed)
- Combined samples of Filipino high school and university physics students (The six scales were analysed independently and no items removed).

Misfitting items were removed one at a time after the conditions for removing/keeping an item presented above were satisfied. Tabulated results include item estimate, error and the unweighted fit statistics. The unweighted fit statistics include the infit mean square and the *t* value. The separation reliability index, chi-square test of parameter equality, degrees of freedom and significance level are also included.

Combined samples South Australian high school and university students

The set of data collected from the South Australian sample were fitted to the rating scale model for each of the six scales. The results are presented in Table 5.18.

With an infit mean square equal to 1.64, only item (ALS30) appear to misfit the model. However, examining carefully the other fit statistics reveal that this item should be kept in the scale.

Table 5.18. Table of response model parameter estimates of the Motivation Towards Learning Science/Physics scale for the South Australian sample (Scales analysed separately and no items removed).

Variables	*Estimates*	*Error*	*Unweighted Fit*		
			INFIT MNSQ	*CI*	*t*
Self-efficacy (SLEFF)					
SLEFF20	0.336	0.062	1.01	(0.84, 1.16)	0.2
SLEFF21R	0.841	0.060	1.05	(0.84, 1.16)	0.6
SLEFF22	0.328	0.062	0.90	(0.84, 1.16)	-1.2
SLEFF23R	-1.204	0.072	1.01	(0.84, 1.16)	0.2
SLEFF24R	0.112	0.064	1.29	(0.84, 1.16)	3.3
SLEFF25R	0.429	0.062	1.11	(0.84, 1.16)	1.4
SLEFF26R	-0.842*	0.156	0.89	(0.84, 1.16)	-1.3
Active Learning Strategy (ALS)					
ALS27	-1.128	0.072	0.77	(0.84, 1.16)	-3.0
ALS28	0.783	0.064	1.24	(0.84, 1.16)	2.7
ALS29	0.815	0.064	1.11	(0.84, 1.16)	1.3
ALS30	-0.170	0.069	1.64	(0.84, 1.16)	6.7
ALS31	0.369	0.066	0.80	(0.84, 1.16)	-2.6
ALS32	-0.442	0.070	0.95	(0.84, 1.16)	-0.5
ALS33	-0.259	0.069	0.75	(0.84, 1.16)	-3.3
ALS34	0.033*	0.179	0.95	(0.84, 1.16)	-0.7
Science Learning Value (SLVAL)					
SLVAL35	0.517	0.064	1.29	(0.84, 1.16)	3.3
SLVAL36	-0.136	0.066	1.10	(0.84, 1.16)	1.2
SLVAL37	-0.570	0.068	0.86	(0.84, 1.16)	-1.8
SLVAL38	0.419	0.064	0.85	(0.84, 1.16)	-1.9
SLVAL39	-0.230*	0.131	1.06	(0.84, 1.16)	0.8
Performance Goal (PERFG)					
PERFG40R	1.440	0.053	1.17	(0.84, 1.16)	2.0
PERFG41R	0.360	0.052	0.93	(0.84, 1.16)	-0.9
PERFG42R	-0.637	0.055	0.97	(0.84, 1.16)	-0.4
PERFG43R	-1.163*	0.093	0.92	(0.84, 1.16)	-1.0
Achievement Goal (ACHVG)					
ACHVG44	-0.807	0.062	1.26	(0.84, 1.16)	3.0
ACHVG45	-0.686	0.062	0.92	(0.84, 1.16)	-0.9
ACHVG46	-0.981	0.063	0.93	(0.84, 1.16)	-0.9
ACHVG47	1.085	0.057	0.94	(0.84, 1.16)	-0.7
ACHVG48	1.389*	0.122	1.04	(0.84, 1.16)	0.5
Learning Environment Stimulation (LERNV)					
LERNV49	-0.538	0.051	1.01	(0.84, 1.16)	0.2
LERNV50	0.043	0.050	0.89	(0.84, 1.16)	-1.4
LERNV51	0.270	0.049	1.00	(0.84, 1.16)	0.0
LERNV52	0.940	0.049	1.25	(0.84, 1.16)	2.9
LERNV53	-0.778	0.052	1.00	(0.84, 1.16)	0.0
LERNV54	0.063*	0.112	0.92	(0.84, 1.16)	-1.0

n = 306

The results of fitting the data to each scale confirm the multidimensional nature of the SMTL instrument which further establishes its authors' claims.

Table 5.20. Table of response model parameter estimates of the Motivation Towards Learning Science/Physics scale for the Filipino sample (Scales analysed separately and no items removed).

Variables	*Estimates*	*Error*	*Unweighted Fit*		
			INFIT MNSQ	*CI*	*t*
Self-efficacy (SLEFF)					
SLEFF20	0.228	0.051	1.01	(0.86, 1.14)	0.2
SLEFF21R	0.835	0.049	1.11	(0.86, 1.14)	1.5
SLEFF22	0.475	0.050	0.82	(0.86, 1.14)	-2.7
SLEFF23R	-1.102	0.058	0.90	(0.86, 1.14)	-1.4
SLEFF24R	0.345	0.051	1.32	(0.86, 1.14)	4.1
SLEFF25R	0.116	0.052	1.13	(0.86, 1.14)	1.8
SLEFF26R	-0.896*	0.127	0.91	(0.86, 1.14)	-1.3
Active Learning Strategy (ALS)					
ALS27	-0.773	0.062	0.85	(0.86, 1.14)	-2.3
ALS28	0.596	0.056	1.31	(0.86, 1.14)	4.1
ALS29	0.402	0.057	1.28	(0.86, 1.14)	3.7
ALS30	0.174	0.058	1.30	(0.86, 1.14)	3.9
ALS31	0.462	0.057	0.87	(0.86, 1.14)	-1.8
ALS32	-0.528	0.061	1.07	(0.86, 1.14)	1.0
ALS33	-0.358	0.061	0.86	(0.86, 1.14)	-2.0
ALS34	0.025*	0.156	0.80	(0.86, 1.14)	-3.0
Science Learning Value (SLVAL)					
SLVAL35	-0.220	0.063	1.22	(0.86, 1.14)	2.9
SLVAL36	0.137	0.061	0.81	(0.86, 1.14)	-2.9
SLVAL37	0.036	0.062	1.08	(0.86, 1.14)	1.1
SLVAL38	0.394	0.060	0.91	(0.86, 1.14)	-1.4
SLVAL39	-0.346*	0.123	0.99	(0.86, 1.14)	-0.1
Performance Goal (PERFG)					
PERFG40R	1.832	0.051	1.23	(0.86, 1.14)	3.1
PERFG41R	0.245	0.050	0.87	(0.86, 1.14)	-1.9
PERFG42R	-0.884	0.050	0.95	(0.86, 1.14)	-0.7
PERFG43R	-1.193*	0.087	1.01	(0.86, 1.14)	0.2
Achievement Goal (ACHVG)					
ACHVG44	-0.864	0.060	1.01	(0.86, 1.14)	0.2
ACHVG45	0.308	0.057	1.11	(0.86, 1.14)	1.6
ACHVG46	-0.838	0.060	1.03	(0.86, 1.14)	0.4
ACHVG47	0.646	0.056	0.88	(0.86, 1.14)	-1.7
ACHVG48	0.748*	0.117	0.95	(0.86, 1.14)	-0.7
Learning Environment Stimulation (LERNV)					
LERNV49	-0.396	0.051	0.88	(0.86, 1.14)	-1.7
LERNV50	-0.271	0.051	0.94	(0.86, 1.14)	-0.8
LERNV51	0.270	0.049	1.26	(0.86, 1.14)	3.4
LERNV52	1.161	0.048	1.07	(0.86, 1.14)	1.0
LERNV53	-0.564	0.051	1.01	(0.86, 1.14)	0.1
LERNV54	-0.200*	0.112	0.96	(0.86, 1.14)	-0.6

n = 403

Combined samples of Filipino high school and university students

Sample respondents consisting of 307 physics students from 11 high schools and 96 first year physics students from two universities in Quezon City, Philippines, compose this set of data.

As described above, the SMTL authors pointed out that the instrument is multidimensional consisting of five latent factors that reflect 'motivation to learn Science'. Therefore, the data from the Filipino sample were fitted to the rating scale model for each of the six SMTL scales. Results are presented in Table 5.20.

Two items (SLEFF24R and ALS28) appear to misfit the model. However, these items' infit mean square values are just outside the upper limit (1.30) of the range defined earlier in the chapter. Examination of the item deltas reveal that there is no swapping of the delta values which indicates that the response choices are in correct order on the scale. Furthermore, close examination of the item texts shows that they contribute to measure important aspects of 'self-efficacy' and 'active learning strategies' which are considered to affect 'motivation' (Tuan, et al., 2005). Thus, these items were not removed.

These results, similar to fitting the South Australian data sets to the rating scale model, provide evidence of the multidimensional characteristic of the SMTL.

Though all of the items in the SMTL were retained fitting the South Australian sample data and the Filipino sample data to the rating scale model, comparison between the two groups cannot be carried out because of the measurement variance exhibited by the instrument when used in two different groups. This measurement variance was demonstrated by the difference in the misfitting items when the rating scale model was fitted to two different groups.

5.6. Model for the study

After examining and comparing the results of the CFA and Rasch analysis tests, it was decided that the six-correlated factors model keeping all the items will be used in the subsequent analyses. The reasons for this decision has been that, undertaking analysis independently for each of the SMTL scale, the results of both the CFA and the Rasch analysis have demonstrated the multidimensionality of the SMTL as pointed out by its authors (Tuan, et al., 2005).

Although the model used is the same for both groups of samples (South Australians and Filipinos), the results provide a clear evidence of measurement variance between them. This is in part exhibited by misfitting items when the model was fitted to different data sets for two different groups of samples. Therefore, the results of analysing the South Australian sample and the Filipino sample cannot be compared.

5.7. Summary

Tuan et al's (2005) Students' Motivation Toward Science Learning (SMTL) was adapted for use as part of the SUPSQ instrument to measure physics students' attitudes towards choosing and studying Physics in high school and university levels. This part of the SUPSQ instrument aimed to measure students' motivation to learn physics. It was hypothesised that motivation could have an effect on students' attitudes towards physics. The SMTL scale consists of 35 items using five-point Likert-type response choices ranging from "strongly disagree" (1) to "strongly agree" (5). The middle point was labelled "no opinion" (3). The authors of the SMTL designed their instrument to measure six motivation factors including self-efficacy, active learning strategies, science learning value, performance goal, achievement goal and learning environment stimulation.

Data from the South Australian cohort were collected from sample of 261 Years 11 and 12 physics high school students and 45 first year university physics students in the Adelaide metropolitan area. From the Philippines, data were also collected from sample of 307 Fourth Year high school students and 96 First Year university physics in the Quezon City area. Data from the South Australian and Filipino samples were analysed separately. CFA (through SEM) using LISREL 8.80 software package was employed to examine the structure of the scale and Rasch analysis with ConQuest 2.0 (using the rating scale model) was used for item-level analysis to test the dimensionality of the items.

The CFA part of instrument validation involved fitting the measurement and alternative models into the South Australian and Filipino data. Based on Tuan et al.'s (2005) instrument design, 35 items loading onto 6 correlated motivation factors compose the measurement model. A second-order (or hierarchical) factor model was also tested as an alternative model to check for model fit improvement. However, the resulting second-order factor model fit using the South Australian university data was not used for comparison because it was considered unreliable due to small sample size relative to what was considered adequate for carrying out CFA. The rest of the results from fitting the second-order factor model into the other sets of data were acceptable for comparison with the results from fitting the SMTL authors' original (six-correlated factors) model. Fit indexes of both the six-correlated factors and the second-order factor models were examined for fit. Most of the fit indexes are the same for both models fitting into the South Australian data. For the models fitting into the Filipino data, their fit indexes show small differences with the six-correlated factors model showing better fit. No items were removed when CFA was carried out.

To test the unidimensionality of the items to measure a common factor in the SMTL instrument, the data was fitted to the rating scale model. There are six scales in the SMTL instrument. Using the unweighted fit statistics, items were examined for their fit into the model. Non-fitting items were examined and decision was made whether they should be removed or kept based on set criteria including the infit mean square values, item deltas and item statements.

The data sets were fitted to the rating scale model independently for each of the six scales to test the instrument's multidimensionality following what was advanced by its authors. Only one item appeared to misfit with the South Australian data and two with the Filipino data. These misfitting items were retained after closely examining them.

Considering the results of the different tests undertaken, the six-correlated factors model was considered to be fit for use in this study's subsequent analyses. All 35 items from the original SMTL instrument remained. Item distribution for each scale are as follows: self-efficacy (7 items); active learning strategy (8 items); science learning value (5 items); performance goal (4 items); achievement goal (5 items); and learning environment stimulation (6 items).

All scales and instruments used in this study were examined using the same steps and techniques. The next chapter discusses how the self-esteem scale was validated.

Chapter 6

Self-esteem Scale

6.1. Introduction

The Rosenberg self-esteem (RSE) (Rosenberg, 1965) scale was used to measure an individual's self-worth in this study. This scale was chosen because of its long history of use, simplicity of its language, its brevity and its one-dimensional factor structure (Schmitt & Allik, 2005). This scale was adapted as part of the Students' Uptake of Physics Study Questionnaire (SUPSQ) instrument used in this study to determine the factors that could affect high school and university physics students' attitudes towards studying physics. The RSE instrument enabled the measurement of the level of self-esteem of individual physics students who participated in this study.

This chapter provides a detailed discussion of the quantitative analyses carried out to validate this instrument used to measure students' general self-esteem. Thorough validation of the RSE scale was necessary in order to obtain results that could be meaningfully interpreted to address various research questions (RQ) advanced in Chapter 1. Research questions concerning student self-esteem include RQ2a, RQ3a, RQ3b, RQ3e, and RQ3h.

Broadly, the structure of the instrument was confirmed using the contemporary approaches (Curtis, 2004) including confirmatory factor analysis (CFA) and Rasch analysis approaches used in Chapters 4 and 5. This study used the terms 'latent factor' and 'latent variable' interchangeably to mean unobserved variable, trait or construct (Andrich, 2004).

This chapter is presented based on the steps followed to validate the RSE scale for this study. It begins with a section briefly describing the instrument and its items that represent the observed variables. This is followed by the description of how the structure of the instrument was investigated using structural equation modeling (SEM) which includes confirmatory factor analysis of the measurement model. The fit indexes of the measurement model were examined. This section is followed by an item-level analysis by the Item-response theory approach (IRT) through Rasch analysis. The chapter concludes with a summary.

6.2. The Rosenberg Self-esteem (RSE) Scale

The general self-esteem of Physics students who participated in this study was measured using the Rosenberg self-esteem (RSE) scale. It consists of 10 items (five positively-worded and five negatively-worded statements) measuring a global, one-dimensional (Hagborg, 1993) construct which is understood to be a person's overall evaluation of his or her worthiness as a human being (Rosenberg, 1979). Each item has four Likert-type choices: 'strongly agree', 'agree', 'disagree' and 'strongly disagree' coded as '1', '2', '3' and '4', respectively. An item not responded to was counted as 'missing item' and was coded '9'. In the SUPSQ instrument, items corresponding to the measurement of self-esteem were items 55 through 64. For the purposes of analyses these items were labelled with a prefix 'S_EST' which stands for the latent variable 'self-esteem'. Negatively-worded statements had to be reverse-scored to keep the scale's scoring consistency (see Rosenberg, 1965). Table 6.1 shows the summary of the items in this scale, their nature (e.g., positively-worded statement or negatively-worded statement), their item code to indicate reverse scoring, and item texts.

6.3. Previous analytic practices

The RSE has been used by a large number of researchers to measure an individual's global self-esteem. The scale has been analysed and validated employing classical and contemporary ways. Exploratory and confirmatory factor analyses have been used by numerous researchers to examine its structure unidimensionality or otherwise. In Schmitt and Allik's (2005) review of literature of the RSE, they described how some studies show the scale's transparent one-dimensional factor structure and how others have found underlying sub-factors within the scale. Gray-Little et al. (1997) also described similar findings in their review of existing literature about the RSE scale.

Table 6.1. Summary of items in the RSE scale used in the SUPSQ instrument.

Item Code	Nature of statement	Item Code to indicate reverse scoring	Item text
S_EST55	Positive	*None*	I feel that I am a person of worth, at least on an equal basis with others.
S_EST56	Positive	*None*	I feel that I have a number of good qualities.
S_EST57	Negative	S_EST57R	All in all, I am inclined to feel that I am a failure.
S_EST58	Negative	S_EST58R	I am able to do things as well as most other people.
S_EST59	Positive	*None*	I feel I don't have much to be proud of.
S_EST60	Negative	*None*	I take a positive attitude toward myself.
S_EST61	Negative	*None*	On the whole, I am satisfied with myself.
S_EST62	Positive	S_EST62R	I wish I could have more respect for myself.
S_EST63	Positive	S_EST63R	I certainly feel useless as times.
S_EST64	Positive	S_EST64R	At times I think I am no good at all.

The RSE has also been subjected to analyses using techniques of item response theory (IRT). Gray-Little et al. (1997) used IRT techniques to provide a more refined item analysis than what is possible with other psychometric procedures. They found that the 10 items of the RSE scale are not equally discriminating and are differentially related to self-esteem. However, according to Gray-Little et al., the items in the scale define a unidimensional trait and provide information across the self-esteem continuum. They also added that the "scale provides a highly reliable and internally consistent measure of global self-esteem" (p. 450).

Literature (such as Schmitt & Allik, 2005; Pullmann & Allik, 2000; Robins et al., 2001; Hagborg, 1993) suggest that the RSE scale has been subject to adequate classical analytic practices to validate its hypothesised structure. However, there has been no literature about employing Rasch analysis techniques in validating the RSE scale. Employing Rasch measurement model analyses techniques could add vital information about the structure of the scale (see Hagborg, 1993, as discussed in Chapter 3), and its reliability and validity (also discussed in Chapter 3). Hence, this study employed Rasch analysis using the rating scale model to examine each item in the RSE scale in addition to employing CFA to examine its overall structure.

6.4. Instrument structure analysis

The section of this study's data set concerned with students' overall or global self-esteem has been subjected to detailed structural analysis. This section describes and discusses results from using data from two main groups of samples: South Australian Physics students and Filipino Physics students. Each sample group consists of two subgroups: high school Physics students and university Physics students. The main methods used to examine the structure of the instrument used to measure self-esteem were CFA, and Rasch measurement modeling – the same techniques employed in the validation of the scales discussed in Chapters 4 and 5.

There is an abundance of literature (see, e.g., Robins et al., 2000; Whiteside-Mansell & Corwyn, 2003; Byrne, 1996 in Schmitt & Allik, 2005) about the RSE structure analyses undertaken by a large number of researchers. Therefore, in this study, EFA of the RSE scale structure was not carried out. CFA was utilised to confirm factor structures as advanced by different researchers who have used the RSE scale.

A single-factor structure was examined using CFA. Because a number of recent studies (Schmitt & Allik, 2005; Whiteside-Mansell & Corwyn, 2003; Robins et al., 2001) suggest that the RSE scale has a clear single-factor structure, alternative models tests were considered to be no longer necessary unless examination of the resulting fit statistics prompt otherwise. LISREL was used to carry out CFA while AMOS was used to draw the diagram that represents the structure of the scale. The following sections report on the results of the CFA tests carried out for each sample of students, school level-wise and country-wise.

Confirmatory factor analysis of the single factor model

The structure of the single factor model for the RSE scale is shown in Figure 6.1. All 10 items were loaded onto a common factor called 'self-esteem' shortened as 'S_EST' for analytic purposes. This model is also known as the 'measurement model' where each observed variable indicates its correlation with the latent variable (Phakiti, 2007). Although not clearly obvious in the diagram, all the positively-worded statement items were grouped and so were the negatively-worded ones. This was intentionally done to easily observe loading behaviour of the positively- and negatively-worded items as found by earlier researchers (see Hagborg, 1993).

The results presented in the following sections drew from this study's data sets collected from samples of South Australian high school and university Physics students, and from Filipino high school and university Physics students. Single-factor models were tested in the order of the following sample groups:

- South Australian high school Physics students
- South Australian university Physics students
- Combined South Australian high school and university Physics students
- Filipino high school Physics students
- Filipino university Physics students
- Combined Filipino high school and university Physics students.

Figure 6.1. Structure of the single factor model for the Rosenberg Self-Esteem Scale.

Results of the CFA runs are presented in table form showing the loading value (together with the standard error) of each observed variable onto the latent factor. Similar to the previous instrument validation chapters, an observed variable should have a minimum loading of 0.40 to indicate good fit to the model. Model fit indexes for each model are also presented for comparison to determine which data set best fits the single-factor model.

Model Fit Indexes

The different model fit indexes from a CFA run using LISREL are the same as the ones presented in Chapter 4 and 5: GFI, AGFI, PGFI, RMR and RMSEA. A model shows good fit when their minimum GFI, AGFI and PGFI value equals 0.90. RMSEA and RMR values should be below 0.05 to indicate good fit. See Table 4.2 in Chapter 4 for a summary of these indexes.

The South Australian sample

The following sections present results of the CFA tests for the single factor model fitted into the South Australian data. These sets of data are the same as the ones used in the previous two chapters. However, this time the section of the data concerning students' self-esteem was used. Three CFA tests were carried out separately using data sets from the South Australian high school students, university students, and a data set combining the high school and university data sets.

South Australian High School Physics Students Sample

The results of fitting the single factor model into the South Australian high school data set are shown in Table 6.2. The result clearly shows that all 10 items loaded onto the common factor reasonably well with only item showing modest fit (S_EST62R=0.52). This suggests that the 10 items reflect a single 'self-esteem' factor which confirms the findings of the earlier validations of the scale by some of the researchers mentioned earlier in the chapter. Overall, the result shows that the model reasonably fits the data well. The unidimensionality of the scale was further tested using Rasch analysis which provides a more refined item-level analysis which will be described later in the chapter.

Table 6.2. Factor loadings of the single factor model (South Australia high school and university and combined high school and university).

Variable	*Loadings (se)* † *S_EST (High School data)*	*Loadings (se)* †† *S_EST (University data)*	*Loadings (se)* ††† *S_EST (Combined data)*
S_EST55	0.71(0.06)	0.90(0.13)	0.75(0.05)
S_EST56	0.82(0.05)	0.99(0.12)	0.86(0.05)
S_EST58	0.74(0.05)	0.80(0.13)	0.75(0.05)
S_EST60	0.78(0.05)	0.81(0.13)	0.80(0.05)
S_EST61	0.75(0.05)	0.84(0.13)	0.77(0.05)
S_EST57R	0.73(0.05)	0.89(0.13)	0.75(0.05)
S_EST59R	0.80(0.05)	0.89(0.13)	0.81(0.05)
S_EST62R	0.52(0.06)	0.77(0.14)	0.57(0.05)
S_EST63R	0.67(0.06)	0.74(0.14)	0.67(0.05)
S_EST64R	0.75(0.05)	0.71(0.14)	0.74(0.05)
	†*n=261*	†† *n=45*	††† *n=306*

South Australian University Physics Students Sample

The results of the CFA test of fitting the single factor model into the South Australian university sample data are shown in Table 6.2. All items appear to load strongly on a common 'self-esteem' factor. However, a strong caution was taken in the interpretation of the results due to the issue of sample size which can be considered too small with only 45 respondents. According to Thompson (2000), the use of CFA is best suited for large sample sizes. However, different researchers suggest different minimum sample size requirements ranging from 100 (Ding, Velicer & Harlow, 1995) to around 400 (Boomsma, 1987).

Combined Samples of South Australian High School and University Students

The feasibility of combining the sets of high school and university data was considered by the author of this study for a number of reasons. The average age difference between the high school and university student samples is around one year. In addition, the first year university student samples were just into their second week of university classes when they filled out the survey questionnaire. It was therefore assumed that student samples from both groups (high school and university) were likely to hold similar attitudes and perceptions towards things – like school subjects, for instance. In addition, combining the two sets of data significantly increases the sample size which makes SEM more fit for use (Thompson, 2000 in Phakiti, 2007).

Combining the two sets of data and fitting the single factor model into it yields item loadings which are mostly slightly higher than those in the model fitted into the high school data (see Table 6.2). No item was identified to have factor loading of less than 0.40. The lowest item factor loading shows modest fit (S_EST62R=0.57). This item with modest loading is the same as that from the high school data. To make conclusions of the model's fit to the data; a number of fit indexes were also examined.

Fit Indexes of the Single-Factor Models (South Australian Sample)

Summarized above are the threshold values for the fit indexes presented in this chapter. Table 6.3 shows the summary of the three single factor models fitted into the South Australian data. It should be noted that the goodness-of-fit indexes presented for the set of data from the university Physics students' group cannot be used for comparison with the other two models due to reasons cited above.

There is not much that can be said about the models fitted into the high school data and the combined high school and university data except for the fact that almost the entire model fit indexes are exactly the same. Both models have RMSEA and RMR values that indicate poor fit. Both GFI and AGFI values are below 0.90 which is the accepted value to indicate good fit. Overall, these fit indexes suggest a poor-fitting model. Both have PGFI indicating that there is a significant amount of complexity within the model. This could be a reason why some researchers tried to explore possible bi-dimensionality or multidimensionality of the self-esteem construct based on the items used in the RSE. As suggested by a variety of modification indexes, the model could be improved by correlating the errors (Byrne, 2001). However, these modifications were not undertaken because of the limited grounding on theories guiding specification of error correlations. Instead, an examination of the items using a more refined approach was carried out using an item-response theory (IRT) technique. Details of this approach and the results can be found later in the chapter.

Table 6.3. Goodness of fit index summary for the single factor model (South Australian sample).

	High School data	University data	Combined data
Chi-Square	458.45	186.19	567.82
df	35	35	35
GFI	0.74	0.57	0.73
AGFI	0.59	0.33	0.58
PGFI	0.47	0.36	0.47
RMR	0.08	0.10	0.08
RMSEA	0.21	0.29	0.22

The Filipino sample

This section presents the results of fitting the single factor model into the data collected from high school and university Physics students in the Philippines. These sets of data are the same as the ones used in the previous two chapters. The section of each data set that concerns students' general self-esteem was subjected to the analysis. Three CFA tests fitting the single-factor model were carried out separately using data sets from Filipino high school students, university students, and a data set combining the high school and university data sets. The same set of fit indexes is reported.

Filipino High School Physics Students Sample

Results of the CFA fitting a single factor model into this set of data are shown in Table 6.4. One item (S_EST62R=0.22) did not fit the model. Factor loadings are generally modest compared to the factor loadings when the model was fitted into the South Australian high school data set.

Table 6.4. Factor loadings of the single factor model (Filipino high school and university and combined high school and university).

Variable	*Loadings (se)* † *S_EST (High School data)*	*Loadings (se)* †† *S_EST (University data)*	*Loadings (se)* ††† *S_EST (Combined data)*
S_EST55	0.45(0.06)	0.63(0.10)	0.49(0.05)
S_EST56	0.50(0.06)	0.65(0.09)	0.53(0.05)
S_EST58	0.46(0.06)	0.60(0.10)	0.50(0.05)
S_EST60	0.76(0.05)	0.83(0.09)	0.77(0.04)
S_EST61	0.56(0.06)	0.62(0.10)	0.57(0.05)
S_EST57R	0.72(0.05)	0.78(0.09)	0.74(0.04)
S_EST59R	0.78(0.05)	0.80(0.09)	0.78(0.04)
S_EST62R	0.22(0.06)	0.51(0.10)	0.29(0.05)
S_EST63R	0.68(0.05)	0.65(0.09)	0.66(0.05)
S_EST64R	0.64(0.05)	0.68(0.09)	0.65(0.05)
	†*n*=307	†† *n*=96	††† *n*=403

Filipino University Physics Students Sample

Results of the test fitting a single-factor model into the data set are shown in Table 6.4. Unlike the previous CFA runs using this set of data, no error warnings were shown which signify that the results can be used for comparison with the results using the other Filipino data sets. The sample size (*n*=96) is close enough to one of the minimum (of 100) suggested by Ding, Velicer and Harlow (1995). Interestingly, no item appeared to be misfitting. Moreover, item loadings appear to be a little higher than the item loadings in the model fitted into the high school data set.

Combined Samples of Filipino High School and University Physics Students

The average age difference between the fourth year high school student samples and the first year university student samples is approximately a year. In addition, the university students who participated in this study were just into their second month of attending university classes when they filled out the study questionnaire. Therefore, the Filipino high school and university data sets were combined for the same reason described above for the South Australian data – that there was an assumption that both groups of samples hold similar attitudes towards and perceptions of school subjects.

Fitting the single factor model into the combined high school and university data sets yields similar results from fitting the model into the high school data set (see Table 6.4). The item S_EST62R misfitted the model albeit the value is a little higher than its value in the model fitted in the high school data set. Most of the fitting items have higher loadings in this model compared to the model fitted to the high school data.

Fit Indexes of the Two Correlated Factors Models (Filipino Sample)

Overall, the fit indexes of the single factor model fitted to any of the sets of Filipino data show poor fit (see Table 6.5). This is indicated by the high values of RMSEA and RMR. Moreover, the values of the GFI, AGFI and PGFI are significantly below the accepted value to indicate good fit. A notable observation in the results of fitting the single factor model fitted to the different Filipino data sets can be found in the results of fitting the model to the university data where the highest factor loadings have been observed but have stood out as having the poorest fit based on their goodness-of-fit statistics. Alternative models were tested to determine whether model fit could be improved.

Table 6.5. Goodness of fit index summary for the Single-Factor model (Filipino sample).

	High School data	University data	Combined data
Chi-Square	468.05	311.05	585.82
df	35	35	35
GFI	0.78	0.66	0.78
AGFI	0.66	0.46	0.66
PGFI	0.50	0.42	0.50
RMR	0.11	0.13	0.10
RMSEA	0.19	0.25	0.19

Alternative model

As described in the above literature about the RSE, some researchers have found sub-factors within the scale. Based on the fit statistics results, it is feasible that the RSE items define different latent constructs that highly correlate to measure self-esteem.

Therefore, a two factor correlated model was tested with an anticipated significant fit statistics improvement. However, results using the combined high school and university data sets show otherwise. The RMSEA (0.18) and the RMR (0.094) still indicate that the model has poor fit. This is further supported by the lower-than-0.90 values of the GFI (0.80), the AGFI (0.68) and the PGFI (0.50). Item S_EST62R still loaded poorly in the model.

Items in the RSE were subjected to item-level analysis using the Rasch model to determine their unidimensionality in measuring a common latent construct as indicated in the structure of the single-factor model used in the confirmatory factor analyses described above.

6.5. Rasch analysis

Rasch analysis enables for a more detailed, item-level examination of the structure and operation of the self-esteem scale.

The data collected in this study concerning physics students' self-esteem were fitted to the rating scale model. All 10 items in the scale were included in the initial analysis.

Item analysis with the Rating Scale Model

The 10 items in the RSE scale were subjected to item analyses fitting the South Australian and Filipino data sets to the rating scale model. This involved examining each item's fit statistics and item threshold values. More specifically, the infit mean square (INFIT MNSQ) statistic was used as a basis for the model fitting or non-fitting items. Similar to the validation of instruments discussed in the previous chapters, a range of 0.72 to 1.30 was used for the infit mean square to indicate good fitting items.

The combined high school and university data sets for self-esteem (for both South Australia and the Philippines) were used in the Rasch analysis fitting the rating scale model. Although the infit statistics is robust enough to be affected by sample size, the data sets were combined for the same reasons advanced above, and to keep consistency in data handling.

The analyses were carried out and results are presented in the following order:

- Combined samples of South Australian high school and university Physics students (all 10 items in the scale included)
- Combined samples of Filipino high school and university Physics students (all 10 items in the scale included)

As part of the model refinement process, removal of a misfitting item based on its infit mean square statistic was considered. However, care was taken in removing items. Items with infit mean square values outside the accepted range whose item deltas (indicator of the location of the response choices on a scale) exhibit order swapping were readily removed. When items have an infit mean square values outside the range but exhibit item deltas in order, item statements were examined carefully as to whether or not they measure what was needed in this study. If deemed not to measure what was required in the study, then they were removed.

Tabulated results include item estimate, error and the unweighted fit statistics. The unweighted fit statistics include the infit mean square and the *t* value. The separation reliability index, chi-square test of parameter equality, degrees of freedom and significance level are also included. The separation reliability index indicates the proportion of the observed variance that is considered true (Adams and Khoo, 1993). High separation reliability index is preferred because this means that measurement error is smaller.

Combined samples of South Australian high school and university physics students

The rating scale model was fitted into this set of data where all the 10 items of the RSE scale were included in the analysis. The results of the initial run are shown in Table 6.6. Item S_EST62R has an infit mean square value that is outside the defined acceptable range. The item delta values which indicate the location of the item choices on a scale was also examined for their numerical order. There was no order swapping detected. This raised some doubts about removing the item. However, after closely examining the item statement (which is about self respect), the author had decided that the item really would not make significant contribution to what was measured in this study. Therefore, this item was removed.

Table 6.6. Table of response model parameter estimates of the RSE scale for the South Australian sample (no items removed).

Variables	*Estimates*	*Error*	**Unweighted Fit**		
			INFIT MNSQ	*CI*	*t*
S_EST55	0.726	0.073	0.97	(0.84, 1.16)	-0.3
S_EST56	0.387	0.072	0.83	(0.84, 1.16)	-2.2
S_EST58	0.318	0.072	1.06	(0.84, 1.16)	0.7
S_EST60	0.055	0.071	0.84	(0.84, 1.16)	-2.0
S_EST61	-0.306	0.070	0.93	(0.84, 1.16)	-0.8
S_EST57R	0.484	0.072	1.06	(0.84, 1.16)	0.8
S_EST59R	0.067	0.071	0.97	(0.84, 1.16)	-0.3
S_EST62R	-0.684	0.070	1.35	(0.84, 1.16)	3.7
S_EST63R	-0.746	0.070	1.12	(0.84, 1.16)	1.4
S_EST64R	-0.302*	0.213	1.08	(0.84, 1.16)	0.9

Separation Reliability = 0.981
Chi-square test of parameter equality = 422.79
df = 9
Significance Level = 0.000

The item analysis was re-run and the infit statistics were examined. The results of the re-run are shown in Table 6.7. All of the remaining items have infit mean square values within the accepted range indicating that they fit the model. The high separation reliability index in the initial run shows a big proportion of the observed variance is considered true, thus giving small error values for the items. After the final run, the separation reliability index dropped a little. However, this drop in value cannot be counted as significant considering that it is still very well close to unity.

The rating scale model was fitted into the Filipino data sets and results were examined. Details of the analyses follow.

Table 6.7. Table of response model parameter estimates of the RSE scale for the South Australian sample (one item removed).

Variables	*Estimates*	*Error*	***Unweighted Fit***		
			INFIT MNSQ	*CI*	*t*
S_EST55	0.711	0.074	0.94	(0.84, 1.16)	-0.7
S_EST56	0.030	0.071	0.90	(0.84, 1.16)	-1.2
S_EST58	0.410	0.073	1.07	(0.84, 1.16)	0.8
S_EST60	-0.040	0.071	0.82	(0.84, 1.16)	-2.4
S_EST61	-0.431	0.070	0.90	(0.84, 1.16)	-1.2
S_EST57R	0.551	0.073	1.20	(0.84, 1.16)	2.4
S_EST59R	-0.154	0.074	0.88	(0.84, 1.17)	-1.4
S_EST63R	-0.746	0.072	1.12	(0.84, 1.17)	1.3
S_EST64R	-0.330*	0.204	1.06	(0.84, 1.17)	0.7

Separation Reliability = 0.979
Chi-square test of parameter equality = 331.18
df = 8
Significance Level = 0.000

Combined samples of Filipino high school and university physics students

All 10 items in the RSE scale were subjected to the analysis using the rating scale model. The results are shown in Table 6.8. Nine items appear to fit the model because their infit mean square statistics are within the acceptable range of 0.72 to 1.30, and only one item fell out of this range. Item S_EST62R's infit mean square value (1.48) is above 1.30 which indicates that it is not fitting and not discriminating well. This item behaved similarly when the model was fitted to the South Australian data. It was therefore removed. Overall, the model including the non-fitting item yielded a separation reliability that is quite high which means that a significant proportion of the observed variance is considered to be true.

The analysis was re-run after removing item S_EST62R. The results are shown in Table 6.9. This time the remaining 9 items showed, through their infit mean square statistics, good fit. There is a slight drop in the separation reliability index but it is not considered significant. It is noteworthy that the item that was removed behaved the same in both of the Rasch analyses undertaken. This extends to the CFA run that used the Filipino high school, and combined high school and university data where item S_EST62R did not fit both single-factor and two-correlated factors models.

Table 6.8. Table of response model parameter estimates of the RSE scale for the Filipino sample (no items removed).

Variables	*Estimates*	*Error*	*Unweighted Fit*		
			INFIT MNSQ	*CI*	*t*
S_EST55	0.683	0.058	0.86	(0.86, 1.14)	-2.1
S_EST56	0.512	0.057	0.87	(0.86, 1.14)	-1.8
S_EST58	0.352	0.057	0.77	(0.86, 1.14)	-3.5
S_EST60	0.619	0.058	0.75	(0.86, 1.14)	-3.8
S_EST61	0.269	0.057	1.30	(0.86, 1.14)	3.9
S_EST57R	0.490	0.057	0.80	(0.86, 1.14)	-3.0
S_EST59R	-0.040	0.056	0.87	(0.86, 1.14)	-1.9
S_EST62R	-1.445	0.055	1.48	(0.86, 1.14)	5.9
S_EST63R	-0.910	0.055	1.10	(0.86, 1.14)	1.4
S_EST64R	-0.531*	0.171	1.23	(0.86, 1.14)	3.0

Separation Reliability = 0.994
Chi-square test of parameter equality = 1428.11
df = 9
Significance Level = 0.000

Table 6.9. Table of response model parameter estimates of the RSE scale for the Filipino sample (one item removed).

Variables	*Estimates*	*Error*	*Unweighted Fit*		
			INFIT MNSQ	*CI*	*t*
S_EST55	0.560	0.060	0.93	(0.86, 1.14)	-0.9
S_EST56	0.376	0.059	0.94	(0.86, 1.14)	-0.8
S_EST58	0.204	0.059	0.80	(0.86, 1.14)	-3.0
S_EST60	0.491	0.060	0.76	(0.86, 1.14)	-3.6
S_EST61	0.115	0.059	1.30	(0.86, 1.14)	4.6
S_EST57R	0.353	0.059	0.84	(0.86, 1.14)	-2.4
S_EST59R	-0.216	0.058	0.90	(0.86, 1.14)	-1.4
S_EST63R	-1.143	0.057	1.13	(0.86, 1.14)	1.8
S_EST64R	-0.741*	0.167	1.29	(0.86, 1.14)	4.1

Separation Reliability = 0.989
Chi-square test of parameter equality = 662.45
df = 8
Significance Level = 0.000

6.6. Model for the study

The results of both the CFA and the Rasch analysis suggest that a single factor model with nine items best fits the South Australian and Filipino data sets. Interestingly, the item removed from the scale (S_EST62R) was the same for both data sets. However, this was somewhat expected due to the fact that the RSE has already been used for decades and has been adapted for use in different countries which may also suggest its 'consistent' behaviour.

6.7. Summary

The Rosenberg Self-esteem (RSE) scale developed by Rosenberg (1965) was adapted for use as part of the SUPSQ instrument to measure Physics students' general self-esteem. This scale consists of 10 items using 4-point response choices ranging from "strongly agree" (1) to "strongly disagree" (4).

As with the preceding two chapters, the same sets of data collected from South Australian and Philippine high school and university Physics students were used. A section of the data sets that concern students' general self-esteem was analysed through CFA employing LISREL 8.80 software package to examine the structure of the scale. Rasch Modeling with ConQuest 2.0 (using the rating scale model) was used for item-level analysis to test for the coherence of the instrument items to measure a common latent factor – self-esteem.

The CFA part of instrument validation involved fitting the measurement and alternative models into the South Australian and Filipino data. The measurement model consisted of 10 items loading onto a common factor called 'self-esteem'. The model fitted in the South Australian data showed all items fitting well based on their factor loadings. The model fitted in the Filipino data showed 9 items fitting well and only one misfitting item – S_EST62R. However, the single-factor models fitted in both the South Australian and Filipino data showed poor fit based on their respective goodness-of-fit statistics. An alternative model was tested – the 2-correlated factors model. This model was fitted in the Filipino data to determine whether or not it will improve the goodness-of-fit statistics. The resulting statistics still showed poor fit with only a very slight improvement in their values. In addition, the item that failed to fit in the single-factor model still did not fit in the two-correlated factors model. No items were removed when CFA was carried out. Items were removed when item-level analyses were carried out using Rasch modeling with the rating scale model.

To test the unidimensionality of the items to measure a common factor in the RSE instrument, the the data was fitted to the rating scale model. Using the unweighted fit statistics, items were examined for their fit in the model. An item whose infit mean square statistic did not fall within the accepted range of 0.72 and 1.30 was removed. Only one item was removed when the rating scale model was fitted into both the South Australian and the Filipino data. The item removed was S_EST62R – the same item that did not fit when CFA analyses were carried out.

Considering the results from both the CFA and the Rasch analysis, the final model used for this study's subsequent analyses was the single factor (or measurement) model with nine items. This single factor model with nine items was used in the regression analysis, single level path analysis (Chapter 11) and in the hierarchical linear modeling in Chapter 12.

All scales and instruments used in this study were examined using the same steps and techniques. The next chapter discusses how the scale 'Attitudes towards Computers' was validated.

Chapter 7

Computer Attitude Scale

7.1. Introduction

One of the factors that were examined was students' attitudes towards computers and its influence on their attitudes towards physics. To the knowledge of this study's author, this may be the first time that this factor has been included in a research that has something to do with students' uptake of physics. The collection of literature reviewed in Chapter 2 mostly concerned the effects of students' use of computers on their achievement. A couple of literature reviewed (Anslow, 1999; Sillitto & MacKinnon, 2000), however, emphasised, information technology-based approach may motivate physics students to learn and may therefore change their perception of learning and understanding the concepts in physics as 'dull', 'difficult', and 'boring.' Therefore, it was hypothesized in this study that students who are into computers have positive attitudes towards physics. However, this may not be necessarily true especially in countries such as the Philippines where physics is a compulsory subject.

To measure students' attitudes towards computers, Jones and Clarke's (1994) Computer Attitude Scale for Secondary Students (CASS) was used. Among the number of instruments available that measure students' attitudes towards computers, their instrument was chosen because it has more items that covered more computer-related behaviours and attitudes. In addition, it also used a bigger number of samples for its validation adding to its suitability for use in this study. A few researchers including Valois, Frenette, Villeneuve, Sabourin and Bordeleau (2000), Bromfield, Clarke and Lynch (2001), and more recently, Graff, Davies and McNorton (2009) have adapted the CASS in their respective studies.

A research question (RQ) advanced in Chapter 1 concerning attitudes towards computers is RQ3f which explores the impact of using computers to attitudes towards physics. Even when there was only one research question pertaining to the effects of computer attitudes towards attitudes to physics, the proper validation of the instrument used was of prime importance.

This chapter provides a detailed discussion of the technique and analysis carried out to validate this instrument used to measure students' attitudes towards computers. Broadly, the structure of the instrument was confirmed using contemporary approaches which included confirmatory factor analysis (CFA) and Rasch measurement modeling used in the previous instrument validation chapters. As with the previous validation chapters, the terms 'latent factor' and 'latent variable' are used interchangeable to mean unobserved variable, trait or construct.

This chapter begins with a section briefly describing the instrument and its items that represent the observed variables. This is then followed by the description of how the structure of the instrument was investigated using structural equation modeling (SEM) which employed confirmatory factor analysis of the measurement model and alternative models. The fit indexes of the measurement model and alternative models were examined and compared to determine which data fitted the model best. This section is followed by an item-level analysis by the Item-response theory approach (IRT) through Rasch analysis. The chapter concludes with a summary.

7.2. The Computer Attitude Scale for Secondary Students (CASS)

Jones and Clarke's (1994) CASS consists a total of 40 items. According to Jones and Clarke, they formulated the scale within the framework that uses the tripartite model of attitudes which consist of affect, behaviour and cognition. The CASS instrument's 40 items therefore is divided into three groups; 15 items assessing the affective component, 15 for the cognitive component, and 10 assessing the behavioural component. Each item has 5-Point Likert-type response choices: 'strongly disagree', 'disagree', 'neutral', 'agree' and 'strongly agree'. These choices were coded '1', '2', '3', '4' and '5', respectively. However, not all 40 items were included in the SUPSQ instrument. Eight items that were considered redundant and not relevant to the needs of this study were removed following a face validity examination by the researcher and two other experts. In the SUPSQ questionnaire, these items were numbers 152 through 183 – a total of 32 items consisting of 20 positively worded items and 12 negatively-worded (see Jones & Clark, 1994). For the purposes of data analysis, items were designated prefixes to represent the factor they measure: AFFC for items measuring the affective component, BEHV for items measuring the behavioural component, and COGN for items corresponding to the cognitive component. Negative statements had to be reverse-scored to keep the scale's scoring consistency (Jones & Clark, 1994).

Table 7.1. Summary of items in the CASS questionnaire used in the SUPSQ instrument.

Item Code	Nature of statement	Item Code to indicate reverse scoring	Item text
AFFC152	Negative	AFFC152R	Computers intimidate and threaten me.
COGN153	Positive	*None*	All computer people talk in a strange and technical language.
BEHV154	Positive	*None*	I learn new computer task by trial and error.
AFFC155	Negative	AFFC155R	Working with a computer makes me feel tense and uncomfortable.
COGN156	Positive	*None*	Computers are difficult to understand.
BEHV157	Positive	*None*	Other students look to me for help when using the computer.
AFFC158	Negative	AFFC158R	I feel hopeless when asked to perform a new task on a computer.
BEHV159	Positive	*None*	When I have a problem with the computer, I will usually solve it on my own.
AFFC160	Positive	*None*	I feel important when others ask me for information about computers.
COGN161	Positive	*None*	Learning about computers is a waste of time.
BEHV162	Positive	*None*	Using the computer has increased my interaction with other students.
AFFC163	Negative	AFFC163R	Computers bore me.
COGN164	Positive	*None*	Anything that a computer can be used for, I can do just as well in another way.
BEHV165	Positive	*None*	I develop shortcuts, and more efficient ways to use computers.
AFFC166	Negative	AFFC166R	Working with computers makes me feel isolated from other people.
COGN167	Positive	*None*	Working with computers will not be important to me in my career.
BEHV168	Positive	*None*	I would like to spend more time using a computer.
AFFC169	Negative	AFFC169R	I do not feel I have control over what I do when I use a computer.

COGN170	Positive	*None*	People that use computers are seen as being more important than those who don't.
BEHV171	Positive	*None*	If I can I will take subjects that will teach me to use computers.
AFFC172	Negative	AFFC172R	Computers sometimes scare me.
BEHV173	Positive	*None*	I would like to learn more about computers.
AFFC174	Negative	AFFC174R	I feel unhappy walking into a room filled with computers.
BEHV175	Positive	*None*	If I need computer skills for my career choice, I will develop them.
AFFC176	Negative	AFFC176R	I am no good with computers.
COGN177	Positive	*None*	To use computers you have to be highly qualified.
BEHV178	Positive	*None*	If my school offered a computer camp I would like to attend it.
COGN179	Positive	*None*	Using computers prevents me from being creative.
COGN180	Positive	*None*	Computers are confusing.
COGN181	Positive	*None*	You have to be a "brain" to work with computers.
AFFC182	Negative	AFFC182R	I get a sinking feeling when I think of trying to use a computer.
AFFC183	Negative	AFFC183R	Computers frustrate me.

Table 7.1 shows the summary of the items in the instrument adapted for use in this study, their nature (e.g., positive statement or negative statement), their recoded equivalent, and item texts.

7.3. Previous analytic practices

In this study, the basis for the discussion of previous analytic practices comes from the articles published by the authors of the instrument, Jones and Clarke (1994), and the few others who have used it such as Valois, Frenette, Villeneuve, Sabourin and Bordeleau (2000).

Jones and Clarke (1994) administered a survey using this initially developed CASS instrument to 231 Year 10 students. A database of responses was created and subjected to factor analysis to reduce the number of items and to test the three components of the scale. Using the reliability program in SPSS, they identified items in each component with the lowest consistency with the remaining items. They carried out this procedure until they arrived at the current CASS instrument. Jones and Clarke tested three aspects of the CASS instrument: the internal consistency, test-retest reliability and the criterion validity.

The internal consistency of the CASS instrument was based on the Cronbach's Alpha value. Based on a sample of 231 high school students, Jones and Clarke calculated the Cronbach's Alpha for the following components of the instrument: affective = 0.95, cognitive = 0.88, behavioural = 0.71 and the total scale = 0.95. They have also reported component correlations using two-tailed tests ranging from 0.59 to 0.90, and components correlated with the scale from 0.74 to 0.97 with all correlations significant at $P<0.01$.

After administering the scale twice to a sample of 163 students over a two-week interval, Jones and Clarke reported a Pearson correlation coefficient as high as 0.84 indicating that the CASS instrument has adequate test-retest reliability. Bromfield, Clarke and Lynch (2001) reported a similar figure in their study. Moreover, testing their instrument's criterion validity, they reported a value of t (1.74 at $P<0.05$) to indicate that CASS successfully distinguished between groups with low and medium levels of computer related experience.

However, Valois et al. (2000) pointed out that Jones and Clarke did not use exploratory or confirmatory factor analyses to test the three-factor structure of the CASS instrument. Furthermore, Valois and his colleagues have revealed that, including Jones and Clarke, psychosocial researchers have mostly used classical test theory (CTT) approach to establish test and item functioning. Considering the shortcomings of CTT, they saw this as an insufficient way of enabling them to make clear predictions about how an individual or group of examinees will perform on a given item.

Valois et al. (2000) used a nonparametric approach using a software called TESTGRAF developed by Ramsey (in Valois et al., 2000) to test both test and item functioning. In addition, they tested alternative *a priori* models of the CASS: first-order single-factor model, first-order uncorrelated three-factor model, and the second-order factor structure (or hierarchical model). They made the first-order three-factor correlated model as the measurement model (based on how Jones and Clarke validated their instrument). Their tests have shown that the three-factor correlated and the hierarchical models fit their data successfully (see Valois et al., 2000). However, Valois et al. have acknowledged some limitations of their validation of the CASS instrument considering different populations coming from different age, location (country), and ethnic groups. Rowe (2005) pointed out that the structural and measurement properties of a scale have to be ascertained before any inferential decision can be made. Similar tests were therefore carried out in this study to validate the CASS instrument which was included in the SUPSQ questionnaire. The following sections present how the structure of the CASS instrument was validated using the data from South Australian and Filipino high school and university Physics students.

7.4. Instrument structure analysis

The section of this study's data set concerned with students' attitudes towards computers has been subjected to detailed structural analysis. This section describes and discusses results from using data from two main groups of samples: South Australian physics students and Filipino physics students. Each sample consists of two subgroups: high school physics students and university physics students. The main methods used to examine the structure of the instrument used to measure students' attitudes towards computers were CFA using SEM, and Rasch measurement modeling – the same techniques employed in the validation of the scales discussed in Chapters 4, 5 and 6.

As described above, some researchers have already subjected the CASS instrument to exploratory factor analyses; therefore, factor analysis using EFA was not carried out with this scale. In addition, researchers such as Ian Robertson, Calder, Fung, Jones and O'Shea (1995) have confirmed that this instrument has already been tested for reliability and validity.

CFA was carried out testing a number of models based on what was reviewed in the literature. LISREL was used to fit these models into the sets of data, and AMOS to draw the figures representing each model. Each model was fitted into different sets of data representing different groups:

- South Australian high school physics students
- South Australian university physics students
- Combined South Australian high school and university physics students

- Filipino high school physics students
- Filipino university physics students
- Combined Filipino high school and university physics students

Results of the CFA runs are presented in tabulated form showing the loading value (together with the standard error and residual) of each observed variable onto its latent factor. A minimum observed variable loading value of 0.40 was used to indicate good model fit. Model fit indexes for each model are also presented for comparison to determine which three-factor model fits best which cohort of physics students.

Model Fit Indexes

The different model fit indexes from a CFA run using LISREL are the same as the ones presented in Chapter 4 and 5: GFI, AGFI, PGFI, RMR and RMSEA. A model shows good fit when their minimum GFI, AGFI and PGFI value equals 0.90. RMSEA and RMR values should be below 0.05 to indicate good fit. A summary of these fit indexes are presented in Table 4.2 in Chapter 4.

Confirmatory factor analysis of the Measurement Model

Following Jones and Clarke's (1994) validation of the CASS instrument where the latent variables were correlated, the measurement model used in the CFA was the first-order three-correlated factors model. The structure of this model is shown in Figure 7.1. The single factor (or measurement) and the three-uncorrelated factors models were no longer considered since these have been found in some research (such as Valois et al.'s) to not fit a set of data.

The three correlated factors model was fitted to the different sets of data described above. Following are sections that show the results of fitting the model into the data.

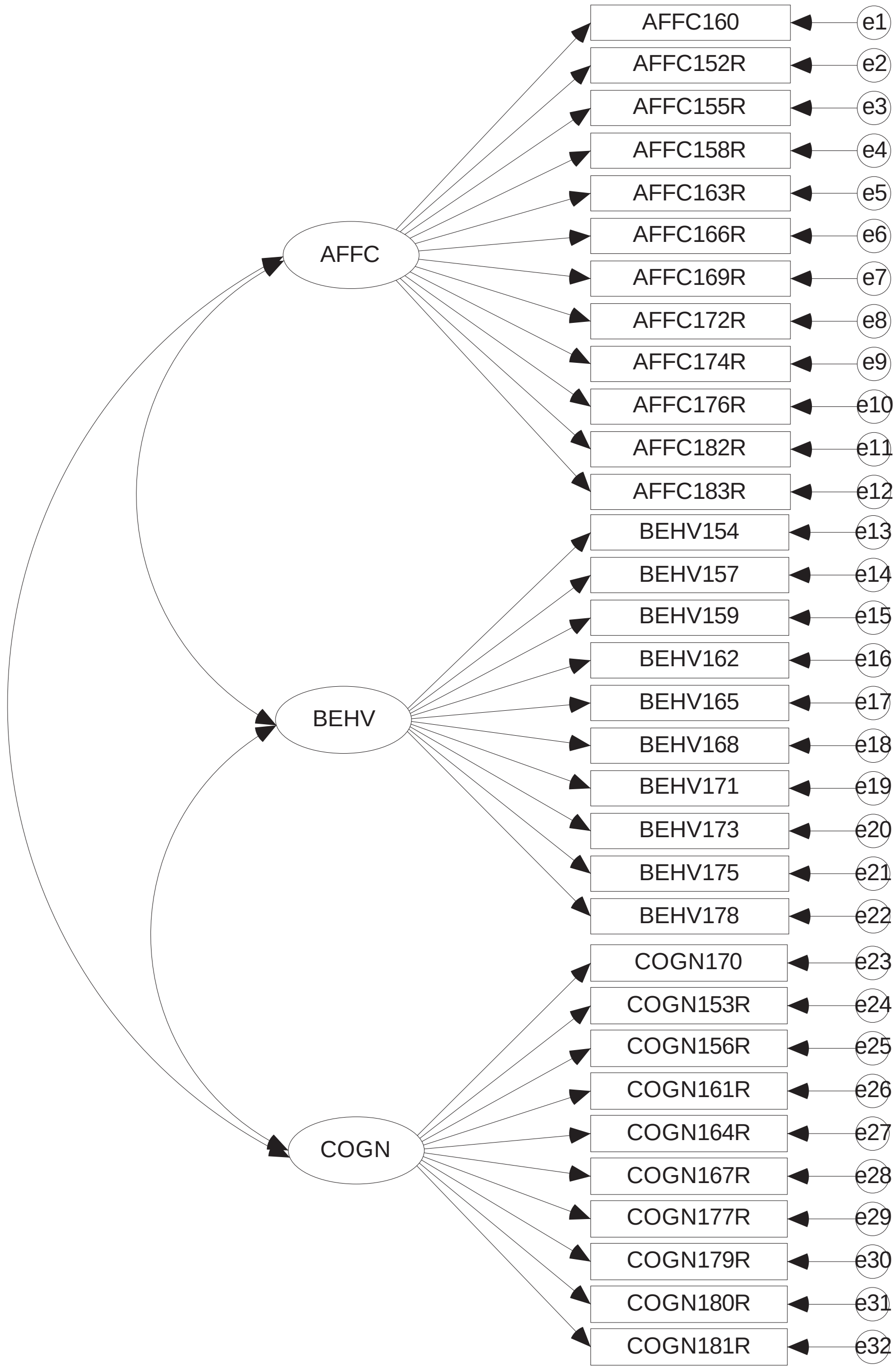


Figure 7.1. Structure of the measurement model for the Computer Attitudes Scale for Secondary Students.

The South Australian sample

The following sections present results of the CFA tests of the first-order three-correlated factors model fitted into the South Australian data. These sets of data are the same as the ones used in the previous validation chapters. However, this time the section of the data concerning students' attitudes towards computers was used. Three CFA tests were carried out separately using data sets from the South Australian high school students, university students, and a data set combining the high school and university data sets.

South Australian High School Physics Students Sample

The results of the first CFA run fitting the South Australian high school data set into the three-correlated factors model revealed two items that had loadings that had an apparent effect on the rest of the items loading onto their respective latent factor. These items were AFFC160 (0.06) and COGN170 (0.36). Item AFFC160 has a very low loading which suggests that it is not reflective of one of the model's latent factors – AFFC. Item COGN170, although it has a much higher loading than item AFFC160, failed to load on the latent factor it is supposed to reflect. In addition, it affected the rest of the cognitive component (COGN) items loading them negatively onto their common latent factor. This item (COGN170) exhibited a 'masking effect' on the other COGN items. Therefore, removal of these items was necessary. CFA test was rerun after each removal of one of these two items. The results of the correlated three-factor model test using the South Australian high school data set are shown in Table 7.2.

After removing items AFFC160 and COGN170, the rest of the items loaded reasonably well onto their respective latent factors except for BEHV154 (0.38), BEHV162 (0.33), BEHV175 (0.39) and BEHV178 (0.26).

Table 7.2. Factor loadings of the three-correlated factors model (South Australia high school sample).

Variable	Loadings (se) † AFFC	BEHV	COGN
AFFC152R	0.72(0.06)		
AFFC155R	0.85(0.05)		
AFFC158R	0.68(0.06)		
AFFC163R	0.67(0.06)		
AFFC166R	0.57(0.06)		
AFFC169R	0.62(0.06)		
AFFC172R	0.79(0.05)		
AFFC174R	0.77(0.05)		
AFFC176R	0.82(0.05)		
AFFC182R	0.84(0.05)		
AFFC183R	0.64(0.06)		
BEHV154		0.38(0.07)	
BEHV157		0.50(0.07)	
BEHV159		0.65(0.07)	
BEHV162		0.33(0.07)	
BEHV165		0.63(0.07)	
BEHV168		0.41(0.07)	
BEHV171		0.40(0.07)	
BEHV173		0.45(0.07)	
BEHV175		0.39(0.07)	
BEHV178		0.26(0.07)	
COGN153R			0.45(0.06)
COGN156R			0.76(0.05)
COGN161R			0.60(0.06)
COGN164R			0.45(0.80)
COGN167R			0.43(0.06)
COGN177R			0.63(0.06)
COGN179R			0.64(0.06)
COGN180R			0.74(0.06)
COGN181R			0.64(0.06)

†*n=243*
Items AFFC160 and COGN170 removed

Table 7.3. Factor loadings of the three-correlated factors model (South Australia university sample).

Variable	*Loadings (se)* † *AFFC*	*BEHV*	*COGN*
AFFC152R	0.69(0.22)		
AFFC155R	0.77(0.21)		
AFFC158R	0.62(0.22)		
AFFC163R	0.30(0.23)		
AFFC166R	0.56(0.22)		
AFFC169R	0.70(0.22)		
AFFC172R	0.64(0.22)		
AFFC174R	0.55(0.22)		
AFFC176R	0.68(0.22)		
AFFC182R	0.77(0.21)		
AFFC183R	0.14(0.23)		
BEHV154		0.59(0.24)	
BEHV157		0.81(0.24)	
BEHV159		0.60(0.24)	
BEHV162		0.12(0.25)	
BEHV165		0.57(0.24)	
BEHV168		0.33(0.25)	
BEHV171		0.34(0.25)	
BEHV173		0.35(0.25)	
BEHV175		0.56(0.24)	
BEHV178		0.33(0.25)	
COGN153R			0.51(0.23)
COGN156R			0.88(0.22)
COGN161R			0.53(0.23)
COGN164R			0.17(0.24)
COGN167R			0.55(0.23)
COGN177R			0.57(0.23)
COGN179R			0.35(0.23)
COGN180R			0.78(0.22)
COGN181R			0.54(0.23)

†*n=45*
Items AFFC160 and COGN170 removed

South Australian University Physics Students Sample

A similar pattern was observed after fitting the model into this set of data – items AFFC160 and COGN170 failed to load above 0.40 onto their respective latent factor and the latter affected the way the rest of the cognitive component (COGN) items loaded onto their latent factor. These items were consequently removed following the same procedure mentioned above. The results of the CFA test of the first-order correlated three-factor model fitted to the South Australian University data after removing the two items are shown in Table 7.3. A number of items appear to load strongly on their respective latent factor but a significant number also failed to load with the minimum accepted value of 0.40. A strong caution was taken in the interpretation of the results which was due to the issue of sample size. The sample size is smaller than the number of parameters which renders the parameter estimates to be unreliable – a warning issued by LISREL as it performed CFA. Therefore, the results presented were not used for comparison purposes. This is consistent with Thompson's (2000) recommendation not to use CFA and SEM with small samples.

Combined South Australian High School and University Students Samples

The author of this study has combined the high school and university data sets for a number of reasons. The average age difference between the high school and university student samples is around one year. In addition, the first year university student samples were just into their second week of university classes when they filled out the survey questionnaire. It was therefore assumed that student samples from both groups (high school and university) were likely to hold similar attitudes and perceptions towards things – like school subjects, for instance. Although the results of the CFA using the university data are considered unreliable due to the small sample size, some of the misfitting items in the CFA results using the high school data consistently misfit when the model was fitted to the university data. This indicates some item invariance in model fitting. Therefore, it was feasible to combine the two data sets. Lastly, combining the two sets of data significantly increases the sample size which makes SEM more fit for use (Thompson, 2000 in Phakiti, 2007).

Results similar to those presented above were observed after fitting the model into the combined high school and university sets of data – item AFFC160 had a very low loading (way below 0.40) and COGN170 failed to load onto their respective latent factor. COGN170 also affected the way the rest of the COGN items loaded onto their latent factor. With COGN170 present, the loadings of the rest of the COGN are all negative. Item COGN170 clearly exhibited a 'masking effect' on the other items. Therefore, items AFFC160 and COGN170 were consequently removed following the same procedure mentioned above. The results of the CFA test of the first-order correlated three-factor model fitted to the South Australian University data after removing the two items are shown in Table 7.4. It can be seen that only the behavioural component (BEHV) of the model have items that failed to load with at least 0.40.

These are: BEHV162 (0.26), BEHV168 (0.31), BEHV171 (0.29), BEHV173 (0.36) and BEHV178 (0.13).

Table 7.4. Factor loadings of the three-correlated factors model (Combined South Australia high school and university samples).

Variable	*Loadings (se)* † *AFFC*	*BEHV*	*COGN*
AFFC152R	0.73(0.05)		
AFFC155R	0.85(0.05)		
AFFC158R	0.69(0.05)		
AFFC163R	0.62(0.05)		
AFFC166R	0.56(0.06)		
AFFC169R	0.62(0.05)		
AFFC172R	0.78(0.05)		
AFFC174R	0.75(0.05)		
AFFC176R	0.81(0.05)		
AFFC182R	0.84(0.05)		
AFFC183R	0.57(0.05)		
BEHV154		0.45(0.06)	
BEHV157		0.51(0.06)	
BEHV159		0.72(0.06)	
BEHV162		0.26(0.07)	
BEHV165		0.64(0.06)	
BEHV168		0.31(0.07)	
BEHV171		0.29(0.07)	
BEHV173		0.36(0.06)	
BEHV175		0.44(0.06)	
BEHV178		0.13(0.07)	
COGN153R			0.47(0.06)
COGN156R			0.77(0.05)
COGN161R			0.60(0.05)
COGN164R			0.44(0.06)
COGN167R			0.46(0.06)
COGN177R			0.63(0.05)
COGN179R			0.63(0.05)
COGN180R			0.74(0.05)
COGN181R			0.64(0.05)

†*n=288 ; p=0.000*
Items AFFC160 and COGN170 removed

There is one more item in the behavioural component in this model that did not load with at least 0.40 compared to the model fitted in the high school data. Items BEHV162 and BEHV178 poorly loaded (loading value of below 0.40) in both 3-factor models fitted in the high school and combined high school and university data. However, examining the item loadings was not sufficient to make conclusions of model fit. An evaluation of a model's fit involves an evaluation of the entire model measured by the goodness-of-fit indexes shown in Table 7.5.

Fit Indexes of the Single-Factor Models (South Australian Sample)

The threshold values for the fit indexes used to determine model fit in this study have been summarized above. Table 7.5 shows the summary of the three-correlated factors model fitted to the South Australian data. It should be noted that the goodness-of-fit indexes presented for the set of data from the university Physics students' group cannot be used for comparison with the other two models due to reasons cited above.

There is not much difference between the goodness-of-fit statistics of the three-correlated factors model fitted into the high school data and the one fitted into the combined high school and university data. The three-factor model fitted into the combined sets of data only shows a very slight increase in the values of GFI and AGFI and a slight drop in the RMR. PGFI and RMSEA remained the same for both models. However, all of the fit indexes for both models suggest poor fit. Modification indexes by correlating error terms were suggested to improve model fit but this was not considered because of the limited grounding on the theories guiding specification of errors. Fitting an alternative model into the data was considered to be more feasible. This is discussed later in the chapter.

Table 7.5. Goodness-of-fit index summary for the three-correlated factors model (South Australian sample).

	High School data *n=243*	University data* *n=45*	Combined data *n=288*
Chi-Square	2030.38	157.13	2190.44
df	402	402	402
GFI	0.62	0.76	0.63
AGFI	0.56	0.73	0.57
PGFI	0.54	0.66	0.54
RMR	0.13	0.18	0.11
RMSEA	0.14	0.0	0.14

**cannot be used for comparison*

The Filipino sample

This section presents the results of fitting the first-order three-correlated factors model to the data collected from a sample of high school and university Physics students in the Philippines. These sets of data are the same as the ones used in the previous two chapters. The section of the data that concerns students' attitudes towards computers was subjected to the analysis. Three CFA tests were carried out separately using data sets from Filipino high school students, university students, and a data set combining the high school and university data sets. The same set of fit indexes is reported.

Filipino High School Physics Students Sample

Similar to the models fitted in the South Australian data, item AFFC160 loaded very poorly (way below 0.40) onto the latent factor AFFC and COGN170 behaved in the same way in addition to the fact that its presence in the model caused the rest of the cognitive component (COGN) items to load negatively. Item COGN170 exhibited a 'masking effect' on the other COGN items. These items were consequently removed. Results of the CFA fitting a first-order correlated three-factor model into this set of data after removing the items are shown in Table 7.6.

The results show that five items failed to load with at least 0.40; one item from the affective component (AFFC169R = 0.33), three items from the behavioural component (BEHV154 = 0.36, BEHV157 = 0.35, BEHV159 = 0.39) and one from the cognitive component (COGN164R = 0.21). All of these five items that did not fit are different from those which did not fit the South Australian high school data. Clearly, this is indicative of the CASS's measurement variance in different groups. Item analysis using the Rasch model, which will be discussed later in the chapter, was used to carry out a more refined examination of the items in the CASS instrument.

Table 7.6. Factor loadings of the three-correlated factors model (Filipino high school sample).

Variable	*Loadings (se)* † *AFFC*	*BEHV*	*COGN*
AFFC152R	0.57(0.05)		
AFFC155R	0.79(0.05)		
AFFC158R	0.75(0.05)		
AFFC163R	0.69(0.05)		
AFFC166R	0.46(0.06)		
AFFC169R	0.33(0.06)		
AFFC172R	0.66(0.05)		
AFFC174R	0.76(0.05)		
AFFC176R	0.69(0.05)		
AFFC182R	0.80(0.05)		
AFFC183R	0.76(0.05)		
BEHV154		0.36(0.06)	
BEHV157		0.35(0.06)	
BEHV159		0.39(0.06)	
BEHV162		0.54(0.06)	
BEHV165		0.58(0.06)	
BEHV168		0.58(0.06)	
BEHV171		0.57(0.06)	
BEHV173		0.76(0.05)	
BEHV175		0.74(0.05)	
BEHV178		0.67(0.05)	
COGN153R			0.49(0.05)
COGN156R			0.74(0.05)
COGN161R			0.65(0.05)
COGN164R			0.21(0.06)
COGN167R			0.57(0.05)
COGN177R			0.43(0.06)
COGN179R			0.53(0.05)
COGN180R			0.70(0.05)
COGN181R			0.42(0.06)

†*n=304*
Items AFFC160 and COGN170 removed

Filipino University Physics Students

Fitting the first-order three-correlated factors model into the Filipino university Physics students' data obtained results that are similar to its South Australian counterpart. This was mainly due to the issue of sample size. Thus, the results shown in Table 7.7 were not used for comparison with the other three-factor models fitted in the high school and combined high school and university data sets to determine which fitted the model best.

Table 7.7. Factor loadings of the three-correlated factors model (Filipino university sample).

Variable	*Loadings (se)* † *AFFC*	*BEHV*	*COGN*
AFFC152R	0.62(0.10)		
AFFC155R	0.82(0.09)		
AFFC158R	0.68(0.10)		
AFFC163R	0.53(0.10)		
AFFC166R	0.28(0.11)		
AFFC169R	0.41(0.11)		
AFFC172R	0.79(0.09)		
AFFC174R	0.71(0.10)		
AFFC176R	0.84(0.09)		
AFFC182R	0.86(0.09)		
AFFC183R	0.88(0.09)		
BEHV154		0.14(0.12)	
BEHV157		0.23(0.12)	
BEHV159		0.16(0.12)	
BEHV162		0.03(0.12)	
BEHV165		0.47(0.11)	
BEHV168		0.45(0.11)	
BEHV171		0.61(0.11)	
BEHV173		0.79(0.10)	
BEHV175		0.82(0.10)	
BEHV178		0.82(0.10)	
COGN153R			0.48(0.11)
COGN156R			0.75(0.10)
COGN161R			0.67(0.10)
COGN164R			0.18(0.11)
COGN167R			0.45(0.11)
COGN177R			0.36(0.11)
COGN179R			0.52(0.11)
COGN180R			0.76(0.10)
COGN181R			0.28(0.11)

†*n=94*
Items AFFC160 and COGN170 removed

Combined Samples of Filipino High School and University Students

The high school and university data sets were combined for the same reasons mentioned above and in earlier chapters. The average age difference between the high school student samples and the university student samples is about a year. In addition, the first year university student samples were only into their second month of university classes when they filled out a survey questionnaire for this study. Thus, it was assumed that their attitudes towards and perceptions of a subject were similar. Furthermore, combining the two sets of data significantly increases the sample size which makes SEM more fit for use (Thompson, 2000 in Phakiti, 2007).

In this particular CFA run using the combined Filipino high school and university data, items AFFC160 and COGN170 exhibited the same attributes (loadings below 0.40 and masking effect on the other items for COGN170) as when they were included in the previous three-factor models fitted into the different sets of South Australian and Filipino data. Hence, they were consequently removed. CFA results without these two items are shown in Table 7.8. Five items loaded onto their latent factors poorly: AFFC169R (0.37), BEHV154 (0.31), BEHV157 (0.32), BEHV159 (0.35) and COGN164R (0.24). These are exactly the same items that did not fit the Filipino high school data. A more refined examination of these items using Rasch analysis was carried out before deciding whether they should be removed or retained. This is discussed later in the chapter. Furthermore, an evaluation of a model's fit involves an evaluation of the entire model measured by the goodness-of-fit indexes shown in Table 7.9.

Table 7.8. Factor loadings of the three-correlated factors model (combined Filipino high school and university samples).

Variable	*Loadings (se)* † *AFFC*	*BEHV*	*COGN*
AFFC152R	0.59(0.05)		
AFFC155R	0.81(0.04)		
AFFC158R	0.72(0.04)		
AFFC163R	0.66(0.05)		
AFFC166R	0.45(0.05)		
AFFC169R	0.37(0.05)		
AFFC172R	0.69(0.04)		
AFFC174R	0.76(0.04)		
AFFC176R	0.71(0.04)		
AFFC182R	0.82(0.04)		
AFFC183R	0.79(0.04)		
BEHV154		0.31(0.05)	
BEHV157		0.32(0.05)	
BEHV159		0.35(0.05)	
BEHV162		0.41(0.05)	
BEHV165		0.55(0.05)	
BEHV168		0.57(0.05)	
BEHV171		0.57(0.05)	
BEHV173		0.76(0.05)	
BEHV175		0.76(0.05)	
BEHV178		0.63(0.05)	
COGN153R			0.50(0.05)
COGN156R			0.72(0.04)
COGN161R			0.65(0.05)
COGN164R			0.24(0.05)
COGN167R			0.58(0.05)
COGN177R			0.43(0.05)
COGN179R			0.56(0.05)
COGN180R			0.72(0.04)
COGN181R			0.40(0.05)

†*n=398*
Items AFFC160 and COGN170 removed

Fit Indexes of the Three Correlated Factors Models (Filipino Sample)

Table 7.9 shows the summary of the goodness of fit statistics of the three-correlated factors model fitted to the data sets from the Filipino sample. It should be noted that the goodness-of-fit indexes presented for the set of data from the university physics students' group cannot be used for comparison with the other two models due to reasons cited above.

There is a little difference between the goodness-of-fit statistics of the three-factor model fitted into the high school data and the one fitted into the combined high school and university data. The three-factor model fitted into the combined sets of data only shows slight increase in the values of GFI, AGFI and PGFI suggesting modest fit (see Table 7.9). RMR and RMSEA values remained the same for both models and they are generally better when compared to the goodness-of-fit statistics from using the South Australian data. However, these fit indexes for both models suggest relatively poor fit. Modification indexes by correlating error terms were suggested to improve model fit but this was not considered because of the limited grounding on the theories guiding specification of errors. Fitting an alternative model into the data was considered to be more feasible based on the premise that, if the first-order factors are correlated, it is possible that the correlation between the first-order factors is due to a single second-order factor (Jöreskog & Sörbom, 1993). Hence, a second-order (hierarchical) factor model was tested for fit into the different sets of data. This is discussed later in the following sections of the chapter.

Table 7.9. Goodness-of-fit index summary for the three-correlated factors model (Philippines).

	High School data *n=304*	University data* *n=94*	Combined data *n=398*
Chi-Square	1850.57	970.44	2099.64
df	402	402	402
GFI	0.68	0.62	0.70
AGFI	0.63	0.57	0.66
PGFI	0.59	0.54	0.61
RMR	0.10	0.14	0.10
RMSEA	0.12	0.11	0.12

**cannot be used for comparison*

Alternative model

A second-order (hierarchical) model was tested to determine whether the three latent factor components of the CASS instrument loaded onto an overall construct that may be termed 'computer attitudes' or COMPATT in the structural equation model. In addition, this model was used to determine whether it improves the model fit into the data. The structure of the hierarchical model is shown in Figure 7.2. The structure shown still contains both items AFFC160 and COGN170 which were removed later on in the analysis. Both the South Australian and Filipino sets of data were used in testing the second-order factor model. The first-order factors loaded onto the second-order factor fairly well. A summary is provided in Table 7.10.

Table 7.10. Summary of first-order factor loadings

First-order latent factors	*Factor Loadings*			
	South Australia – high school sample data	*South Australia – combined high school and university samples data*	*Philippines – high school sample data*	*Philippines – combined high school and university samples data*
AFFC	0.97	0.98	0.97	0.95
BEHV	0.49	0.60	0.49	0.50
COGN	1.07	1.04	1.05	1.06

Goodness-of-fit statistics of the second-order factor models indicate that model fit has not improved when compared to the correlated three-factor model. These fit statistics are summarised in Table 7.11.

Table 7.11. Goodness-of-fit index summary for the second-order factor models.

	South Australia Sample			*Philippines Sample*		
	High School data	University data*	Combined data	High School data	University data*	Combined data
Chi-Square	2030.38	157.13	2190.44	1850.57	970.44	2099.64
df	402	402	402	402	402	402
GFI	0.62	0.76	0.63	0.68	0.62	0.70
AGFI	0.56	0.73	0.57	0.63	0.57	0.66
PGFI	0.54	0.66	0.54	0.59	0.54	0.61
RMR	0.13	0.18	0.11	0.10	0.14	0.10
RMSEA	0.14	0.0	0.14	0.12	0.11	0.12

**cannot be used for comparison*

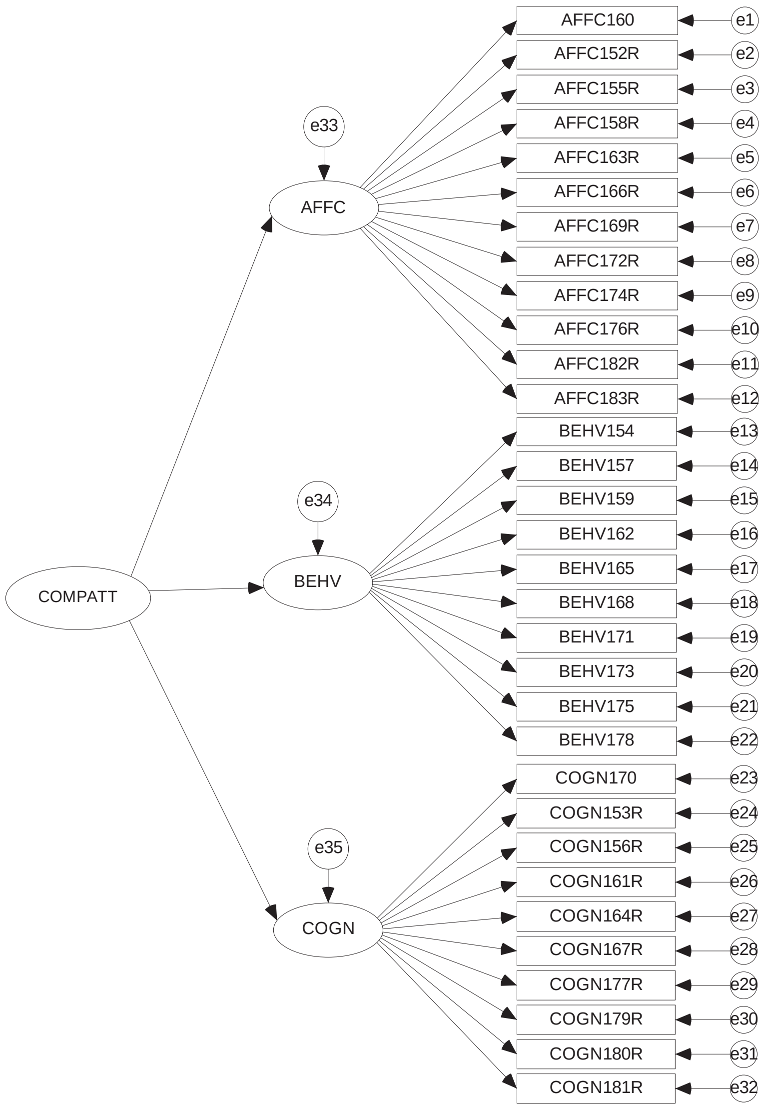


Figure 7.2. Structure of the second-order (hierarchical) factor model for the Computer Attitudes Scale for Secondary Students.

Items in the CASS instrument were subjected to item-level analysis using the Rasch model to determine their coherence in measuring their respective single latent construct.

7.5. Rasch analysis

Rasch analysis enables for a more detailed, item-level examination of the structure and operation of the CASS.

The data collected in this study concerning Physics students' attitudes towards computers were fitted to the rating scale model. All 32 items in the scale were included in the initial analysis.

Item analysis with the Rating Scale Model

The 32 items in the CASS instrument were subjected to item analyses by fitting the South Australian and Filipino sample data on Physics students' attitudes towards computers to the Rating Scale Model. This involved examining each item's fit statistics and item threshold values. More specifically, the infit mean square (INFIT MNSQ) statistic was used as a basis for the model fitting or non-fitting items. Similar to the validation of instruments discussed in the previous chapters, a range of 0.72 to 1.30 was used for the infit mean square to indicate good fitting items.

The combined high school and university physics student sample data sets for students' attitudes towards computers (for both South Australia and the Philippines) were used in the Rasch analysis fitting the rating scale model.

The analyses were carried out and results are presented in the following order:

- Combined samples of South Australian high school and university physics students (all 32 items in the scale included)
- Combined samples of South Australian high school and university physics students (misfitting items removed)
- Combined samples of Filipino high school and university physics students (all 32 items in the scale included)
- Combined samples of Filipino high school and university physics students (misfitting items removed)

The refinement process involved subsequent runs of the item analysis using ConQuest after removing items that did not fit the model. This was to ascertain that there is no item dependence or no item 'masking effects' on other items. Carefully examined misfitting items were removed one at a time. Tabulated results include item estimate, error and the unweighted fit statistics. The unweighted fit statistics include the infit mean square and the *t*-value. The separation reliability index, chi-square test of parameter equality, degrees of freedom and significance level are also included. Adams and Khoo (1993) defined separation reliability index as an indication of the proportion of the observed variance that is considered true. There is generally a preference for high separation reliability index because this means that measurement error is smaller.

Table 7.12. Table of response model parameter estimates of the CASS for the South Australian sample (no items removed).

Variables	*Estimates*	*Error*	*Unweighted Fit*		
			INFIT MNSQ	*CI*	*t*
AFFC160	0.736	0.044	0.97	(0.84, 1.16)	-0.4
AFFC152R	-0.917	0.051	1.32	(0.84, 1.16)	3.6
AFFC155R	-0.727	0.050	0.89	(0.84, 1.16)	-1.4
AFFC158R	-0.249	0.047	0.79	(0.84, 1.16)	-2.8
AFFC163R	-0.312	0.048	0.93	(0.84, 1.16)	-0.8
AFFC166R	0.038	0.046	0.91	(0.84, 1.16)	-1.1
AFFC169R	-0.076	0.046	1.00	(0.84, 1.16)	0.1
AFFC172R	-0.381	0.048	1.08	(0.84, 1.16)	1.0
AFFC174R	-0.589	0.049	0.94	(0.84, 1.16)	-0.7
AFFC176R	-0.374	0.048	0.82	(0.84, 1.16)	-2.3
AFFC182R	-0.628	0.050	0.97	(0.84, 1.16)	-0.4
AFFC183R	0.221	0.045	1.26	(0.84, 1.16)	-1.0
BEHV154	0.023	0.046	0.96	(0.84, 1.16)	-1.7
BEHV157	0.653	0.044	0.92	(0.84, 1.16)	-1.0
BEHV159	0.060	0.046	0.86	(0.84, 1.16)	-1.7
BEHV162	0.731	0.044	1.36	(0.84, 1.16)	4.0
BEHV165	0.005	0.046	0.92	(0.84, 1.16)	-0.9
BEHV168	0.760	0.044	1.12	(0.84, 1.16)	1.4
BEHV171	0.875	0.044	1.15	(0.84, 1.16)	1.8
BEHV173	0.049	0.046	1.07	(0.84, 1.16)	0.8
BEHV175	-0.536	0.049	0.78	(0.84, 1.16)	-2.9
BEHV178	1.331	0.045	1.72	(0.84, 1.16)	7.3
COGN170	1.411	0.045	1.67	(0.84, 1.16)	6.9
COGN153R	0.008	0.046	1.15	(0.84, 1.16)	1.8
COGN156R	-0.239	0.047	0.93	(0.84, 1.16)	-0.8
COGN161R	-0.702	0.050	0.86	(0.84, 1.16)	-1.8
COGN164R	0.023	0.046	1.02	(0.84, 1.16)	0.3
COGN167R	-0.326	0.048	0.93	(0.84, 1.16)	-0.8
COGN177R	-0.382	0.048	0.98	(0.84, 1.16)	-0.2
COGN179R	-0.230	0.047	0.90	(0.84, 1.16)	-1.2
COGN180R	-0.013	0.046	0.93	(0.84, 1.16)	-0.8
COGN181R	-0.242*	0.260	1.13	(0.84, 1.16)	1.5

Separation Reliability = 0.994
Chi-square test of parameter equality = 4873.47
df = 31
Significance Level = 0.000

The South Australian sample

The rating scale model was fitted into the set of data on students' attitudes towards computers where all the 32 items of the CASS instrument were included in the analysis without taking into account the independence of the three constructs as described by the instrument's authors. This was carried out to determine the feasibility of unidimensionality of all the items. The results of the initial run are shown in Table 7.12. Three items (BEHV162, BEHV178 and COGN170) have infit mean squares outside the accepted range of 0.72 to 1.30. Having the highest infit mean square value, BEHV178 was removed first.

After removing the item, the analysis was re-run and the infit statistics were examined. This procedure was carried out until all of the remaining items indicate that they fit the model. The results of the final run of the CASS instrument item analysis are shown in Table 7.13 where only 19 items out of 32 remain. The high separation reliability index in the initial run shows a big proportion of the observed variance is considered true, thus giving small error values for the items. After the final run, the separation reliability index dropped a little. However, this drop in value cannot be counted as significant considering that it is still very well close to unity. Nevertheless, a significant number of items were removed as they appeared to misfit the model. This is indicative of the non-unidimensional nature of the scale as forwarded by its authors, Jones and Clarke (1994).

Table 7.13. Table of response model parameter estimates of the CASS for the South Australian sample (13 items removed).

Variables	*Estimates*	*Error*	**Unweighted Fit**		
			INFIT MNSQ	*CI*	*t*
AFFC155R	-0.523	0.056	0.81	(0.84, 1.16)	-2.5
AFFC158R	0.071	0.053	0.87	(0.84, 1.16)	-1.6
AFFC163R	-0.008	0.053	1.17	(0.84, 1.16)	2.1
AFFC166R	0.432	0.051	1.07	(0.84, 1.16)	0.8
AFFC169R	0.285	0.052	1.07	(0.84, 1.16)	0.9
AFFC172R	-0.091	0.054	1.08	(0.84, 1.16)	1.0
AFFC174R	-0.352	0.055	0.97	(0.84, 1.16)	-0.3
AFFC176R	-0.082	0.054	0.82	(0.84, 1.16)	-2.3
AFFC182R	-0.397	0.055	0.81	(0.84, 1.16)	-2.5
BEHV159	0.461	0.051	1.27	(0.84, 1.16)	3.1
BEHV175	-0.273	0.055	1.26	(0.84, 1.16)	3.0
COGN156R	0.090	0.053	0.96	(0.84, 1.16)	-0.4
COGN161R	-0.486	0.056	1.07	(0.84, 1.16)	0.8
COGN164R	0.419	0.051	1.29	(0.84, 1.16)	3.3
COGN167R	-0.022	0.053	1.28	(0.84, 1.16)	3.2
COGN177R	-0.087	0.054	0.99	(0.84, 1.16)	-0.0
COGN179R	0.103	0.053	0.95	(0.84, 1.16)	-0.6
COGN180R	0.373	0.052	1.05	(0.84, 1.16)	0.6
COGN181R	0.086*	0.226	1.17	(0.84, 1.16)	2.0

Separation Reliability = 0.972
Chi-square test of parameter equality = 600.43
df = 18
Significance Level = 0.000

The Filipino data sets were also fitted to the rating scale model and results were examined. Details of the analyses follow.

The Filipino sample

All 32 items in the CASS instrument were subjected to the analysis fitting the Filipino data into the rating scale model. The results are shown in Table 7.14. Two items (BEHV178 and COGN170) have infit mean square statistic outside the acceptable range. Between these two items, COGN170 has a higher infit mean square value. Thus, this item was removed. This item behaved similarly when the model was fitted to the South Australian data. Overall, the model including the non-fitting item yielded a separation reliability that is quite high which means that a significant proportion of the observed variance is considered to be true.

Table 7.14. Table of response model parameter estimates of the CASS for the Filipino sample (no items removed).

Variables	*Estimates*	*Error*	***Unweighted Fit***		
			INFIT MNSQ	*CI*	*t*
AFFC160	0.550	0.040	1.19	(0.86, 1.14)	2.6
AFFC152R	-0.196	0.042	1.09	(0.86, 1.14)	1.3
AFFC155R	-0.362	0.042	0.86	(0.86, 1.14)	-2.0
AFFC158R	0.145	0.041	0.74	(0.86, 1.14)	-4.1
AFFC163R	-1.063	0.045	1.20	(0.86, 1.14)	2.7
AFFC166R	0.220	0.040	1.12	(0.86, 1.14)	1.6
AFFC169R	0.390	0.040	1.21	(0.86, 1.14)	2.8
AFFC172R	0.057	0.041	1.19	(0.86, 1.14)	2.6
AFFC174R	-0.581	0.043	0.87	(0.86, 1.14)	-1.9
AFFC176R	-0.232	0.042	0.80	(0.86, 1.14)	-3.0
AFFC182R	-0.332	0.042	0.70	(0.86, 1.14)	-4.8
AFFC183R	-0.527	0.043	0.88	(0.86, 1.14)	-1.8
BEHV154	0.028	0.041	1.27	(0.86, 1.14)	3.6
BEHV157	0.958	0.039	0.94	(0.86, 1.14)	-0.8
BEHV159	0.532	0.040	0.97	(0.86, 1.14)	-0.3
BEHV162	0.165	0.040	0.96	(0.86, 1.14)	-0.6
BEHV165	0.222	0.040	0.80	(0.86, 1.14)	-3.0
BEHV168	0.187	0.040	1.16	(0.86, 1.14)	2.1
BEHV171	0.314	0.040	1.21	(0.86, 1.14)	2.9
BEHV173	-0.734	0.044	1.00	(0.86, 1.14)	0.1
BEHV175	-0.850	0.044	0.87	(0.86, 1.14)	-2.0
BEHV178	0.092	0.041	1.36	(0.86, 1.14)	4.6
COGN170	1.164	0.039	1.53	(0.86, 1.14)	6.5
COGN153R	0.466	0.040	1.00	(0.86, 1.14)	-0.0
COGN156R	-0.367	0.042	0.95	(0.86, 1.14)	-0.7
COGN161R	-0.967	0.045	0.85	(0.86, 1.14)	-2.2
COGN164R	0.799	0.039	1.24	(0.86, 1.14)	3.2
COGN167R	-0.794	0.044	1.16	(0.86, 1.14)	2.2
COGN177R	0.161	0.041	1.12	(0.86, 1.14)	1.7
COGN179R	0.036	0.041	1.08	(0.86, 1.14)	1.1
COGN180R	0.109	0.041	0.91	(0.86, 1.14)	-1.3
COGN181R	0.411*	0.231	1.24	(0.86, 1.14)	3.2

Separation Reliability = 0.994
Chi-square test of parameter equality = 5290.35
df = 31
Significance Level = 0.000

Non-fitting items were removed one at a time. After removal of each non-fitting item, the analysis was re-run and infit mean square statistics were examined. Re-running the analysis stopped when all items have fit statistics indicating good fit to the model. The results of the final run of the item analysis are shown in Table 7.15 where 29 items out of 32 remain. There was no observed drop in the separation reliability index.

A considerable difference can be observed when comparing the results obtained from fitting the model into the South Australian and Filipino sets of data. It appears that fitting the Filipino data into the rating scale model was less 'problematic' (suggesting more unidimensionality) due to the fact that only three items were removed compared to the 13 removed when fitted into the South Australian data. This is a clear indication that the CASS's measurement variance in different groups of samples used in this study. Therefore, groups cannot be compared.

However, the results above show what happens to the number of items in the scale when removal of an item was solely based on the infit mean square value that fell outside the accepted range. This was considered to be an unwise decision since valuable information from these items that appear to be misfitting could prove to be useful in the study. Therefore, the removal of an item was not solely based on the infit mean square value. The decision to remove an item was also based on careful examination of the item's delta value (which indicates the location of each Likert response choice on a scale) and the item statement (whether or not it measures what is required to measure in the study). Since response choices in Likert-type questionnaires are set in order (e.g., from 'strongly disagree', 'disagree', 'agree', to 'strongly agree'), the resulting item delta values after subjecting it to Rasch item analysis should also be in order.

In addition, a significant number of items in the CASS appear to misfit when all of them were fitted to the rating scale model suggesting that the scale is not unidimensional. In fact, Jones and Clarke (1994) have developed the CASS to include three sub-scales that represented three major domains of attitudes which, according to them based on their analysis, exhibited scale independence with a bit of overlapping. Thus, the CASS was also subjected to Rasch analysis where the three sub-scales, representing affective, behavioural and cognitive domains, were analysed separately.

Table 7.15. Table of response model parameter estimates of the CASS for the Filipino sample (Three items removed).

Variables	*Estimates*	*Error*	*Unweighted Fit*		
			INFIT MNSQ	*CI*	*t*
AFFC160	0.589	0.040	1.27	(0.86, 1.14)	3.5
AFFC152R	-0.170	0.042	1.07	(0.86, 1.14)	0.9
AFFC155R	-0.340	0.043	0.84	(0.86, 1.14)	-2.3
AFFC158R	0.177	0.041	0.75	(0.86, 1.14)	-3.9
AFFC163R	-1.051	0.046	1.24	(0.86, 1.14)	3.2
AFFC166R	0.264	0.041	1.12	(0.86, 1.14)	1.6
AFFC169R	0.438	0.040	1.23	(0.86, 1.14)	3.0
AFFC172R	0.087	0.041	1.19	(0.86, 1.14)	2.6
AFFC174R	-0.562	0.044	0.87	(0.86, 1.14)	-1.9
AFFC176R	-0.206	0.042	0.81	(0.86, 1.14)	-2.9
AFFC183R	-0.506	0.043	0.88	(0.86, 1.14)	-1.8
BEHV154	0.058	0.041	1.28	(0.86, 1.14)	3.7
BEHV157	1.007	0.039	0.98	(0.86, 1.14)	-0.2
BEHV159	0.577	0.040	0.97	(0.86, 1.14)	-0.4
BEHV162	0.198	0.041	1.00	(0.86, 1.14)	-0.0
BEHV165	0.259	0.041	0.83	(0.86, 1.14)	-2.5
BEHV168	0.220	0.041	1.21	(0.86, 1.14)	2.8
BEHV171	0.352	0.040	1.29	(0.86, 1.14)	3.8
BEHV173	-0.715	0.044	1.06	(0.86, 1.14)	0.8
BEHV175	-0.834	0.045	0.89	(0.86, 1.14)	-1.6
COGN153R	0.514	0.040	1.00	(0.86, 1.14)	-0.0
COGN156R	-0.335	0.043	0.95	(0.86, 1.14)	-0.8
COGN161R	-0.953	0.045	0.84	(0.86, 1.14)	-2.3
COGN164R	0.845	0.039	1.26	(0.86, 1.14)	3.5
COGN167R	-0.778	0.045	1.20	(0.86, 1.14)	2.7
COGN177R	0.203	0.041	1.14	(0.86, 1.14)	1.9
COGN179R	0.065	0.041	1.09	(0.86, 1.14)	1.2
COGN180R	0.144	0.041	0.92	(0.86, 1.14)	-1.1
COGN181R	0.453*	0.221	1.25	(0.86, 1.14)	3.3

Separation Reliability = 0.994
Chi-square test of parameter equality = 4450.54
df = 28
Significance Level = 0.000

Table 7.16. Table of response model parameter estimates of the CASS for the South Australian and Filipino samples (scales analysed separately and no items removed).

Variables	*Estimates SA/PH*	*Error SA/PH*	*Unweighted Fit SA/PH*		
			INFIT MNSQ	*CI*	*t*
Affective (AFFC)					
AFFC160	1.190/0.811	0.046/0.045	1.75/1.65	(0.84,1.16)/(0.86,1.14)	7.5/7.8
AFFC152R	-0.736/-0.044	0.052/0.048	1.23/1.11	(0.84,1.16)/(0.86,1.14)	2.6/1.6
AFFC155R	-0.528/-0.232	0.051/0.049	0.78/0.80	(0.84,1.16)/(0.86,1.14)	-2.9/-3.1
AFFC158R	0.018/0.346	0.049/0.047	0.87/0.79	(0.84,1.16)/(0.86,1.14)	-1.7/-3.2
AFFC163R	-0.055/-1.013	0.049/0.053	1.02/1.27	(0.84,1.16)/(0.86,1.14)	0.3/3.6
AFFC166R	0.355/0.433	0.048/0.047	1.03/1.24	(0.84,1.16)/(0.86,1.14)	0.4/3.2
AFFC169R	0.220/0.627	0.048/0.046	1.06/1.39	(0.84,1.16)/(0.86,1.14)	0.8/4.9
AFFC172R	-0.131/0.246	0.050/0.047	0.95/1.12	(0.84,1.16)/(0.86,1.14)	-0.6/1.7
AFFC174R	-0.370/-0.477	0.051/0.050	0.92/0.89	(0.84,1.16)/(0.86,1.14)	-0.9/-1.7
AFFC176R	-0.123/-0.083	0.050/0.048	0.81/0.84	(0.84,1.16)/(0.86,1.14)	-2.5/-2.3
AFFC182R	-0.414/-0.196	0.051/0.049	0.82/0.67	(0.84,1.16)/(0.86,1.14)	-2.3/-5.2
AFFC183R	-0.57*/-0.417*	0.164/0.160	1.33/0.89	(0.84,1.16)/(0.86,1.14)	3.6/-1.6
Behavioural (BEHV)					
BEHV154	-0.428/-0.075	0.046/0.045	1.00/1.19	(0.84,1.16)/(0.86,1.14)	0.0/2.5
BEHV157	0.311/0.993	0.044/0.043	0.92/0.99	(0.84,1.16)/(0.86,1.14)	-0.9/-0.1
BEHV159	-0.382/0.507	0.046/0.043	1.14/1.15	(0.84,1.16)/(0.86,1.14)	1.7/2.1
BEHV162	0.400/0.085	0.044/0.045	1.25/0.99	(0.84,1.16)/(0.86,1.14)	2.9/-0.1
BEHV165	-0.448/0.150	0.046/0.044	1.00/0.81	(0.84,1.16)/(0.86,1.14)	0.0/-2.8
BEHV168	0.438/0.108	0.044/0.044	0.90/1.18	(0.84,1.16)/(0.86,1.14)	-1.2/2.5
BEHV171	0.560/0.257	0.044/0.044	0.87/1.06	(0.84,1.16)/(0.86,1.14)	-1.6/0.9
BEHV173	-0.405/-0.947	0.046/0.048	0.94/0.88	(0.84,1.16)/(0.86,1.14)	-0.8/-1.7
BEHV175	-1.108/-1.078	0.049/0.049	0.96/0.90	(0.84,1.16)/(0.86,1.14)	-0.5/-1.5
BEHV178	1.061*/0.000*	0.137/0.135	1.19/1.13	(0.84,1.16)/(0.86,1.14)	2.2/1.8
Cognitive (COGN)					
COGN170	1.467/1.011	0.045/0.038	1.83/1.44	(0.84,1.16)/(0.86,1.14)	8.2/5.5
COGN153R	0.076/0.343	0.046/0.039	1.09/0.90	(0.84,1.16)/(0.86,1.14)	1.0/-1.4
COGN156R	-0.168/-0.442	0.047/0.041	0.94/0.97	(0.84,1.16)/(0.86,1.14)	-0.7/-0.3
COGN161R	-0.625/-1.011	0.050/0.044	0.91/0.89	(0.84,1.16)/(0.86,1.14)	-1.1/-1.6
COGN164R	0.092/0.660	0.046/0.038	0.93/1.01	(0.84,1.16)/(0.86,1.14)	-0.8/0.2
COGN167R	-0.254/-0.846	0.047/0.043	0.96/1.12	(0.84,1.16)/(0.86,1.14)	-0.5/1.7
COGN177R	-0.310/0.054	0.048/0.039	0.88/0.95	(0.84,1.16)/(0.86,1.14)	-1.4/-0.7
COGN179R	-0.160/-0.064	0.047/0.040	0.84/0.98	(0.84,1.16)/(0.86,1.14)	-2.1/-0.3
COGN180R	0.054/0.005	0.046/0.040	0.93/0.97	(0.84,1.16)/(0.86,1.14)	-0.8/-0.4
COGN181R	-0.173*/0.289*	0.140/0.121	1.04/1.01	(0.84,1.16)/(0.86,1.14)	0.5/0.2

**constrained*
Significance Level = 0.000

Fitting separately each sub-scale in the CASS to the rating scale model provides the results shown in Tables 7.16. Each sub-scale exhibited a fairly good unidimensionality with minimal misfitting items based on their infit statistics. The affective (AFFC) sub-scale showed one misfitting item with the South Australian sample while two did not fit with the Filipino sample. There were no misfitting items for the behavioural (BEHV) sub-scale while only one item showed misfit for the cognitive (COGN) sub-scale for both groups of samples.

Misfitting items were examined carefully looking not only at their infit statistics but also at the item statement and the item deltas that indicate the location of each Likert choice on a scale.

It can be observed in Table 7.16 that Item AFFC160's infit mean square is outside the accepted range of 0.72 and 1.30 for both the South Australian and the Filipino samples. In addition, examining the item's delta ordering reveals that there is order swapping. Furthermore, this item showed very little contribution to reflect the Affective sub-scale in the CFA. Therefore, this item was removed.

A similar observation can be stated about how Item COGN170 behaved in the model fitting the South Australian and Filipino data sets. Its misfitting behaviour is consistent in the CFA and Rasch analysis. Thus, in this study, this item was also removed from the CASS.

7.6. Model for the study

The final model considered for use in this study was the three-correlated factors model without the items AFFC160 and COGN170, applicable to both the South Australian and the Filipino samples.

7.7. Summary

The Computer Attitude Scale for Secondary students (CASS) scale developed by Jones and Clarke (1994) was adapted for use as part of the SUPSQ instrument to measure Physics students' attitudes towards computers. This scale consists of 40 items using 5-point Likert response choices ranging from "strongly disagree" (1) to "strongly agree"

(5). However, after close examination of their useability only 32 from the original 40 items were retained.

As with the preceding three chapters, the same sets of data collected from South Australian and Philippine high school and university Physics student samples were used. A section of the data sets that concern students' attitudes towards computers was analysed through CFA employing LISREL 8.80 software package to examine the structure of the whole CASS instrument. Rasch Modeling with ConQuest 2.0 (using the rating scale model) was used for item-level analysis to test for the coherence of the instrument items to measure a common latent factor – attitudes towards computers.

The CFA part of instrument validation involved fitting the measurement and alternative models into the South Australian and Filipino data. The South Australian data consists of three different groups of samples: high school Physics students, university Physics students and combined high school and university Physics students. The Filipino data consists of the similar groups of samples. The measurement model was fitted in each of these sets or groups from each data set. The model fitted into the university Physics students data sets for both South Australia and the Philippines were not used for comparisons with the others because of the issue of sample size giving unreliable fit statistics. The measurement model consisted of three correlated latent factors that form part of the tripartite model of attitudes. These are the affective component, behaviour component and cognitive component. Of the 32 items in the CASS instrument retained and used in this study, 12 items loaded onto the affective component, 10 items loaded onto the behaviour component and 10 items loaded onto the cognitive component. The model fitted in the South Australian data showed a total of seven items misfitting based on their factor loadings. In addition, items AFFC160 and COGN170 had to be removed because they had a profound effect on the loadings of the other factors. The model fitted in the Filipino data showed seven items not fitting well. Similarly, the two items removed when the model was fitted into the South Australian data (AFFC160 and COGN170) had to be removed because of the same issue cited. However, the correlated three-factor model fitted in both the South Australian and Filipino data showed poor fit based on their respective goodness-of-fit statistics. An alternative model was tested – the second-order (or hierarchical) factor model. This model was fitted in the South Australian and the Filipino data to determine whether or not it will improve the goodness-of-fit statistics. The resulting statistics still showed poor fit with no improvement in their values. Except for items AFFC160 and COGN170, no items were removed when CFA was carried out. Items were removed when item-level analyses were carried out using Rasch modeling with the rating scale model.

To test the unidimensionality of the 32 items to measure a common factor in the CASS instrument, the sets of data were fitted to the rating scale model. Using the unweighted fit statistics, items were examined for their fit in the model. An item whose infit mean square statistic did not fall within the accepted range of 0.72 and 1.30 was removed. Thirteen items were removed when the rating scale model was fitted into the combined South Australian high school and university data. Only three items were removed when the rating scale model was fitted into the Filipino data. The results demonstrated the CASS's multidimensionality. Moreover, this was a clear indication that the CASS instrument adapted for use in this study exhibited measurement variance for the two different sample groups

However, the model, which included three sub-scales representing attitude domains, forwarded by the authors of the CASS, was also tested using this study's data sets. Each of the sub-scales was independently subjected to Rasch analysis. The results show all of the CASS items fitted the model except items AFFC160 and COGN170 which had to be removed after carefully examining their infit statistics and item deltas. These items similarly did not fit the models used in the CFA.

The model used in the subsequent analyses of the South Australian and Filipino data sets was the three-correlated factors model including all items except for items AFFC160 and COGN170.

All scales and instruments used in this study were examined using the same steps and techniques. The next chapter discusses how the scale that intends to measure classroom climate was validated.

Chapter 8

The Classroom Climate Scale

8.1. Introduction

A part of this study examined the school-level factors and their impact on physics students' attitudes towards physics and their subsequent uptake of physics. Two of these school-level factors are student experiences in the physics classroom and how physics teachers affect their students' attitudes towards physics. In trying to measure physics students' experiences in a physics classroom, Barry Fraser's (1990) Individualised Classroom Environment Questionnaire (ICEQ) was adapted. It was also used to determine the teachers' impact on students' attitudes and interest towards physics based on how teachers interact with their students. Since the students sampled in this study were at the time already doing a physics subject/course, the ICEQ instrument was also used to examine their experiences in the physics classroom and their impact on subsequent decision to continue doing physics or physics-related courses. The ICEQ scale formed part of the Students' Uptake of Physics Study Questionnaire (SUPSQ) instrument used in this study. The rationale for choosing the ICEQ instrument was presented in Chapter 3. This instrument was chosen to address the research questions (RQ) presented in Chapter 1. These research questions include RQ1b, RQ2a, RQ2b, RQ2c, RQ2d and RQ2e. These questions were advanced to address the effects of classroom climate on students' attitudes towards physics, their self-esteem and their motivation to learn physics. They also partly address how teachers influence classroom climate. These questions need to be carefully addressed using an instrument that is both reliable and valid. Therefore it was necessary to rigorously validate the ICEQ instrument even when this instrument has already been validated a number of times in different contexts (see Chapter 3). In addition, the results of the data analysis using this instrument could be used to confirm research findings of similar studies on the influence of classroom environment on attitudes presented in Chapter 2.

This chapter provides a detailed account of the technique and analysis carried out for the validation of Fraser's (1990) ICEQ instrument used to measure physics students' experiences in a physics classroom and the impact of physics teachers in shaping their students' attitudes towards physics. Broadly, the structure of the instrument was confirmed using contemporary approaches which included confirmatory factor analysis (CFA) and Rasch measurement modeling used in the previous instrument validation chapters (Chapters 4, 5, 6 and 7).

This chapter begins with a section briefly describing the instrument and its items that represent the observed variables. Then follows a brief description of how this instrument was used and validated by other researchers. This is followed by the description of how the structure of the instrument was investigated using structural equation modeling (SEM) which includes confirmatory factor analysis of the five-factor correlated model and an alternative model. Each of these models' fit indexes was examined to determine which model fit the data best. This section is followed by an item-level analysis using Rasch modeling. The chapter concludes with a summary.

8.2. The Individualised Classroom Environment Questionnaire (ICEQ)

Development of the ICEQ began in the 1970s (see Fraser, 1980). Its aim was to fill the voids of the shortcomings of the instruments considered to be the most widely used in assessing classroom environment (Fraser, 1990). These instruments were the Learning Environment Inventory (LEI) (Fraser, Anderson & Walberg, 1982) and the Classroom Environment Scale (CES) (Moos & Tricket, 1974). According to Fraser (1990, p. 1), the LEI and the CES "are limited in that they exclude dimensions which are important in open or individualised classrooms."

Several characteristics distinguish the ICEQ from other classroom climate questionnaires. Two are noteworthy for use in this study. First, the ICEQ assesses five constructs that represent classroom dimensions namely: Personalisation, Participation, Independence, Investigation and Differentiation. In this study, these dimensions are considered to be important in examining the extent of Physics students' positive or negative experiences in their Physics classroom. Second, it has forms for both the assessment of actual classroom environment and preferred classroom environment. This enables for the comparison of what students actually experience in the classroom and what they would like to happen in the classroom. In the context of this study, this was considered important in determining how Physics students' attitudes towards Physics were formed from their experiences in the Physics classroom (which also includes how their teachers interact with them).

The ICEQ is composed of the long and the short forms (for both the Actual Classroom and the Preferred Classroom). This study adapted the short form (see Chapter 3 for reasons for adapting this form). The Actual Classroom and the Preferred Classroom short forms each comprise of 25 items covering five dimensions of the classroom environment: Personalisation (5 items), Participation (5 items), Independence (5 items), Investigation (5 items) and Differentiation (5 items). In the SUPSQ these were items 65 through 114 covering both the Actual and Preferred Classrooms. For the purposes of data analysis, items were designated prefixes to represent the classroom environment dimension they measure. For the Actual Classroom form, the following prefixes were used: PERSN for personalisation, PARTI for participation, INDEP for independence, INVES for investigation and DFFER for differentiation. For the Preferred Classroom form, the following prefixes were used: PRSN for personalisation, PRTI for participation, INDP for independence, INVS for investigation and DFER for differentiation. Presented in the Tables 8.1 and 8.2 are codes for the items used in the validation, nature (i.e. positive or negative) of each statement, item code to indicate which statements have been reverse-scored, and the text corresponding to each item.

Table 8.1. Summary of ICEQ items used in the SUPSQ instrument (Actual Classroom).

Item Code	Nature of statement	Item Code to indicate reverse scoring	Item text
PERSN65	Positive	*None*	The teacher talks with each student.
PARTI66	Positive	*None*	Students give their opinions during discussions.
INDEP67	Negative	INDEP67R	The teacher decides where students sit.
INVES68	Negative	INVES68R	Students find out the answers to questions from textbooks rather than from investigations.
DFFER69	Positive	*None*	Different students do different work.
PERSN70	Positive	*None*	The teacher takes a personal interest in each student.
PARTI71	Negative	PARTI71R	The teacher lectures without students asking or answering questions.
INDEP72	Positive	*None*	Students choose their partners for group work.
INVES73	Positive	*None*	Students carry out investigations to test ideas.
DFFER74	Negative	DFFER74R	All students in the class do the same work at the same time.
PERSN75	Negative	PERSN75R	The teacher is unfriendly to students.
PARTI76	Positive	*None*	Students' ideas and suggestions are used during classroom discussion.
INDEP77	Negative	INDEP77R	Students are told how to behave in the classroom.
INVES78	Positive	*None*	Students carry out investigations to answer questions coming from class discussions.
DFFER79	Positive	*None*	Different students use different books, equipment and materials.
PERSN80	Positive	*None*	The teacher helps each student who is having trouble with the work.
PARTI81	Positive	*None*	Students ask the teacher questions.
INDEP82	Negative	INDEP82R	The teacher decides which students should work together.
INVES83	Positive	*None*	Students explain the meanings of statements, diagrams and graphs.
DFFER84	Positive	*None*	Students who work faster than others move on to the next topic.
PERSN85	Positive	*None*	The teacher considers students' feelings.
PARTI86	Positive	*None*	There is classroom discussion.
INDEP87	Negative	INDEP87R	The teacher decides how much movement and talk there should be in the classroom.
INVES88	Positive	*None*	Students carry out investigations to answer questions which puzzle them.
DFFER89	Negative	DFFER89R	The same teaching aid (e.g. blackboard or overhead projector) is used for all students in the class.

Table 8.2. Summary of ICEQ items used in the SUPSQ instrument (Preferred Classroom).

Item Code	Nature of statement	Item Code to indicate reverse scoring	Item text
PRSN90	Positive	*None*	The teacher would talk to each student.
PRTI91	Positive	*None*	Students would give their opinions during discussions.
INDP92	Negative	INDP92R	The teacher would decide where students sat.
INVS93	Negative	INVS93R	Students would find out the answers to questions from textbooks rather than from investigations.
DFER94	Positive	*None*	Different students would do different work.
PRSN95	Positive	*None*	The teacher would take personal interest in each student.
PRTI96	Negative	PRTI96R	The teacher would lecture without students asking or answering questions.
INDP97	Positive	*None*	Students would choose their partners for group work.
INVS98	Positive	*None*	Students would carry out investigations to test ideas.
DFER99	Negative	DFER99R	All students in the class would do the same work at the same time.
PRSN100	Negative	PRSN100R	The teacher would be unfriendly to students.
PRTI101	Positive	*None*	Students' ideas and suggestions would be used during classroom discussion.
INDP102	Negative	INDP102R	Students would be told how to behave in the classroom.
INVS103	Positive	*None*	Students would carry out investigations to answer questions coming from class discussions.
DFER104	Positive	*None*	Different students would use different books, equipment and materials.
PRSN105	Positive	*None*	The teacher would help each student who was having trouble with the work.
PRTI106	Positive	*None*	Students would ask the teacher questions.
INDP107	Negative	INDP107R	The teacher would decide which students should work together
INVS108	Positive	*None*	Students would explain the meanings of statements, diagrams and graphs.
DFER109	Positive	*None*	Students who worked faster than others would move on to the next topic.
PRSN110	Positive	*None*	The teacher would consider students' feelings.
PRTI111	Positive	*None*	There would be classroom discussion.
INDP112	Negative	INDP112R	The teacher would decide how much movement and talk there should be in the classroom.
INVS113	Positive	*None*	Students would carry out investigations to answer questions which puzzled them.
DFER114	Negative	DFER114R	The same teaching aid (e.g. blackboard or overhead projector) would be used for all students in the class.

Each item in the ICEQ has five Likert-type choices: ‘almost never’, ‘seldom’, ‘sometimes’, ‘often’ and ‘very often’ coded as ‘1’, ‘2’, ‘3’, ‘4’ and ‘5’, respectively. Missing or omitted response was coded ‘9’. Of the 25 items, nine are negatively worded. The negatively worded items were reverse-scored to keep the scale’s scoring consistency (see scoring details in Fraser, 1990).

The following section describes how past researchers, including its author, validated the ICEQ. It also shows some of their findings in terms of the instrument’s validity and reliability.

8.3. Previous analytic practices

Fraser (1990) has comprehensively tested his ICEQ instrument for a number of years in different contexts using different groups of samples from Australia and overseas since its inception. Indonesia, the Netherlands (Fraser, 1990) and the UK (Burden & Fraser, 1993) were among the countries that he used for his ICEQ instrument cross-validation. Cross-validation carried out in Australia and overseas provided him with information for both the long and short forms about the internal consistency reliability and independence of each ICEQ scale. For the short form of the ICEQ, Fraser obtained an alpha coefficient ranging from 0.63 to 0.85, which, “is typically 0.1 smaller than the reliability of the long form” (Fraser, 1990, p. 16). He pointed that these values suggest satisfactory reliability for applications based on class means. In terms of correlations between scales, Fraser found the values of the mean correlation of a scale with the other scales to range from 0.13 to 0.36 which is comparable with those of the long form. Fraser (1990) suggested that these values show an adequate level of scale independence which means that the “ICEQ measures distinct although somewhat overlapping aspects of classroom environment” (p. 14). Test-retest reliability coefficients for the five scales (Personalisation = 0.78, Participation = 0.67, Independence = 0.83, Investigation = 0.75 and Differentiation = 0.78) in the ICEQ were found to be satisfactory according to Fraser (1980). These statistics for the ICEQ short form resulted from the following total number of samples used by Fraser in his studies: Actual Classroom Form = 1083 students, and Preferred Classroom Form = 1092 students.

In Fraser’s (1990) ICEQ handbook, he has outlined how researchers and teachers from several different countries used the ICEQ for different purposes. They have been:

- Associations between student outcomes and classroom environment;
- Differences between scores of various groups on the ICEQ;
- Evaluation of innovations in classroom individualisation;
- Study of teachers' attitudes to classroom individualisation;
- Person-environment fit studies; and
- Practical attempts to improve classroom environments

According to Wheldall, Beaman and Mok (1999), the ICEQ may be considered a relatively good instrument to measure classroom climate based on their findings of the study they carried out using 1,467 high school students in New South Wales. They have derived intraclass correlations through multilevel variance analysis components models to determine the degree to which ICEQ scores may validly be said to measure aspects of classroom climate as against individual student attitude. Furthermore, they have added that their analysis results showed that the class variable accounted for large and noteworthy proportions of overall variance in all five ICEQ scales and that subsequent analyses showed that only small and non-significant proportions of variance were attributable to the school variable.

However, it seems that classroom environment researchers such as Fraser, Walberg and Moos have only used classical test theory (CTT) techniques to validate their instruments. Research has shown that CTT has a number of shortcomings that could affect the results of analysing data (see Chapter 3). Recently, researchers have used contemporary statistical analysis techniques such as CFA and other multi-level analysis techniques to examine classroom learning environment instruments (see Dorman, 2003; Aldridge, Dorman & Fraser, 2004) but there appears to be no mention of the ICEQ being subjected to these kinds of analyses. For this reason, the author of this study has taken this opportunity to investigate the associations of the different dimensions of the ICEQ using contemporary techniques such as CFA to examine the structure of the instrument as a whole and Rasch Modeling for item-level examination.

8.4. Instrument structure analysis

The section of this study's data set concerned with students' individualised classroom environment experiences has been subjected to detailed structural analysis. This section describes and discusses results from using data from two main groups of samples: South

Australian Physics students from 11 metropolitan Adelaide schools and a university, and Filipino Physics students from 11 Quezon City District high schools and two universities (see Chapter 3 for sample details). Each sample consists of two subgroups: high school Physics students and university Physics students. The main methods used to examine the structure of the instrument used to measure students' individualised classroom environment experiences were CFA and Rasch measurement modeling – the same techniques employed in the validation of the scales discussed in Chapters 4, 5, 6 and 7.

Literature on the validation of the ICEQ is quite abundant; therefore, CFA was utilised to confirm factor structures as advanced by the ICEQ author.

LISREL was used to carry out CFA while AMOS was used to draw the diagram that represents the structure of the scale. LISREL was used because of its flexibility to handle a variety of scales (e.g. whether they are ordinal, continuous, etc.). Some programs are different from LISREL because they (like AMOS) make assumptions about the scale on which variables are measured. AMOS was used to draw diagrams since structural diagrams can be drawn easily and neatly using its user-friendly interface. The following sections report on the results of the CFA tests carried out for each sample of students, school level-wise and country-wise.

Confirmatory factor analysis of the Measurement Model

Based on the ICEQ author's analysis findings, the five scales measure discrete but somewhat overlapping aspects the classroom environment. This incited the author of this study to make the five-correlated factors model to become the measurement model. The five-correlated factors are Personalisation (PERSN/PRSN), Participation (PARTI/PRTI), Independence (INDEP/INDP), Investigation (INVES/INVS) and Differentiation (DFFER/DFER). Figure 8.1 shows the structure of the measurement model for the actual classroom environment (as perceived by the students) including the five latent factors and their corresponding observed variables. This is exactly the same measurement model structure used for the student preferred classroom environment (Figure 8.2).

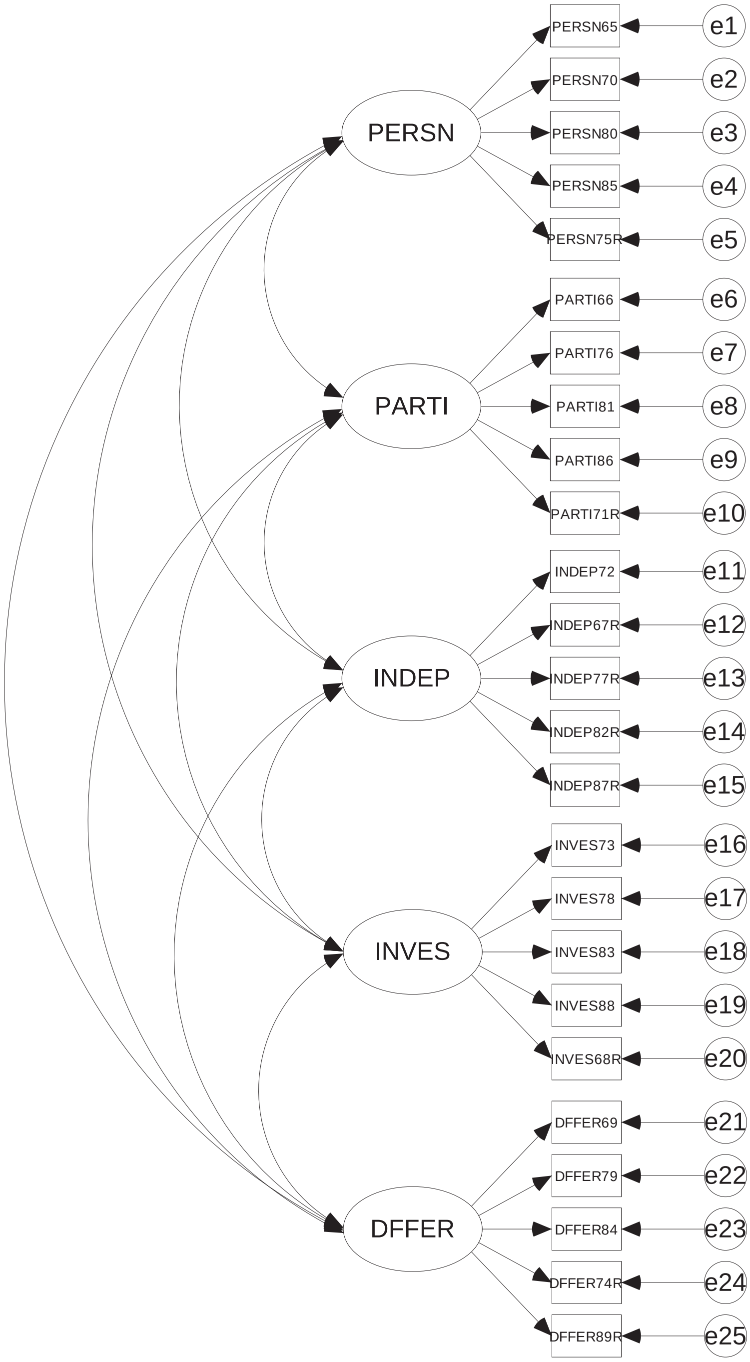


Figure 8.1. Structure of the 5-correlated factors Model for the Individualised Classroom Environment Questionnaire (Actual).

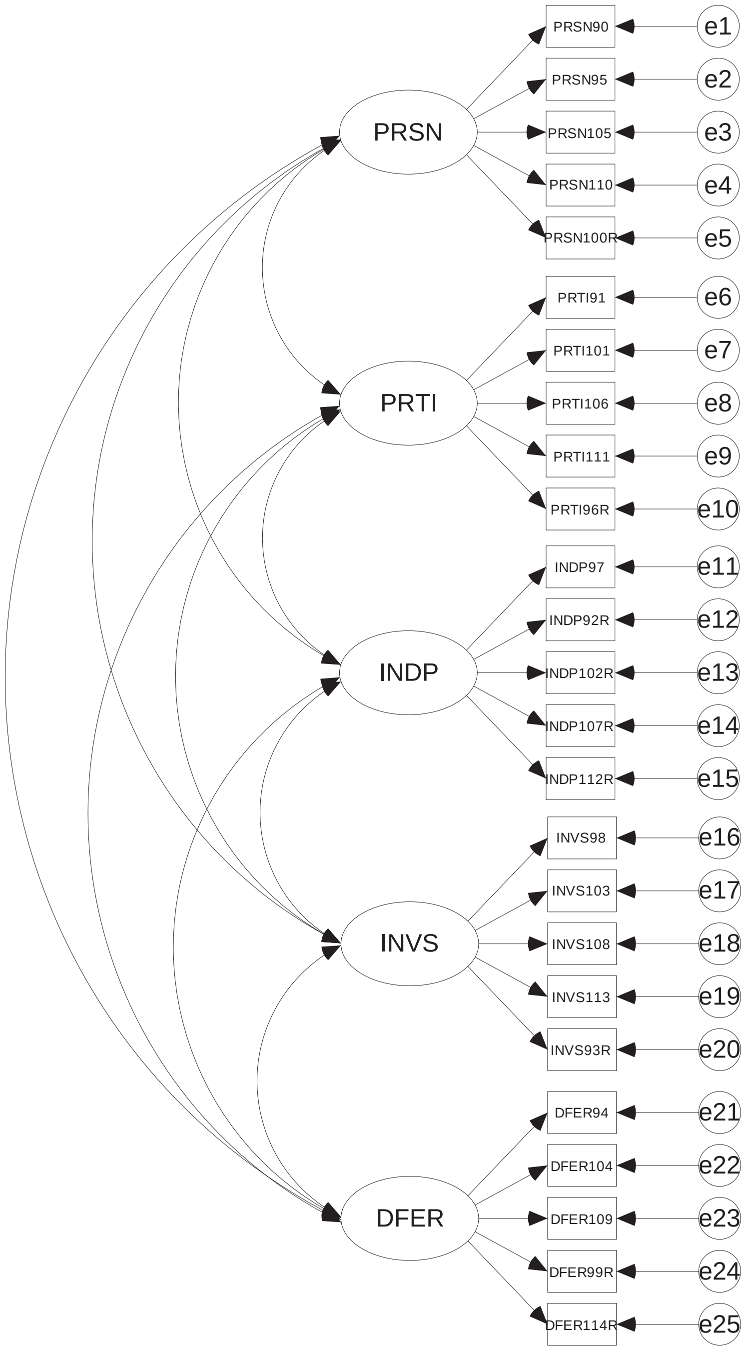


Figure 8.2. Structure of the 5-correlated factors Model for the Individualised Classroom Environment Questionnaire (Preferred).

The results presented in the following sections drew from this study's data sets collected from a sample of South Australian high school and university Physics students, and from sample of Filipino high school and university Physics students. A Five-factor model was fitted to each set of data in the following order of samples:

- South Australian high school physics students
- South Australian university physics students
- Combined South Australian high school and university physics students
- Filipino high school physics students
- Filipino university physics students
- Combined Filipino high school and university physics students.

Results of the CFA runs are presented in table form showing the loading value (together with the standard error and residual) of each observed variable onto its latent factor. For an observed variable to fit the latent factor, it should have a minimum loading value of 0.40. Items loading above 0.40 indicate that they are reflective of the latent factor being measured. Model fit indexes for each model are also presented for comparison to determine which 5-factor model fits best which sample of Physics students.

Tabulated results for the CFA of the measurement model fitted into the 'actual classroom' data and the 'preferred classroom' data are presented separately.

Model Fit Indexes

The different model fit indexes from a CFA run using LISREL are the same as the ones presented in the previous validation chapters: GFI, AGFI, PGFI, RMR and RMSEA. A model shows good fit when their minimum GFI, AGFI and PGFI value equals 0.90. RMSEA and RMR values should be below 0.05 to indicate good fit. These fit indexes indicate the extent to which the data is different from the model fitted. According to Cramer (2003, p. 28), "If the data support the model, the data will not differ significantly from the model."

The South Australian sample

The following sections present results of the CFA tests for the five-correlated factors model fitted into the data from the South Australian sample. These sets of data are the same as the ones used in the previous validation chapters. However, this time the section of the data concerning students' classroom environment was used. Three CFA tests were carried out separately using data sets from samples of South Australian high school students, university students, and a data set combining the high school and university data sets.

South Australian High School Physics Students Sample

The results of the five-correlated factors test using the data set from South Australian high school Physics students sample are shown in Tables 8.3 and 8.4. With reference to Table 8.3 showing the results of fitting the model into the high sample data (for the 'actual classroom'), five out of the 25 items in the ICEQ did not fit the model. The items include: PERSN65 (0.34), PERSN70 (0.20), PERSN85 (0.32), INDEP87R (0.32) and INVES68R (0.13). The rest of the items show modest to strong associations with their corresponding latent factor they intend to reflect or measure. In addition, correlation figures of one latent factor to the other latent factors range from a low 0.05 (INVES – DFFER) to a strong 0.87 (PERSN – INDEP). This indicates that some latent factors show independence of the others while some show dependence of the others. This seems to confirm Fraser's findings of the independent but somewhat overlapping nature of the different aspects of classroom climate in the ICEQ. However, the scale independence in the ICEQ seems not to be adequate enough when the model was fitted to this set of data due to moderate to high correlation values between some of the factors (e.g., PERSN – INDEP = 0.87; PERSN – PART = 0.73; PARTI – INVES = 0.51).

Results of fitting the model into the 'preferred classroom' data are shown in Table 8.4. Three of the 25 items did not fit the model. The items include PRSN95 (0.39), PRTI96R (0.35) and INVS93R (0.28). Similar to the 'Actual Classroom' form of the ICEQ, the last items (PRTI96R and INVS93R) in the 'participation' (PRTI) and the 'investigation' (INVS) aspects of the classroom climate did not fit the model.

Table 8.3. Factor loadings of the 5-correlated factors model for 'Actual Classroom' (South Australian high school sample).

Variable	*Loadings (se)** *PERSN*	*PARTI*	*INDEP*	*INVES*	*DFFER*
PERSN65	0.34(0.07)				
PERSN70	0.20(0.07)				
PERSN80	0.57(0.06)				
PERSN85	0.32(0.07)				
PERSN75R	0.82(0.06)				
PARTI66		0.67(0.06)			
PARTI76		0.53(0.07)			
PARTI81		0.74(0.06)			
PARTI86		0.65(0.06)			
PARTI71R		0.47(0.07)			
INDEP72			0.58(0.06)		
INDEP67R			0.87(0.05)		
INDEP77R			0.49(0.06)		
INDEP82R			0.70(0.06)		
INDEP87R			0.32(0.07)		
INVES73				0.58(0.07)	
INVES78				0.63(0.07)	
INVES83				0.54(0.07)	
INVES88				0.65(0.07)	
INVES68R				0.13(0.08)	
DFFER69					0.64(0.07)
DFFER79					0.60(0.07)
DFFER84					0.45(0.07)
DFFER74R					0.59(0.07)
DFFER89R					0.53(0.07)

**n=240; p=0.000*

Generally, the items in the 'preferred classroom' form of the ICEQ have higher loadings than the items in the 'Actual Classroom' form. However this does not guarantee better model fit. An examination of the different model fit indexes would give a better overall 'view' of the instruments in terms of their fit to the data. Summary of the model fit indexes are discussed later in the chapter.

Table 8.4. Factor loadings of the 5-correlated factors model for 'Preferred Classroom' (South Australian high school sample).

Variable	*Loadings (se)** *PRSN*	*PRTI*	*INDP*	*INVS*	*DFER*
PRSN90	0.63(0.07)				
PRSN95	0.39(0.07)				
PRSN105	0.78(0.06)				
PRSN110	0.70(0.06)				
PRSN100R	0.64(0.07)				
PRTI91		0.75(0.06)			
PRTI101		0.67(0.06)			
PRTI106		0.75(0.06)			
PRTI111		0.83(0.06)			
PRTI96R		0.35(0.07)			
INDP97			0.61(0.07)		
INDP92R			0.79(0.06)		
INDP102R			0.60(0.07)		
INDP107R			0.78(0.06)		
INDP112R			0.48(0.07)		
INVS98				0.81(0.06)	
INVS103				0.87(0.06)	
INVS108				0.47(0.07)	
INVS113				0.71(0.06)	
INVS93R				0.28(0.07)	
DFER94					0.93(0.06)
DFER104					0.64(0.06)
DFER109					0.55(0.07)
DFER99R					0.59(0.07)
DFER114R					0.45(0.07)

$n=222$; $p=0.000$

South Australian University Physics Students Sample

This set of data was collected from a sample of 45 first year university Physics students. They came from one of the three universities in South Australia which is located in the Adelaide Metropolitan area. The results of the CFA test of the 5-correlated factors model using the data are shown in Table 8.5 for the 'Actual Classroom' form of the ICEQ, and Table 8.6 for the 'Preferred Classroom' form. It appears that all items, except one (DFFER89R = 0.37), show modest to strong loading values. Moreover, scales do not show adequate independence with correlation values range from 0.57 to 0.90 indicating modest to strong correlations. However, a strong caution was taken in the interpretation of the results due the issue of sample size. The sample size is smaller than the number of parameters which renders the parameter estimates to be unreliable –

a warning issued by LISREL as it performed CFA. Therefore, the results presented were not used for comparison purposes. This is consistent with Thompson's (2000) recommendation not to use CFA and SEM with small samples.

Table 8.5. Factor loadings of the 5-correlated factors model for 'Actual Classroom' (South Australian university sample).

	*Loadings (se)**				
Variable	*PERSN*	*PARTI*	*INDEP*	*INVES*	*DFFER*
PERSN65	0.68(0.22)				
PERSN70	0.89(0.22)				
PERSN80	0.83(0.22)				
PERSN85	0.81(0.22)				
PERSN75R	0.54(0.23)				
PARTI66		0.86(0.21)			
PARTI76		0.79(0.22)			
PARTI81		0.75(0.22)			
PARTI86		0.91(0.21)			
PARTI71R		0.76(0.22)			
INDEP72			0.81(0.24)		
INDEP67R			0.92(0.24)		
INDEP77R			0.43(0.25)		
INDEP82R			0.51(0.25)		
INDEP87R			0.49(0.25)		
INVES73				0.67(0.23)	
INVES78				0.66(0.24)	
INVES83				0.82(0.23)	
INVES88				0.72(0.23)	
INVES68R				0.49(0.24)	
DFFER69					0.75(0.24)
DFFER79					0.73(0.24)
DFFER84					0.80(0.24)
DFFER74R					0.63(0.25)
DFFER89R					0.37(0.25)

**n=45; p=1.000*

The results above have shown differences with the results (see Table 8.6) when the model was fitted into the university sample data concerning the students' preferred Physics classroom environment. Four items (PRSN100R = 0.35, INDP102R = 0.34, INVS93R = 0.31 and DFER114R = 0.27) did not fit the model. Scales for the different aspects of classroom environment also showed somewhat adequate independence with correlation values ranging from 0.08 to 0.73. Only the pairs of 'Participation' (PRTI) and 'investigation' (INVS), and 'personalisation' (PRSN) and 'participation' (PRTI) show strong correlation (0.70 and 0.73, respectively).

Table 8.6. Factor loadings of the 5-correlated factors model for 'Preferred Classroom' (South Australian university sample).

	*Loadings (se)**				
Variable	*PRSN*	*PRTI*	*INDP*	*INVS*	*DFER*
PRSN90	0.71(0.25)				
PRSN95	0.95(0.25)				
PRSN105	0.69(0.25)				
PRSN110	0.47(0.26)				
PRSN100R	0.35(0.26)				
PRTI91		0.57(0.24)			
PRTI101		0.82(0.23)			
PRTI106		0.91(0.22)			
PRTI111		0.78(0.23)			
PRTI96R		0.57(0.24)			
INDP97			0.49(0.27)		
INDP92R			0.41(0.26)		
INDP102R			0.34(0.26)		
INDP107R			1.17(0.36)		
INDP112R			0.47(0.26)		
INVS98				0.92(0.23)	
INVS103				0.83(0.23)	
INVS108				0.82(0.23)	
INVS113				0.78(0.24)	
INVS93R				0.31(0.25)	
DFER94					0.99(0.27)
DFER104					0.74(0.25)
DFER109					0.42(0.26)
DFER99R					0.87(0.26)
DFER114R					0.27(0.26)

**n=43; p=1.000*

However, a similar caution was taken in the interpretation of the results due the issue of sample size. Thus, the results from the CFA run using the university sample data were not used for comparison with the other CFA results using the high school sample data and the combined samples data.

Combined South Australian High School and University Student Samples

Combining the data sets collected from the high school and the university samples was considered feasible by the author for a number of reasons. The author of this study has combined the high school and university data sets for a number of reasons. The average age difference between the high school and university student samples is around one year. In addition, the first year university student samples were just into their second week of university classes when they filled out the survey questionnaire. It was therefore assumed that student samples from both groups (high school and university) were likely to hold similar attitudes and perceptions towards things – like school subjects, for instance. Another reason is, based on the results of the CFA runs using the high school and university samples data, there is some degree of similarity in the pattern in terms of misfitting items. Lastly, combining the two sets of data significantly increases the sample size which makes SEM more fit for use (Thompson, 2000 in Phakiti, 2007).

Table 8.7. Factor loadings of the 5-correlated factors model for 'Actual Classroom' (South Australia combined samples).

	*Loadings (se)**				
Variable	*PERSN*	*PARTI*	*INDEP*	*INVES*	*DFFER*
PERSN65	0.72(0.05)				
PERSN70	0.54(0.06)				
PERSN80	0.81(0.05)				
PERSN85	0.66(0.06)				
PERSN75R	0.48(0.06)				
PARTI66		0.78(0.05)			
PARTI76		0.60(0.06)			
PARTI81		0.79(0.05)			
PARTI86		0.72(0.05)			
PARTI71R		0.62(0.06)			
INDEP72			0.65(0.06)		
INDEP67R			0.76(0.06)		
INDEP77R			0.43(0.06)		
INDEP82R			0.78(0.06)		
INDEP87R			0.32(0.06)		
INVES73				0.53(0.06)	
INVES78				0.69(0.06)	
INVES83				0.52(0.06)	
INVES88				0.74(0.06)	
INVES68R				0.19(0.07)	
DFFER69					0.73(0.06)
DFFER79					0.66(0.06)
DFFER84					0.46(0.06)
DFFER74R					0.61(0.06)
DFFER89R					0.38(0.07)

**n=282; p=0.000*

Combining the two sets of data and fitting the 5-correlated factors data into it yields the results shown in Table 8.7. Out of 25 items, three items were identified to not fit the model. These items include INDEP87R (0.32), INVES68R (0.19) and DFFER89R (0.38). This is two items less than the number of items that failed to fit when the high school data was used. Items INDEP87R and INVES68R failed to fit in both models fitted to the high school and the combined sets of data. Similar to the high school sample's 5-correlated factors model, there is a significant amount of unexplained variance in this model that used the combined sets of data.

Values to indicate independence between scales appear to be not too adequate with correlations ranging from 0.04 to 0.91. Of the ten scales correlation values, six show modest to strong correlations.

Table 8.8 shows the results from fitting the 5-correlated factors model to the 'preferred classroom' data from the combined samples. Only two misfitting items appear. These misfitting items are different from those in the results presented in Table 8.7. These include PRTI96R (0.38) and INVS93R (0.31). These items also did not fit the model fitted to the high school 'actual classroom' data.

Scale correlation values range from 0.05 to 0.76. Correlated scales showing strong correlations are 'personalisation' (PRSN) and 'participation (PRTI) (0.76), and 'participation' (PRTI) and investigation (INVS) (0.62). This indicates, to a certain degree, scale independence. It also demonstrates the overlapping nature of the different aspects of classroom climate in the ICEQ.

However, the statistics provided above do not necessarily indicate which model best fitted the different data sets. An examination of some goodness-of-fit statistics was carried out to make conclusions about model fit.

Table 8.8. Factor loadings of the 5-correlated factors model for 'Preferred Classroom' (South Australia combined samples).

	*Loadings (se)**				
Variable	*PRSN*	*PRTI*	*INDP*	*INVS*	*DFER*
PRSN90	0.65(0.06)				
PRSN95	0.46(0.06)				
PRSN105	0.77(0.06)				
PRSN110	0.69(0.06)				
PRSN100R	0.63(0.06)				
PRTI91		0.73(0.06)			
PRTI101		0.69(0.06)			
PRTI106		0.77(0.05)			
PRTI111		0.82(0.05)			
PRTI96R		0.38(0.06)			
INDP97			0.62(0.06)		
INDP92R			0.72(0.06)		
INDP102R			0.56(0.06)		
INDP107R			0.82(0.06)		
INDP112R			0.48(0.06)		
INVS98				0.83(0.05)	
INVS103				0.86(0.05)	
INVS108				0.52(0.06)	
INVS113				0.73(0.06)	
INVS93R				0.31(0.06)	
DFER94					0.94(0.05)
DFER104					0.65(0.06)
DFER109					0.56(0.06)
DFER99R					0.63(0.06)
DFER114R					0.41(0.06)

**n=265; p=0.000*

Fit Indexes of the 5-Correlated Factors Models (South Australian Sample)

Summarized above are the threshold values for the fit indexes presented in this chapter. Tables 8.9 (Actual Classroom) and 8.10 (Preferred Classroom) show the summary of the three 5-correlated factors models fitted to the different groups of South Australian sample data. It should be noted that the goodness-of-fit indexes presented for the set of data from the university Physics students' group cannot be used for comparison with the other two models due to the limited sample size; too few that it generated errors (as indicated in the output) when subjected to CFA using LISREL.

In Table 8.9, both models have RMSEA and RMR values that indicate poor fit. Both GFI and AGFI values are below 0.90 which is the accepted value to indicate good fit. A slight improvement in the model fit can be observed when the model was fitted into the combined sets of data. However, overall, these fit indexes suggest a poor-fitting model.

Table 8.9: Goodness-of-fit index summary for the 5-correlated factors model fitted to 'Actual Classroom' data (South Australian sample).

	High School data	University data*	Combined data
Chi-Square	1309.61	69.98	1246.70
df	265	265	265
GFI	0.70	0.89	0.74
AGFI	0.63	0.86	0.68
PGFI	0.57	0.72	0.60
RMR	0.13	0.12	0.12
RMSEA	0.13	0.0	0.11

**cannot be used for comparison*

Both have PGFI indicating that there is a moderate amount of complexity within the models. A variety of modification indexes, a majority of them for error correlations, suggested that the model could be improved. However, these modifications were not undertaken because of the limited grounding on theories guiding specification of error correlations.

Results in Table 8.10 show similar trend in terms of overall model fit. Values of all the fit indexes suggest that the model fits poorly into the data. A very slight improvement in the GFI, AGFI, PGFI and RMR values can be observed when the model was fitted into the combined sets of data.

Table 8.10. Goodness-of-fit index summary for the 5-correlated factors model fitted to 'Preferred Classroom' data (South Australian sample).

	High School data	University data*	Combined data
Chi-Square	1306.95	100.08	1427.99
df	265	265	265
GFI	0.68	0.84	0.70
AGFI	0.61	0.80	0.63
PGFI	0.55	0.68	0.57
RMR	0.13	0.18	0.12
RMSEA	0.13	0.0	0.13

**cannot be used for comparison*

Similar to the results fitting the model into the 'Actual Classroom' data, a variety of modification indexes, where a majority of them are for error correlations, suggested that the model could be improved. However, these modifications were no longer considered because of the limited grounding on theories guiding specification of error correlations. Instead, an examination of alternative models which will be discussed in the later sections of this chapter was carried out.

The Filipino sample

This section presents the results of fitting the 5-correlated factors model into the data collected from a sample of high school and university Physics students in the Philippines. These sets of data are the same as the ones used in the previous two chapters. The section of the data that concerns students' experiences in the Physics classroom was subjected to the analysis. Three CFA tests were carried out separately using data sets from a sample of Filipino high school students, university students, and a data set combining the high school and university data sets. The same set of fit indexes is reported.

Filipino High School Physics Students Sample

Fitting the data for the 'actual classroom' from the Filipino high school sample yielded results shown in Table 8.11. Six items from the ICEQ did not fit the model when their item loadings fell below 0.40. The items loading below 0.40 were PERSN70 (0.05), INDEP77R (0.31), INVES68R (0.02), DFFER84 (0.39), DFFER74R (0.19) and

DFFER89R (0.23). Of these six items, two PERSN70 and INVES68R) failed to fit the 5-correlated factors model fitted to both the South Australian high school sample data and the Filipino high school sample data.

Table 8.11. Factor loadings of the 5-correlated factors model for 'Actual Classroom' (Filipino high school sample).

	*Loadings (se)**				
Variable	*PERSN*	*PARTI*	*INDEP*	*INVES*	*DFFER*
PERSN65	0.50(0.06)				
PERSN70	0.05(0.06)				
PERSN80	0.65(0.06)				
PERSN85	0.64(0.06)				
PERSN75R	0.58(0.06)				
PARTI66		0.71(0.05)			
PARTI76		0.77(0.05)			
PARTI81		0.64(0.06)			
PARTI86		0.60(0.06)			
PARTI71R		0.45(0.06)			
INDEP72			0.41(0.07)		
INDEP67R			0.63(0.06)		
INDEP77R			0.31(0.07)		
INDEP82R			0.69(0.06)		
INDEP87R			0.52(0.06)		
INVES73				0.77(0.05)	
INVES78				0.74(0.05)	
INVES83				0.46(0.06)	
INVES88				0.73(0.05)	
INVES68R				0.02(0.06)	
DFFER69					0.53(0.08)
DFFER79					0.68(0.08)
DFFER84					0.39(0.07)
DFFER74R					0.17(0.07)
DFFER89R					0.23(0.07)

**n=304; p=0.000*

With the model fitted to this data, the scales demonstrate reasonable independence from each other. When the five scales were correlated, only two pairs showed strong correlation: 'personalisation' (PERSN) and 'participation' (PARTI) with 0.87, and 'participation' (PARTI) and 'investigation' (INVES) with 0.70.

Fitting the model into the 'preferred classroom' Filipino high school sample data yielded results provided in Table 8.12. Six of the 25 items did not fit the model with some of them loading very poorly. The items include PRSN95 (0.07), PRTI96R (0.39), INDP97 (0.27), INVS93R (0.14), DFER104 (0.33) and DFER114R (0.33). Of these, three (PRSN95, PRTI96R and INVS93R) are the same as those that did not fit the South Australian high school sample data.

Table 8.12. Factor loadings of the 5-correlated factors model for 'Preferred Classroom' (Filipino high school sample).

	*Loadings (se)**				
Variable	*PRSN*	*PRTI*	*INDP*	*INVS*	*DFER*
PRSN90	0.50(0.06)				
PRSN95	0.07(0.06)				
PRSN105	0.77(0.05)				
PRSN110	0.72(0.05)				
PRSN100R	0.44(0.06)				
PRTI91		0.74(0.05)			
PRTI101		0.73(0.05)			
PRTI106		0.73(0.05)			
PRTI111		0.72(0.05)			
PRTI96R		0.39(0.06)			
INDP97			0.27(0.07)		
INDP92R			0.66(0.07)		
INDP102R			0.52(0.07)		
INDP107R			0.59(0.07)		
INDP112R			0.51(0.07)		
INVS98				0.80(0.05)	
INVS103				0.77(0.05)	
INVS108				0.50(0.06)	
INVS113				0.84(0.05)	
INVS93R				0.14(0.06)	
DFER94					0.56(0.07)
DFER104					0.33(0.07)
DFER109					0.54(0.07)
DFER99R					0.49(0.07)
DFER114R					0.33(0.07)

**n=302; p=0.000*

When the five constructs were correlated, the following pairs show strong correlation: 'personalisation' (PRSN) and 'participation' (PRTI) with 0.87, and 'participation' (PRTI) and 'investigation' (INVS) with 0.67. These pairs also showed strong correlation in the 'actual classroom' ICEQ.

Filipino University Physics Students Sample

Fitting the 5-correlated factors model into the data for the ICEQ 'actual classroom' from a sample of Filipino university Physics students obtained results as shown in Table 8.13. Five out of 25 items failed to load with at least 0.40 and were considered to not fit the model. The items include PERSN75R (0.23), INDEP72 (0.18), INDEP77R (0.31), DFFER79 (0.08) and DFFER89R (0.31). This CFA run using LISREL had no warnings about the sample size and the number of parameters, hence, making the results usable for comparison with the results fitting the model in the other sets of Filipino data. These results were not compared to the ones from using the data from the sample of South Australian university students due to reasons cited above. Items INDEP77R and DFFER89R demonstrated misfit in the model fitted to both 'actual classroom' high school and university sets of 'actual classroom' data.

Using the university data, the correlation values between scales were low enough to suggest scale independence except for the following correlated scales: 'personalisation' (PERSN) and 'participation' (PARTI) with a correlation value of 0.75, and 'personalisation' (PERSN) and 'investigation' (INVES) with 0.59.

Table 8.14 provides the results of carrying out CFA with the 5-correlated factors model into the data for the ICEQ 'preferred classroom' from a sample of Filipino university Physics students. Four items out of 25 show misfit to the model. The items include PRTI96R (0.33), DFFER104 (0.32), DFFER109 (0.34) and DFFER114R (0.11). The 5-correlated factors model fitted to the Filipino high school data produced six misfitting items. Similar to the results of using the 'actual classroom' data, this CFA run using LISREL had no warnings about the sample size and the number of parameters, hence, making the results usable for comparison with the results fitting the model in the other sets of Filipino data. These results were not compared to the ones from using the data from the sample of South Australian university students due to reasons cited above. Items PRTI96R, DFER104 and DFER114R demonstrated misfit in the model fitted to both 'actual classroom' high school and university sets of 'preferred classroom' data.

Table 8.13. Factor loadings of the 5-correlated factors model for 'Actual Classroom' (Filipino university sample).

Variable	*Loadings (se)** *PERSN*	*PARTI*	*INDEP*	*INVES*	*DFFER*
PERSN65	0.62(0.10)				
PERSN70	0.67(0.10)				
PERSN80	0.69(0.10)				
PERSN85	0.54(0.10)				
PERSN75R	0.23(0.11)				
PARTI66		0.72(0.10)			
PARTI76		0.70(0.10)			
PARTI81		0.75(0.09)			
PARTI86		0.60(0.10)			
PARTI71R		0.66(0.10)			
INDEP72			0.18(0.11)		
INDEP67R			0.84(0.10)		
INDEP77R			0.31(0.11)		
INDEP82R			0.82(0.10)		
INDEP87R			0.48(0.11)		
INVES73				0.79(0.09)	
INVES78				0.72(0.10)	
INVES83				0.48(0.10)	
INVES88				0.73(0.10)	
INVES68R				0.49(0.10)	
DFFER69					0.70(0.14)
DFFER79					0.08(0.13)
DFFER84					0.11(0.13)
DFFER74R					0.45(0.12)
DFFER89R					0.31(0.12)

**n=96; p=0.000*

Similar to the pattern observed in the previous 5-correlated factors model fitted to different sets of data, correlation values resulting from correlating the scales demonstrate a reasonable amount of independence between them. Pairs of scales showing high correlation values when the model was fitted to this set of data were 'personalisation' (PRSN) and 'investigation' (INVS) with 0.85, 'personalisation' (PRSN) and 'participation' (PRTI) with the same value, and 'participation' (PRTI) and 'investigation' (INVS) with 0.72.

Table 8.14. Factor loadings of the 5-correlated factors model for 'Preferred Classroom' (Filipino university sample).

	*Loadings (se)**				
Variable	*PRSN*	*PRTI*	*INDP*	*INVS*	*DFER*
PRSN90	0.69(0.10)				
PRSN95	0.62(0.10)				
PRSN105	0.56(0.10)				
PRSN110	0.51(0.10)				
PRSN100R	0.63(0.10)				
PRTI91		0.88(0.09)			
PRTI101		0.72(0.10)			
PRTI106		0.69(0.10)			
PRTI111		0.83(0.09)			
PRTI96R		0.33(0.11)			
INDP97			0.49(0.11)		
INDP92R			0.81(0.11)		
INDP102R			0.42(0.11)		
INDP107R			0.86(0.10)		
INDP112R			0.52(0.11)		
INVS98				0.91(0.09)	
INVS103				0.97(0.08)	
INVS108				0.49(0.11)	
INVS113				0.87(0.09)	
INVS93R				0.48(0.11)	
DFER94					0.91(0.15)
DFER104					0.32(0.12)
DFER109					0.34(0.12)
DFER99R					0.62(0.13)
DFER114R					0.11(0.12)

$n=96$; $p=0.000$

Combined Samples of Filipino High School and University Students

CFA runs were carried out using the combined data from samples of Filipino high school and university Physics students. Combining the two sets of data was considered feasible by the author due to the following reasons. The average age difference between the high school and university student samples is around one year. In addition, the first year university student samples were only into their second month of university classes when they filled out the survey questionnaire. It was therefore assumed that student samples from both groups (high school and university) were likely to hold similar attitudes and perceptions towards things – like school subjects, for instance. Although the results of the CFA using the university data are considered unreliable due to the small sample size, some of the misfitting items in the CFA results using the high school data consistently misfit when the model was fitted to the university data. This indicates some item invariance in model fitting. Therefore, it was feasible to combine the two data sets. Lastly, combining the two sets of data significantly increases the sample size which makes SEM more fit for use (Thompson, 2000 in Phakiti, 2007). The results are shown in Tables 8.15 and 8.16.

Table 8.15. Factor loadings of the 5-correlated factors model for 'Actual Classroom' (Philippines combined samples).

	*Loadings (se)**				
Variable	*PERSN*	*PARTI*	*INDEP*	*INVES*	*DFFER*
PERSN65	0.53(0.05)				
PERSN70	0.20(0.06)				
PERSN80	0.68(0.05)				
PERSN85	0.62(0.05)				
PERSN75R	0.49(0.05)				
PARTI66		0.71(0.05)			
PARTI76		0.76(0.05)			
PARTI81		0.66(0.05)			
PARTI86		0.59(0.05)			
PARTI71R		0.49(0.05)			
INDEP72			0.51(0.05)		
INDEP67R			0.78(0.05)		
INDEP77R			0.54(0.05)		
INDEP82R			0.82(0.05)		
INDEP87R			0.46(0.05)		
INVES73				0.79(0.05)	
INVES78				0.75(0.05)	
INVES83				0.45(0.05)	
INVES88				0.70(0.05)	
INVES68R				0.16(0.05)	
DFFER69					0.59(0.08)
DFFER79					0.50(0.07)
DFFER84					0.39(0.07)
DFFER74R					0.25(0.07)
DFFER89R					0.25(0.07)

$^*n$=400; p=0.000

Table 8.15 shows the results of carrying out CFA using a 5-correlated factors model fitted to the combined 'actual classroom' data. Five items demonstrated misfit to the model. These include PERSN70 (0.20), INVS68R (0.16), DFFER84 (0.39), DFFER74R (0.25) and DFFER89R (0.25). Comparing the misfitting items in this model fitted to this data and the misfitting items in the model fitted to the combined South Australian sample 'actual classroom' data, items INVS68R and DFFER89R showed model misfit in both groups of samples.

With regard to the correlation values resulting from correlating the scales, a reasonable amount of independence between them is demonstrated. This is similar to the pattern observed in the previous 5-correlated factors model fitted to different sets of data. Pairs of scales showing moderate to high correlation values when the model was fitted to this set of data were 'personalisation' (PERSN) and 'participation' (PARTI) with 0.83, 'personalisation' (PERSN) and 'investigation' (INVES) with 0.64, and 'participation' (PARTI) and 'investigation' (INVES) with 0.63.

Fitting the 5-correlated factors model to the combined 'preferred classroom' data yields the results shown in Table 8.16 where five out of the 25 items did not fit. The misfitting items include PRSN95 (0.24), PRTI96R (0.39), INVS93R (0.25), DFER104 (0.36) and DFER114R (0.31). Comparing the 5-correlated factors models fitted to combined 'preferred classroom' data for the South Australian sample and the Filipino sample, PRTI96R and INVS93R failed to fit in both. The difference in the number of misfitting items already indicates variance in model fitting. In other words, the ICEQ behaves differently when used in different groups of samples, particularly in this study. This has been a common observation for all the comparisons made with the results of fitting the 5-correlated factors model to different groups of samples used in this study.

With regard to the correlation values resulting from correlating the scales, a reasonable amount of independence between them is demonstrated. This is similar to the pattern observed in the previous 5-correlated factors model fitted to different sets of data. Pairs of scales showing moderate to high correlation values when the model was fitted to this set of data were 'personalisation' (PRSN) and 'participation' (PRTI) with 0.88, 'personalisation' (PRSN) and 'investigation' (INVS) with 0.61, and 'participation' (PARTI) and 'investigation' (INVES) with 0.69.

Table 8.16. Factor loadings of the 5-correlated factors model for 'Preferred Classroom' (Philippines combined samples).

	*Loadings (se)**				
Variable	*PRSN*	*PRTI*	*INDP*	*INVS*	*DFER*
PRSN90	0.56(0.05)				
PRSN95	0.24(0.05)				
PRSN105	0.74(0.05)				
PRSN110	0.69(0.05)				
PRSN100R	0.45(0.05)				
PRTI91		0.77(0.04)			
PRTI101		0.73(0.05)			
PRTI106		0.72(0.05)			
PRTI111		0.74(0.05)			
PRTI96R		0.39(0.05)			
INDP97			0.46(0.05)		
INDP92R			0.76(0.05)		
INDP102R			0.60(0.05)		
INDP107R			0.72(0.05)		
INDP112R			0.53(0.05)		
INVS98				0.85(0.04)	
INVS103				0.83(0.04)	
INVS108				0.48(0.05)	
INVS113				0.83(0.04)	
INVS93R				0.25(0.05)	
DFER94					0.65(0.06)
DFER104					0.36(0.06)
DFER109					0.46(0.06)
DFER99R					0.52(0.06)
DFER114R					0.31(0.06)

**n=398; p=0.000*

Fit Indexes of the 5-Correlated Factors Models (Filipino Sample)

Summarized above are the threshold values for the fit indexes presented in this chapter. Tables 8.17 (Actual Classroom) and 8.18 (Preferred Classroom) show the summary of the three 5-correlated factors models fitted to the different groups of Filipino sample data.

In Table 8.17, the models fitted to the high school and the combined high and university data have the same RMSEA values that indicate mediocre fit (Diamantopoulos & Siguaw, 2000). However, these two models' GFI, AGFI and RMR values indicate poor fit to the data. The PGFI values for both models demonstrate some model complexity which may have brought down the values of the GFI and AGFI. This conflict raises doubts regarding the models' fit to the data. Nonetheless, the 5-correlated factors model shows the best fit among the three models compared. The model fitted to the university data shows the worst fit.

Table 8.17. Goodness-of-fit index summary for the 5-correlated factors model fitted to 'Actual Classroom' data (Filipino sample).

	High School data	University data	Combined data
Chi-Square	977.79	642.54	1169.96
df	265	265	265
GFI	0.79	0.81	0.81
AGFI	0.75	0.77	0.77
PGFI	0.65	0.66	0.66
RMR	0.10	0.10	0.10
RMSEA	0.09	0.12	0.09

Table 8.18 summarizes the goodness-of-fit statistics of the models fitted to the different groups of 'preferred classroom' data from the Filipino sample. The model fitted to the high school data and the model fitted to the combined data both show an RMSEA value that indicate mediocre fit (Diamantopoulos & Siguaw, 2000). However, the other fit indexes indicate otherwise which raises some doubt about the model's fit to the data. This may have been the result of the PGFI values for both models indicating their complexity.

Among the three models fitted to the different sets of data, the model fitted to the combined data shows the best statistical fit, and the model fitted to the university data shows the worst fit.

Table 8.18. Goodness-of-fit index summary for the 5-correlated factors model fitted to 'Preferred Classroom' data (Filipino sample).

	High School data	University data	Combined data
Chi-Square	1010.72	626.14	1247.11
df	265	265	265
GFI	0.79	0.65	0.80
AGFI	0.74	0.58	0.75
PGFI	0.64	0.53	0.65
RMR	0.10	0.14	0.10
RMSEA	0.10	0.12	0.10

In the light of the premise that "more than one model of the data can be tested to establish which model…provide the…best explanation of the data" (Cramer, 2003, p. 28), structural equation modeling (SEM) was carried out using a second-order (hierarchical) factor model to determine whether the five scales of the ICEQ measure a common underlying factor which was called 'classroom climate' in this study. Consequently, an indication of model fit improvement using this model was also examined.

Alternative model

Drawing from the results of the CFA runs fitting the 5-correlated factors model to the different sets of data used in this study, a second-order (hierarchical) factor model was tested for the reasons stated above. In addition, if the first-order factors are correlated, it is possible that the correlation between the first-order factors is due to a single second-order factor (Jöreskog & Sörbom, 1993). Only the summaries of first-order factor loadings and the goodness-of-fit statistics are provided. The structure of this model is shown in Figure 8.3. For the purpose of analysis, the second-order factor 'classroom climate' was labelled "CLSCLMTE". Both the sets of data collected from South Australian and Filipino high school and university samples were used in testing the second-order factor model. A summary of the first-order factor loadings is provided in Table 8.19.

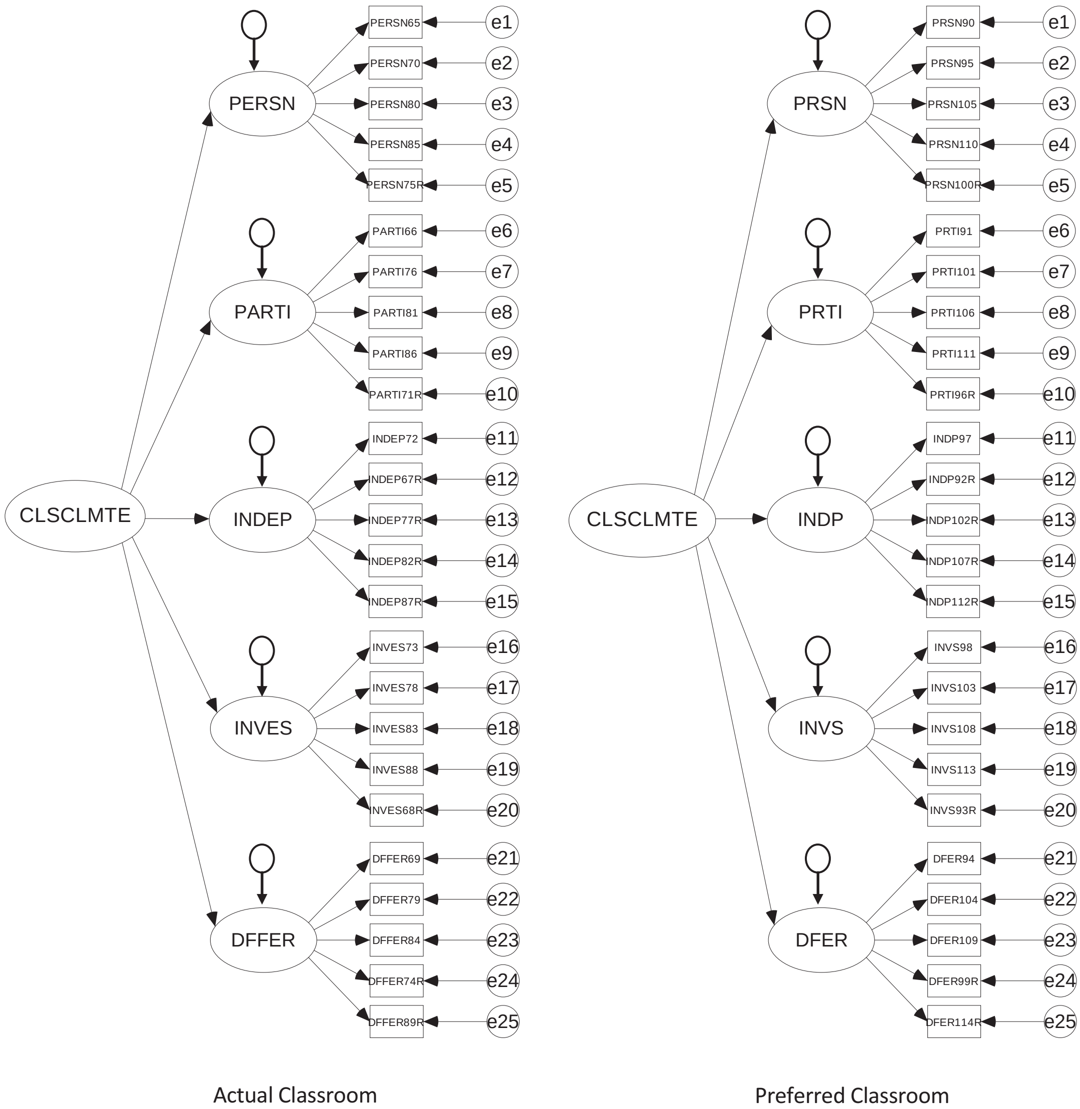


Figure 8.3. Structure of the Second-Order Factor Model for the Individualised Classroom Environment Questionnaire (Actual and Preferred Classrooms).

It can be observed that some of the factor loadings of some of the first-order factors have exceeded 1.0. This is problematic since factor loadings should not exceed this value. In addition, a few of the factor loadings have a negative sign which is another problem. These issues may be a result of fitting the model into a relatively small sample size. Therefore, the second-order factor model does not fit this study's data on 'classroom environment'.

Table 8.19. Summary of first-order factor loadings

First-order latent factors (Actual/Preferred)	*Factor Loadings onto the second-order factor*					
	South Australia – high school sample data	*South Australia – university sample data*	*South Australia – combined high school and university samples data*	*Philippines – high school sample data*	*Philippines – university sample data*	*Philippines – combined high school and university samples data*
PERSN/PRSN	1.01/0.90	0.92/0.57	0.90/0.77	0.90/0.85	1.12/1.09	0.93/0.89
PARTI/PRTI	0.86/0.89	0.93/1.29	1.01/1.00	0.94/1.03	0.67/0.93	0.89/1.00
INDEP/INDP	0.48/0.31	0.71/-0.27	0.16/0.14	0.17/-0.18	-0.14/-0.20	0.09/-0.07
INVES/INVS	0.42/0.60	0.84/0.53	0.53/0.60	0.72/0.65	0.53/0.77	0.69/0.69
DFFER/DFER	-0.47/-0.33	0.68/0.14	-0.45/-0.19	0.15/-0.52	0.01/-0.13	0.09/-0.40

This generalization about the model's fit to the data is further supported by the following goodness-of-fit measures presented as a result of fitting the second-order factor into the different sets of data used in this study.

Table 8.20. Goodness-of-fit index summary for the second-order factor models (Actual Classroom).

	South Australia Sample			*Philippines Sample*		
	High School data	University data*	Combined data	High School data	University data	Combined data
Chi-Square	1467.30	72.92	1407.96	1016.47	670.41	1176.61
df	270	270	270	270	270	270
GFI	0.67	0.88	0.71	0.79	0.64	0.81
AGFI	0.60	0.86	0.66	0.75	0.57	0.77
PGFI	0.56	0.73	0.59	0.65	0.53	0.67
RMR	0.14	0.12	0.13	0.10	0.15	0.10
RMSEA	0.14	0.0	0.12	0.10	0.12	0.09

cannot be used for comparison

Referring to Table 8.20, although neither of the models tested in this study provide satisfactory fit as the chi-square is statistically significant and the RMSEA is larger than 0.1, it can be observed that the second-order factor model for the actual classroom for both South Australian and Filipino sample overall shows poorer fit to the data compared to the 5-correlated factors model fitted to the same samples.

Moreover, the statistical fit shown in Table 8.21 for the second-order factor model fitted to the 'preferred classroom' data from South Australian and Filipino sample show no improvement on the model fit over the 5-correlated factors model. Comparing the all the goodness-of-fit measures presented for the 5-correlated factors model and the second-order factor model, it is clear that the former provides a more satisfactory fit to the data than the latter.

Table 8.21. Goodness-of-fit index summary for the second-order factor models (Preferred Classroom).

	South Australia Sample			*Philippines Sample*		
	High School data	University data*	Combined data	High School data	University data	Combined data
Chi-Square	1483.81	101.02	1591.42	1051.17	633.43	1305.21
df	270	270	270	270	270	270
GFI	0.65	0.84	0.67	0.78	0.65	0.79
AGFI	0.58	0.81	0.61	0.74	0.58	0.75
PGFI	0.54	0.70	0.56	0.65	0.54	0.66
RMR	0.14	0.18	0.14	0.10	0.15	0.10
RMSEA	0.14	0.0	0.14	0.10	0.12	0.10

**For South Australia sample only: figures cannot be used for comparison*

It is evident from the results of the CFA tests that the 5-correlated factors model fitted to the study data provides better fit. Model fit at item-level was verified through Rasch analysis.

8.5. Rasch analysis

Rasch analysis enables for a more detailed, item-level examination of the structure and operation of the CASS.

The data collected in this study concerning physics students' experiences in a physics classroom were fitted to the rating scale model. All 25 items from both the 'actual classroom' and the 'preferred classroom' versions of the ICEQ were included in the initial analysis. In addition, since Fraser's (1990) ICEQ (both versions) covers five different dimensions of the classroom environment (hence, five different scales) which are found to have a certain degree of scale independence, each scale with all their corresponding items was also subjected to Rasch analysis independently. Results are shown in Tables 8.22, 8.23, 8.24 and 8.25.

Item analysis with the Rating Scale Model

The Actual Classroom and the Preferred Classroom versions of the ICEQ were subjected to item analyses by fitting the South Australian and Filipino samples data on Physics students' individualised classroom experiences into the Rating Scale Model. This involved examining each item's fit statistics and item threshold values. More specifically, the infit mean square (INFIT MNSQ) statistic was used as a basis for the model fitting or non-fitting items. Similar to the validation of instruments discussed in the previous chapters, a range of 0.72 to 1.30 was used for the infit mean square to indicate good fitting items.

The combined high school and university sample data sets for Physics students' classroom experiences (for both South Australia and the Philippines) were used in the Rasch analysis fitting the rating scale model. Even when the infit statistics was robust enough not to be affected so much by sample size (Adams & Khoo, 1993), the high school and university student sample data sets were combined for the same reasons stated in the CFA sections, and to keep consistency in handling data for analysis.

The analyses were carried out and results are presented in the following order:

- Combined samples of South Australian high school and university physics students, and Filipino high school and university physics students (Actual Classroom ICEQ – all 25 items included and treated as one scale)
- Combined samples of South Australian high school and university physics students, and Filipino high school and university physics students (Preferred Classroom ICEQ – all 25 items included and treated as one scale)

- Combined samples of South Australian high school and university physics students, and Filipino high school and university physics students (Actual Classroom ICEQ – scales analysed separately and no items removed)
- Combined samples of South Australian high school and university physics students, and Filipino high school and university physics students (Preferred Classroom ICEQ – scales analysed separately and no items removed)

The refinement process involved subsequent runs of the item analysis using ConQuest after removing items that did not fit the model. Misfitting items were removed one at a time. Tabulated results include item estimate, error and the unweighted fit statistics. The unweighted fit statistics include the infit mean square and the *t* value. The separation reliability index, chi-square test of parameter equality, degrees of freedom and significance level are also included. Adams and Khoo (1993) defined separation reliability index as an indication of the proportion of the observed variance that is considered true. There is generally a preference for high separation reliability index because this means that measurement error is smaller.

Table 8.22 provides the results of fitting all the 25 items into the rating scale model. Fitting the data into the rating scale model including all items was undertaken (even when it has been suggested by Fraser that the ICEQ has five scales) to confirm the instruments multidimensionality. Data from the South Australian and Filipino samples were used.

Fitted to the model using the South Australian sample data, eight items appear to misfit having their infit mean squares lie outside the accepted range mentioned above. The misfitting items include PERSN75R (1.47), PARTI76 (0.67), INDEP72 (1.42), INDEP67R (2.12), INDEP82R (1.65), INVES83 (0.68), DFFER69 (1.52) and DFFER79 (1.40). Using the Filipino sample data, five items misfit the model; these include PARTI81 (0.66), PARTI86 (1.36), INDEP67R (1.80), INVES78 (0.59) and DFFER84 (1.33). This simply shows how the Actual Classroom ICEQ behaves differently between the two groups of samples from two different countries. This is similar to behaviour of the instruments presented in the previous chapters. Therefore, comparing the South Australian and the Filipino samples was not possible.

Table 8.22. Table of response model parameter estimates of the Actual Classroom ICEQ for the South Australian and Filipino samples (no items removed).

Variables	*Estimates SA/PH*	*Error SA/PH*	*Unweighted Fit SA/PH*		
			INFIT MNSQ	*CI*	*t*
PERSN65	-0.057/-0.110	0.045/0.039	0.79/0.88	(0.84,1.16)/(0.86,1.14)	-2.7/-1.8
PERSN70	0.415/0.679	0.044/0.038	1.23/1.22	(0.84,1.16)/(0.86,1.14)	2.6/3.0
PERSN80	-0.688/-0.461	0.049/0.040	0.95/0.75	(0.84,1.16)/(0.86,1.14)	-0.6/-3.9
PERSN85	-0.131/-0.249	0.045/0.039	0.76/0.77	(0.84,1.16)/(0.86,1.14)	-3.2/-3.5
PERSN75R	-1.751/-1.610	0.060/0.046	1.47/1.24	(0.84,1.16)/(0.86,1.14)	5.1/3.2
PARTI66	-0.311/-0.457	0.046/0.040	0.72/0.78	(0.84,1.16)/(0.86,1.14)	-3.8/-3.3
PARTI76	-0.049/-0.424	0.045/0.039	0.67/0.85	(0.84,1.16)/(0.86,1.14)	-4.6/-2.2
PARTI81	-0.860/-0.855	0.051/0.041	0.79/0.66	(0.84,1.16)/(0.86,1.14)	-2.7/-5.5
PARTI86	-0.210/-1.337	0.046/0.044	0.91/1.36	(0.84,1.16)/(0.86,1.14)	-1.2/4.6
PARTI71R	-0.307/-0.722	0.046/0.041	1.02/1.18	(0.84,1.16)/(0.86,1.14)	0.3/2.4
INDEP72	-0.918/0.201	0.051/0.038	1.42/1.05	(0.84,1.16)/(0.86,1.14)	4.6/0.7
INDEP67R	-1.997/-0.430	0.062/0.039	2.12/1.80	(0.84,1.16)/(0.86,1.14)	10.5/9.2
INDEP77R	-0.045/0.608	0.045/0.038	1.12/1.23	(0.84,1.16)/(0.86,1.14)	1.5/3.1
INDEP82R	-1.210/0.008	0.054/0.038	1.65/1.18	(0.84,1.16)/(0.86,1.14)	6.7/2.4
INDEP87R	0.382/0.211	0.044/0.038	1.18/1.25	(0.84,1.16)/(0.86,1.14)	2.1/3.4
INVES73	-0.108/-0.088	0.045/0.038	0.77/0.71	(0.84,1.16)/(0.86,1.14)	-3.1/-4.5
INVES78	0.440/0.049	0.043/0.038	0.75/0.59	(0.84,1.16)/(0.86,1.14)	-3.3/-6.8
INVES83	0.120/-0.051	0.044/0.038	0.68/0.80	(0.84,1.16)/(0.86,1.14)	-4.4/-3.0
INVES88	0.540/0.069	0.044/0.038	0.75/0.75	(0.84,1.16)/(0.86,1.14)	-3.3/-3.9
INVES68R	0.194/0.141	0.044/0.038	0.83/0.85	(0.84,1.16)/(0.86,1.14)	-2.2/-2.2
DFFER69	1.189/0.443	0.046/0.038	1.52/1.08	(0.84,1.16)/(0.86,1.14)	5.5/1.1
DFFER79	1.278/0.555	0.047/0.038	1.40/1.01	(0.84,1.16)/(0.86,1.14)	4.4/0.2
DFFER84	1.110/1.361	0.046/0.041	1.15/1.33	(0.84,1.16)/(0.86,1.14)	1.8/4.3
DFFER74R	1.112/0.900	0.045/0.039	1.10/0.91	(0.84,1.16)/(0.86,1.14)	1.2/-1.3
DFFER89R	1.862*/1.567*	0.233/0.194	1.25/1.28	(0.84,1.16)/(0.86,1.14)	2.8/3.7

Separation Reliability = 0.997/0.997
Chi-square test of parameter equality = 6387.76/6001.86
df = 24/24
Significance Level = 0.000

Similarly, the results of the Rasch analysis of the Preferred Classroom ICEQ fitted to the South Australian sample and the Filipino sample show measurement variance. Eight items showed misfit when the rating scale model was fitted to the South Australian sample. These include PRSN100R (1.69), PRTI 91 (0.64), PRTI101 (0.60), INDP92R (1.80), INDP107R (1.44), INVS98 (0.69), INVS103 (0.61) and DFER109

(1.35). On the other hand, the model fitted to the Filipino sample exhibited nine misfitting items including PRSN95 (1.38), PRSN100R (1.34), PRTI91 (0.62), PRTI101 (0.69), INDP92R (1.42), INVS98 (0.67), INVS103 (0.62), INVS113 (0.69) and DFER109 (1.45). Aside from the number of misfitting items for each sample, difference includes some of the items showing misfits in one sample are different from the items misfitting in the other.

Table 8.23. Table of response model parameter estimates of the Preferred Classroom ICEQ for the South Australian and Filipino samples (no items removed).

Variables	*Estimates SA/PH*	*Error SA/PH*	*Unweighted Fit SA/PH*		
			INFIT MNSQ	*CI*	*t*
PRSN90	-0.209/-0.068	0.043/0.035	0.83/0.81	(0.84,1.16)/(0.86,1.14)	-2.1/-2.9
PRSN95	0.151/0.731	0.041/0.034	1.29/1.38	(0.84,1.16)/(0.86,1.14)	3.2/4.9
PRSN105	-0.941/-0.878	0.050/0.039	0.92/0.87	(0.84,1.16)/(0.86,1.14)	-0.9/-1.9
PRSN110	-0.333/-0.637	0.045/0.038	1.01/1.02	(0.83,1.17)/(0.86,1.14)	0.1/0.4
PRSN100R	-1.577/-1.819	0.055/0.045	1.69/1.34	(0.83,1.17)/(0.86,1.14)	7.1/4.3
PRTI91	-0.289/-0.491	0.044/0.037	0.64/0.62	(0.84,1.16)/(0.86,1.14)	-5.0/-6.2
PRTI101	-0.116/-0.411	0.043/0.037	0.60/0.69	(0.84,1.16)/(0.86,1.14)	-5.7/-4.8
PRTI106	-0.800/-0.723	0.049/0.038	0.74/0.75	(0.84,1.16)/(0.86,1.14)	-3.3/-3.8
PRTI111	-0.380/-0.957	0.045/0.040	0.79/0.97	(0.83,1.17)/(0.86,1.14)	-2.6/-0.5
PRTI96R	-0.324/-0.736	0.044/0.039	1.23/1.27	(0.83,1.17)/(0.86,1.14)	2.6/3.5
INDP97	-0.625/-0.039	0.046/0.035	1.16/1.00	(0.84,1.16)/(0.86,1.14)	1.9/0.1
INDP92R	-1.07/-0.351	0.051/0.036	1.80/1.42	(0.84,1.16)/(0.86,1.14)	8.0/5.3
INDP102R	0.133/0.406	0.041/0.034	1.10/1.24	(0.84,1.16)/(0.86,1.14)	1.2/3.1
INDP107R	-0.626/0.033	0.047/0.035	1.44/1.08	(0.84,1.16)/(0.86,1.14)	4.6/1.2
INDP112R	0.410/0.243	0.042/0.034	1.22/1.27	(0.83,1.17)/(0.86,1.14)	2.5/3.6
INVS98	-0.084/-0.120	0.042/0.035	0.69/0.67	(0.83,1.17)/(0.86,1.14)	-4.3/-5.3
INVS103	0.183/0.011	0.042/0.035	0.61/0.62	(0.84,1.16)/(0.86,1.14)	-5.3/-6.2
INVS108	0.170/0.155	0.042/0.035	0.75/0.79	(0.83,1.17)/(0.86,1.14)	-3.1/-3.1
INVS113	0.141/-0.082	0.042/0.035	0.78/0.69	(0.83,1.17)/(0.86,1.14)	-2.8/-4.9
INVS93R	0.236/0.257	0.041/0.034	0.88/0.82	(0.83,1.17)/(0.86,1.14)	-1.5/-2.8
DFER94	1.256/0.988	0.043/0.035	1.25/1.15	(0.84,1.16)/(0.86,1.14)	2.9/2.0
DFER104	1.201/0.613	0.043/0.034	1.17/1.17	(0.83,1.17)/(0.86,1.14)	1.9/2.4
DFER109	0.784/1.350	0.041/0.037	1.35/1.45	(0.83,1.17)/(0.86,1.14)	3.8/5.7
DFER99R	1.133/1.179	0.042/0.036	1.05/1.00	(0.84,1.16)/(0.86,1.14)	0.7/0.1
DFER114R	1.574*/1.345*	0.218/0.179	1.27/1.28	(0.83,1.17)/(0.86,1.14)	2.9/3.7

Separation Reliability = 0.996/0.998
Chi-square test of parameter equality = 5434.07/8320.93
df = 24/24
Significance Level = 0.000

These results confirm that the ICEQ instrument is not unidimensional but multidimensional. To further confirm this, both the Actual Classroom and the Preferred Classroom ICEQs were also subjected to Rasch analysis where all the scales, each representing the five different dimensions of the classroom environment, were analysed independently. This was based on the literature reviewed earlier in the chapter that the scales in the ICEQ exhibited some degree of independence from each other.

Fitting the data sets for each scale of the Actual Classroom ICEQ to the rating scale model provides the results shown in Table 8.24. Using the data sets from South Australian sample, only the scales 'personalisation' (PERSN) and 'participation' (PARTI) exhibited misfitting items – more specifically one misfitting item for each scale. The same observation can be said when data from the Filipino sample was fitted to the model. This clearly indicates the unidimensionality of each scale and the multidimensionality of the whole instrument. Therefore, fitting all the 25 items of the Actual Classroom ICEQ into the rating scale model would yield more misfitting items as demonstrated in the earlier tabulated results (see Tables 8.22 and 8.23). Because of this, the succeeding analyses were carried out separately for each scale.

Fitting the Preferred Classroom ICEQ data using the South Australian sample and the Filipino sample to the rating scale model provides an observation similar to the above. The Preferred Classroom ICEQ exhibited measurement variance between the two samples used in this study. As shown in Table 8.25, for the South Australian sample, four scales (PRSN, PRTI, INVS and DFER) show misfitting items. Each scale has one misfitting item. Using the Filipino sample yields results showing three scales (PRSN, PRTI and INVS) each having a misfitting item. Compared to the results presented in Table 8.25 when scales were analysed separately, there were more misfitting items when all 25 items were used in the model fitted to the data. Therefore, succeeding Rasch analyses using the rating scale model were carried out for each separate scale.

Table 8.24. Table of response model parameter estimates of the Actual Classroom ICEQ for the South Australian and Filipino samples (scales analysed separately and no items removed).

Variables	*Estimates SA/PH*	*Error SA/PH*	*Unweighted Fit SA/PH*		
			INFIT MNSQ	*CI*	*t*
Personalisation (PERSN)					
PERSN65	0.511/0.297	0.057/0.044	0.82/0.92	(0.84,1.16)/(0.86,1.14)	-2.3/-1.2
PERSN70	1.161/1.200	0.055/0.043	1.18/1.24	(0.84,1.16)/(0.86,1.14)	2.1/3.2
PERSN80	-0.354/-0.123	0.063/0.046	0.91/0.83	(0.84,1.16)/(0.86,1.14)	-1.1/-2.5
PERSN85	0.407/0.132	0.058/0.045	0.86/0.78	(0.84,1.16)/(0.86,1.14)	-1.7/-3.4
PERSN75R	-1.725*/1.506*	0.116/0.090	1.72/1.39	(0.84,1.16)/(0.86,1.14)	7.3/4.9
Participation (PARTI)					
PARTI66	0.057/0.424	0.055/0.045	0.81/0.86	(0.84,1.16)/(0.86,1.14)	-2.5/-2.0
PARTI76	0.513/0.470	0.054/0.045	0.94/0.91	(0.84,1.16)/(0.86,1.14)	-0.7/-1.2
PARTI81	-0.864/-0.138	0.058/0.047	0.94/0.81	(0.84,1.16)/(0.86,1.14)	-0.7/-2.9
PARTI86	0.229/-0.804	0.054/0.049	1.06/1.23	(0.84,1.16)/(0.86,1.14)	0.8/3.0
PARTI71R	0.065*/0.049*	0.110/0.093	1.32/1.30	(0.84,1.16)/(0.86,1.14)	3.6/4.0
Independence (INDEP)					
INDEP72	-0.187/0.081	0.044/0.036	1.06/1.03	(0.84,1.16)/(0.86,1.14)	0.7/0.4
INDEP67R	-1.229/-0.577	0.050/0.036	0.97/1.15	(0.84,1.16)/(0.86,1.14)	-0.4/2.0
INDEP77R	0.713/0.532	0.040/0.037	0.91/0.97	(0.84,1.16)/(0.86,1.14)	-1.1/-0.3
INDEP82R	-0.474/-0.126	0.046/0.036	1.03/0.79	(0.84,1.16)/(0.86,1.14)	0.3/-3.1
INDEP87R	1.176*/0.091*	0.091/0.073	0.95/1.05	(0.84,1.16)/(0.86,1.14)	-0.5/0.8
Investigation (INVES)					
INVES73	-0.546/-0.183	0.049/0.045	0.96/0.93	(0.84,1.16)/(0.86,1.14)	-0.5/-1.0
INVES78	0.324/0.041	0.048/0.045	0.92/0.79	(0.84,1.16)/(0.86,1.14)	-0.9/-3.2
INVES83	-0.187/-0.124	0.048/0.045	1.01/1.06	(0.84,1.16)/(0.86,1.14)	0.1/0.8
INVES88	0.481/0.073	0.048/0.045	0.89/0.92	(0.84,1.16)/(0.86,1.14)	-1.4/-1.2
INVES68R	-0.073*/0.193*	0.097/0.089	1.21/1.30	(0.84,1.16)/(0.86,1.14)	2.5/3.9
Differentiation (DFFER)					
DFFER69	-0.144/-0.552	0.050/0.039	1.01/0.90	(0.84,1.16)/(0.86,1.14)	0.2/-1.4
DFFER79	-0.038/-0.433	0.051/0.039	1.07/1.05	(0.84,1.16)/(0.86,1.14)	0.9/0.8
DFFER84	-0.239/0.418	0.050/0.042	1.02/1.20	(0.84,1.16)/(0.86,1.14)	0.3/2.7
DFFER74R	-0.237/-0.066	0.050/0.040	0.82/0.79	(0.84,1.16)/(0.86,1.14)	-2.4/-3.2
DFFER89R	0.658*/0.633*	0.100/0.081	1.11/1.14	(0.84,1.16)/(0.86,1.14)	1.4/2.0

**constrained*
Significance Level = 0.000

Table 8.25. Table of response model parameter estimates of the Preferred Classroom ICEQ for the South Australian and Filipino samples (scales analysed separately and no items removed).

Variables	*Estimates SA/PH*	*Error SA/PH*	*Unweighted Fit SA/PH*		
			INFIT MNSQ	*CI*	*t*
Personalisation (PRSN)					
PRSN90	0.436/0.513	0.055/0.044	0.84/0.80	(0.84,1.16)/ (0.86,1.14)	-2.1/-3.1
PRSN95	0.872/1.377	0.052/0.043	1.19/1.30	(0.84,1.16)/ (0.86,1.14)	2.2/3.9
PRSN105	-0.430/-0.380	0.068/0.053	0.81/0.80	(0.84,1.16)/ (0.86,1.14)	-2.4/-3.1
PRSN110	0.298/-0.115	0.059/0.050	1.03/0.91	(0.84,1.16)/ (0.86,1.14)	0.3/-1.3
PRSN100R	-1.175*/-1.395	0.117/0.095	1.61/1.42	(0.84,1.16)/ (0.86,1.14)	6.3/5.3
Participation (PRTI)					
PRTI91	0.147/0.275	0.054/0.049	0.89/0.77	(0.84,1.16)/(0.86,1.14)	-1.3/-3.6
PRTI101	0.431/0.404	0.053/0.049	0.84/0.90	(0.84,1.16)/(0.86,1.14)	-2.0/-1.5
PRTI106	-0.668/-0.099	0.059/0.051	0.87/0.93	(0.84,1.16)/(0.86,1.14)	-1.6/-0.9
PRTI111	0.003/-0.463	0.056/0.053	0.87/1.01	(0.84,1.16)/(0.86,1.14)	-1.5/0.2
PRTI96R	0.087*/-0.118*	0.111/0.101	1.64/1.63	(0.84,1.16)/(0.86,1.14)	6.6/7.5
Independence (INDP)					
INDP97	-0.322/-0.122	0.046/0.037	1.16/1.07	(0.84,1.16)/(0.86,1.14)	1.9/1.0
INDP92R	-0.808/-0.488	0.049/0.037	1.18/1.03	(0.84,1.16)/(0.86,1.14)	2.1/0.4
INDP102R	0.557/0.426	0.042/0.036	0.86/1.00	(0.84,1.16)/(0.86,1.14)	-1.8/0.0
INDP107R	-0.324/-0.036	0.046/0.036	0.97/0.85	(0.84,1.16)/(0.86,1.14)	-0.4/-2.2
INDP112R	0.896*/0.221*	0.091/0.073	1.01/1.06	(0.84,1.16)/(0.86,1.14)	0.1/0.9
Investigation (INVS)					
INVS98	-0.381/-0.297	0.052/0.045	0.79/0.82	(0.84,1.16)/(0.86,1.14)	-2.7/-2.7
INVS103	0.095/-0.064	0.052/0.045	0.76/0.75	(0.84,1.16)/(0.86,1.14)	-3.1/-3.9
INVS108	0.068/0.201	0.052/0.044	1.12/1.18	(0.84,1.16)/(0.86,1.14)	1.4/2.4
INVS113	0.009/-0.231	0.052/0.045	0.93/0.85	(0.84,1.16)/(0.86,1.14)	-0.8/-2.2
INVS93R	0.209*/0.390*	0.104/0.089	1.43/1.39	(0.84,1.16)/(0.86,1.14)	4.6/5.0
Differentiation (DFER)					
DFER94	0.095/-0.115	0.049/0.036	0.83/0.93	(0.84,1.16)/(0.86,1.14)	-2.2/-1.0
DFER104	0.014/-0.497	0.050/0.035	0.97/1.07	(0.84,1.16)/(0.86,1.14)	-0.3/1.0
DFER109	-0.548/0.266	0.048/0.038	1.32/1.22	(0.84,1.16)/(0.86,1.14)	3.5/3.0
DFER99R	-0.074/0.085	0.048/0.037	0.86/0.77	(0.84,1.16)/(0.86,1.14)	-1.7/-3.5
DFER114R	0.514*/0.260*	0.098/0.073	1.14/1.10	(0.84,1.16)/(0.86,1.14)	1.6/1.4

**constrained*
Significance Level = 0.000

For each scale in both the Actual and the Preferred Classroom ICEQ, non-fitting items were examined carefully one at a time. The examination included the checking of the infit statistics, the item's deltas and the item's statement. When a non-fitting item was removed, the analysis was re-run to see whether it had affected the other items (i.e., for masking effects). Re-running the analysis stopped when all items have infit statistics and/or item deltas indicating good fit in the model.

For the Actual Classroom ICEQ, the misfitting item(s) from each scale were carefully examined for their infit statistics, the item's deltas and the item statement. A total of two items became candidates for removal when the South Australian sample data was fitted to the model. However these items were not removed. Only one item (PERSN75R) appeared to misfit when the data from the Filipino sample was fitted to the rating scale model. After careful examination of the items, it was decided that the item should be kept.

Misfitting items in each scale of the Preferred Classroom ICEQ were also examined. A total of four items appeared to misfit when data from the South Australian sample was fitted to the rating scale model. Items include PRSN100R, PRTI96R, INVS93R and DFER109. Only Item PRTI96R was removed due to its high infit mean square (1.64) and swapping delta values. The same number of misfitting items appeared to misfit when data from the Filipino sample was fitted to the rating scale model. These items include PRSN100R, PRTI96R, INVS93R and INVS108. These items were carefully examined and was decided that they should be kept.

8.6. Model for the study

There was not much modification made with the initial model tested. The final model used in the subsequent analyses can be summarized as follows:

South Australian sample

- Actual Classroom Climate ICEQ – all items kept
- Preferred Classroom Climate ICEQ – all items kept except for Item PRTI96R (infit=1.64; swapping item deltas)

Filipino sample

- Actual and Preferred Classroom Climate ICEQ – all items kept

8.7. Summary

The Individualised Classroom Environment Questionnaire (ICEQ) developed by Fraser (1990) was adapted for use as part of the SUPSQ instrument to measure physics students' experiences in a Physics classroom. There are two versions of this instrument – a long form and a short form. Each form consists of two different ICEQ instruments: the Actual Classroom ICEQ and the Preferred Classroom ICEQ. The short form was used in this study. Both the Actual Classroom and the Preferred Classroom ICEQs consist of five scales that represent five different dimensions of the classroom environment. These are 'personalisation' (PERSN/PRSN), 'participation' (PARTI/PRTI), 'independence' (INDEP/INDP), 'investigation' (INVES/INVS) and 'differentiation' (DFFER/DFER). Each scale consists of five items. Altogether the short form ICEQ consists of 25 items using 5-point Likert response choices ranging from "almost never" (1) to "very often" (5).

Similar to the preceding four chapters, the same sets of data collected from South Australian and Philippine high school and university physics student samples were used. A section of the data sets that concern students' experiences in a Physics classroom was analysed through CFA employing LISREL 8.80 software package to examine the structure of the whole ICEQ instrument. Rasch Modeling with ConQuest 2.0 (using the rating scale model) was used for item-level analysis to test for the coherence of the instrument items to measure a common latent factor. In the case of the ICEQ, five different latent factors which were claimed by the instrument's author to exhibit adequate independence were tested independently. Testing all 25 items simultaneously was also carried out to verify the ICEQ's author's claim of scale independence.

The CFA part of instrument validation involved fitting the measurement and alternative models into the data from samples of South Australian and Filipino high school and university physics students. The measurement model was fitted to each of these sets or groups from each data set. The result of fitting the model into the South Australian university physics students sample data set were not used for comparison with the other models because of the issue of sample size giving unreliable fit statistics. The measurement model consisted of five correlated latent factors that form different dimensions of the classroom environment. Results were presented for both the Actual Classroom ICEQ and the Preferred Classroom ICEQ (see analyses results above).

Based on the resulting goodness-of-fit statistics, the five-correlated factors model exhibited poor fit to the 'actual classroom' data from the South Australian sample, and modest fit to the data from the Filipino sample. The goodness-of-fit statistics for the model fitted to the 'preferred classroom' data from the South Australian and the Filipino samples both showed poor fit. This was true even when the results from fitting the model into the Filipino data showed goodness-of-fit statistics values that indicate better fit compared to the model fitted to the South Australian data. An alternative model was tested – the second-order (or hierarchical) factor model. This model was fitted in the South Australian and the Filipino data to determine whether or not it will improve the goodness-of-fit statistics. In addition, this model was tested to determine whether the five latent factors measure a common latent factor called in this study as 'classroom climate' (CLSCLMTE). The resulting statistics still showed poor fit with no or little improvement in their values to indicate better fit.

Items were removed when item-level analyses were carried out using Rasch modeling with the rating scale model.

To examine the unidimensionality of the 25 items in both Actual Classroom and Preferred Classroom ICEQs to measure a common latent factor, the combined high school and university data from each group of samples was fitted into the rating scale model. Using the unweighted fit statistics, items were examined for their fit in the model. An item whose infit mean square statistic did not fall within the accepted range of 0.72 and 1.30 became candidate for removal. However, before an item was removed, its item deltas (indicating Likert-choice swapping or otherwise) and item statement were carefully examined first. For the Actual Classroom ICEQ, eight items exhibited model misfit with the South Australian and five items exhibited model misfit with the Filipino data. For the Preferred Classroom ICEQ, eight and five items exhibited misfit to the model with the South Australian sample and the Filipino sample, respectively. However, no items were removed as the results only served as a guide to confirm the instrument's multidimensionality.

Because of the results from fitting the data to the rating scale model with all 25 items included, each of the five scales in each ICEQ was also subjected to Rasch analysis. This was to validate and confirm the author's (Fraser) claim that the scales exhibit adequate scale independence. The results of the analysis confirmed this by showing a fewer number of misfitting items. Misfitting items were examined. For the Actual Classroom ICEQ, following the examination of the misfitting items, no items were removed when the South Australian data was fitted to the rating scale model. Likewise, no item was removed when the Filipino data was fitted to the model. For the Preferred Classroom ICEQ, one item (PRTI96R) was removed when the South Australian data was fitted to the model and no item was removed when the Filipino data was fitted to the model.

Based on the results of the different CFA and Rasch analysis tests carried out, the five-correlated factors model (for both the Actual Classroom and the Preferred Classroom ICEQ) was used in the subsequent analyses. The Actual Classroom ICEQ will include, for the South Australian and Filipino samples, all 25 items in the ICEQ instrument. All items the in Preferred Classroom ICEQ were used in the succeeding analyses except for item PRTI96R for the South Australian sample while all items were used for the Filipino sample.

All scales and instruments used in this study were examined using the same steps and techniques. The next chapter discusses how the scale that intends to measure parents' aspirations and support for their child's learning and education was validated.

Chapter 9

Parents' Aspirations Scale

9.1. Introduction

A part of this study examined some family factors and their impact on physics students' attitudes towards physics and their subsequent uptake of physics. More specifically, this study examined parental educational and occupational aspirations as perceived by their child who is enrolled in a Physics subject or course. In trying to measure parents' aspirations as perceived by their child, Kevin Marjoribanks' (2002) Perceived Family Capital Scale (PFCS) was adapted. Since the students sampled in this study were at the time already doing a physics subject/course, the PFCS was also used to determine whether their perceived parental aspirations for them could influence their subsequent decision to continue doing physics or physics-related courses. The PFCS formed part of the Students' Uptake of Physics Study Questionnaire (SUPSQ) instrument used in this study. The research questions (RQ) advanced in Chapter 1 addressed using the PFCS are RQ3g and RQ3h. As with the rest of the instruments adapted in this study, it was necessary to carefully and rigorously validate the PFCS to get results that could be meaningfully interpreted to properly address the questions raised in this study. Therefore, it was considered necessary to present the procedure on how the PFCS instrument was validated.

This chapter provides a detailed account of the technique and analysis carried out for the validation of the PFCS used to measure parental aspirations as perceived by their child who is already enrolled in a physics subject or course. Broadly, the structure of the instrument was confirmed using contemporary approaches which included confirmatory factor analysis (CFA) and Rasch measurement modeling used in the previous instrument validation chapters (Chapters 4, 5, 6, 7 and 8).

This chapter is presented based on the steps followed to validate Marjoribanks' (2002) PFCS. It begins with a section briefly describing the instrument and its items that represent the observed variables. Then follows a brief description of how this instrument was used and validated by other researchers. This is followed by the description of how the structure of the instrument was investigated using structural equation modeling (SEM) which includes confirmatory factor analysis of the measurement model and an alternative model. Each of these models' fit indexes was examined to determine which model fit the data best. This section is followed by an item-level analysis using Rasch modeling to examine the instrument. The chapter concludes with a summary.

9.2. The Perceived Family Capital Scale (PFCS)

For many years, Marjoribanks (1972, 1981, 1991, 1999, 2002, 2005) has extensively examined family environments and their influence to children's academic achievement and outcomes such as aspirations. In one of his studies (see Marjoribanks, 1998), he has proposed and developed what he called the "Environment-Academic Capital Mediational Model" (p. 179) which shows that relationships of factors consisting of family background, childhood social capital, children's academic capital, adolescents' social capital and adolescents' aspirations. This study focused on parents' aspirations for their child (or children), which, according to Marjoribanks (1998), is a part of a typology to investigate associations between social structure and individual behaviour to examine a child's family social capital. To measure parents' aspirations, Marjoribanks developed an instrument that assessed the parents' idealistic and realistic aspirations for their children. The instrument also consists of items pertaining to the encouragement children received from their parents about their education, and also their parents' interest in their education (Marjoribanks, 1999). The instrument became the Perceived Family Capital Scale (PFCS). In this study, the Physics students' parents were not surveyed or interviewed for what aspirations they have for their children. Information was collected by asking the Physics student participants about their perceptions of their parents' educational and occupational aspirations for them, ideally and realistically. According to Marjoribanks (2002), asking both sets of questions is more likely to draw a more valid assessment of realistic parents' aspirations. In the SUPSQ items that covered the PFCS were from item 125 to item 146. For the purposes of data analysis, items were designated prefixes to represent the scale they measure. Items relating to mother were prefixed with PASPM and items relating to father were prefixed with PASPF. Actual items in the SUPSQ that pertain to parents' aspirations were 132 to 135 and 143 to 146. These items were not subjected to CFA because they formed part of the descriptive and qualitative data. Table 9.1 shows the summary of the items in the PFCS that compose two factor scales that Marjoribanks (2002) labelled as "adolescents' perceptions of fathers' and mothers' support for learning" (p. 63). Presented in the table are codes for items used in the validation, nature (i.e. positive or negative) of each statement, item code to indicate which statements have been reverse-scored, and the text corresponding to each item.

Table 9.1. Summary of PFCS items used in the SUPSQ instrument.

Item Code	Nature of statement	Item Code to indicate reverse scoring	Item text
Items related to mother			
PASPM125	Positive	None	My mother is *very interested* in my schoolwork.
PASPM126	Positive	None	My mother *often helps* me with my homework.
PASPM127	Positive	None	My mother *often speaks* to me about my schoolwork.
PASPM128	Positive	None	My mother *often praises* me for what I do at school.
PASPM129	Positive	None	My mother is a *great support* to me in my schoolwork.
PASPM130	Positive	None	My mother gives me *great encouragement* to stay on at school.
PASPM131	Positive	None	My mother *often tells* me about the importance of getting good education.
Items related to father			
PASPF136	Positive	None	My father is *very interested* in my schoolwork.
PASPF137	Positive	None	My father *often helps* me with my homework.
PASPF138	Positive	None	My father *often speaks* to me about my schoolwork.
PASPF139	Positive	None	My father *often praises* me for what I do at school.
PASPF140	Positive	None	My father is a *great support* to me in my schoolwork.
PASPF141	Positive	None	My father gives me *great encouragement* to stay on at school.
PASPF142	Positive	None	My father *often tells* me about the importance of getting good education.

Each item in the PFCS presented above has five Likert-type choices: 'strongly disagree', 'disagree', 'neutral', 'agree' and 'strongly agree' coded as '1', '2', '3', '4' and '5', respectively. Missing or omitted response was coded '9'. There are no negatively worded items in the PFCS which means that no items were reverse-scored.

The following items, including possible choices, pertain to mother's educational and occupational aspirations for her children:

- Item 132: How much education do you think your mother would like you to achieve, if at all possible?
  1. Leave as soon as possible.
  2. Finish high school, or as much high school as possible.
  3. Finish high school, plus some further education such as junior college, community college, or vocational education college, but not go to university.
  4. At least some university.
  5. Graduate from university with a general degree such as a B.A.
  6. Graduate from university with a degree from a professional faculty such as medicine, law, engineering, dentistry, or architecture
  7. Graduate from university with a postgraduate qualification such as a Master's or Doctoral degree.

- Item 133: How much education do you think your mother *really* expects you to achieve?
  1. Leave as soon as possible.
  2. Finish high school, or as much high school as possible.
  3. Finish high school, plus some further education such as junior college, community college, or vocational education college, but not go to university.
  4. At least some university.
  5. Graduate from university with a general degree such as a B.A.
  6. Graduate from university with a degree from a professional faculty such as medicine, law, engineering, dentistry, or architecture
  7. Graduate from university with a postgraduate qualification such as a Master's or Doctoral degree.

- Item 134: What job or occupation do you think your mother would like you to have, if at all possible, when are about 25 years old?

- Item 135: What job or occupation do you think your mother *really* expects you to have when you are about 25 years old?

The following items, including possible choices, pertain to father's educational and occupational aspirations for his children:

- Item 143: How much education do you think your father would like you to achieve, if at all possible?

1. Leave as soon as possible.
2. Finish high school, or as much high school as possible.
3. Finish high school, plus some further education such as junior college, community college, or vocational education college, but not go to university.
4. At least some university.
5. Graduate from university with a general degree such as a B.A.
6. Graduate from university with a degree from a professional faculty such as medicine, law, engineering, dentistry, or architecture
7. Graduate from university with a postgraduate qualification such as a Master's or Doctoral degree.

- Item 144: How much education do you think your father *really* expects you to achieve?

1. Leave as soon as possible.
2. Finish high school, or as much high school as possible.
3. Finish high school, plus some further education such as junior college, community college, or vocational education college, but not go to university.
4. At least some university.
5. Graduate from university with a general degree such as a B.A.
6. Graduate from university with a degree from a professional faculty such as medicine, law, engineering, dentistry, or architecture
7. Graduate from university with a postgraduate qualification such as a Master's or Doctoral degree.

- Item 145: What job or occupation do you think your father would like you to have, if at all possible, when are about 25 years old?

- Item 146: What job or occupation do you think your father *really* expects you to have when you are about 25 years old?

The following section describes how past researchers, including its author, validated the PFCS. It also shows some of their findings in terms of the instrument's validity and reliability.

9.3. Previous analytic practices

The PFCS's items subjected to principal components analyses have generated two factor scales items. Marjoribanks (2002) labelled these factors as adolescents' perceptions of fathers' and mothers' support for learning. Based on his study's collected data, Alpha reliability estimates for these factors were found to be 0.76 and 0.78, respectively. For the items used to measure parents' aspirations, the calculated correlation between idealistic and realistic educational aspirations was 0.72 while the correlation for occupational aspirations was 0.70.

Parents' aspirations, as measured by PFCS, form part of the mediational model that Marjoribanks developed to examine the relationships of a number of predictor variables and adolescents' aspirations. Marjoribanks (1998) used latent variable path modeling techniques to examine these relationships.

Searching for literature that concerns the use of the PFCS published by researchers other than Marjoribanks appears to be non-existent. However, this may not be the actual case. Nevertheless, research articles published by the instrument's author only show limited information on the details of how the instrument was validated and how data collected were analysed. From a number of readings (both journal articles and books) that he had written, it appears that he mostly used regression surface models. In one of his published research articles (Marjoribanks, 1999, p. 58), he described the regression surfaces being "generated from regression models that included product and squared terms to test for possible interaction and curvilinear relations." This description of the models he used was accompanied by a mathematical equation of the form:

$$Z = \mathrm{a}X + \mathrm{b}Y + \mathrm{c}X.Y + \mathrm{d}X^2 + \mathrm{e}Y^2 + \text{constant},$$

where Z, X, and Y represent the different latent factors being examined. Other techniques that he had used appear to revolve around the Classical Test Theory (CTT) models.

For this reason, the author of this study has taken this opportunity to examine the PFCS structurally at the instrument and item levels using contemporary techniques such as CFA and Rasch Modeling.

9.4. Instrument structure analysis

The section of this study's data set concerned with students' perceptions of their parents' (the mother's and the father's) support for their learning has been subjected to detailed structural analysis. This section describes and discusses results from using data from two main groups of samples: South Australian Physics students from 11 metropolitan Adelaide schools and a university, and Filipino Physics students from 11 Quezon City District high schools and two universities (see Chapter 3 for sample details). Each sample consists of two subgroups: high school Physics students and university Physics students. The main methods used to examine the structure of the instrument used to measure students' perceptions of their parents' support for their learning were CFA and Rasch measurement modeling – the same techniques employed in the validation of the scales described and discussed in Chapters 4, 5, 6, 7 and 8.

Based on the literature presented above, the PFCS has already been subjected by its author to validation procedures; therefore, CFA was utilized to confirm factor structures as advanced by the author.

LISREL was used to carry out CFA while AMOS was used to draw the diagram that represents the structure of the scale. LISREL was used because of its flexibility to handle a variety of scales (e.g. whether they are ordinal, continuous, etc.). Some programs are different from LISREL because they (like AMOS) make assumptions about the scale on which variables are measured. AMOS was used to draw diagrams since its graphical user interface is easy to use and neat-looking diagrams could easily be created. The following sections report on the results of the CFA tests carried out for each sample of students, school level-wise and country-wise.

Confirmatory factor analysis of the Measurement Model

The measurement model for the PFCS is a single factor model. The structure of this model is shown in Figure 9.1. The structure for both the model that pertains to the mother and the model that pertains to the father is exactly the same.

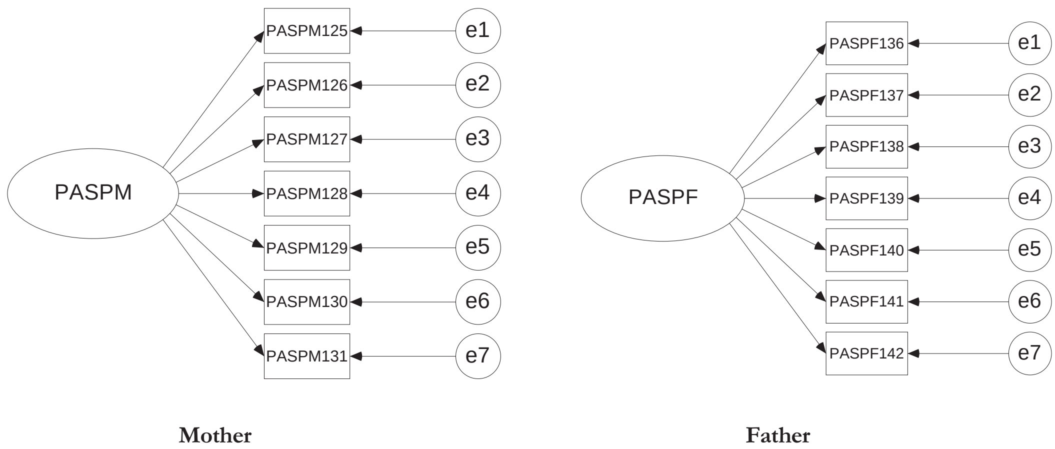


Figure 9.1. Structure of the Single Factor Model for the PFCS (for Mother and Father).

In the measurement model, the latent factor was labelled PASPM to represent mother's support for her children's learning, and PASPF for father's support for his children's learning. Seven observed variables were loaded onto each latent factor.

The results presented in the following sections drew from this study's data sets collected from a sample of South Australian high school and university Physics students, and from a sample of Filipino high school and university Physics students. A single-factor model was fitted to different data sets in the following order of samples:

- South Australian high school Physics students
- South Australian university Physics students
- Combined South Australian high school and university Physics students
- Filipino high school Physics students
- Filipino university Physics students
- Combined Filipino high school and university Physics students.

Results of the CFA runs are presented in table form showing the loading value (together with the standard error) of each observed variable onto its latent factor. For an observed variable to fit the latent factor, it should have a minimum loading value of 0.40. Items loading above 0.40 indicate that they are reflective of the latent factor being measured. Model fit indexes for the single factor model fitted to each set of data are also presented for comparison to determine which model fits best which sample of Physics students.

Model Fit Indexes

The different model fit indexes from a CFA run using LISREL are the same as the ones presented in the previous validation chapters: GFI, AGFI, PGFI, RMR and RMSEA. A model shows good fit when their minimum GFI, AGFI and PGFI value equals 0.90. RMSEA and RMR values should be below 0.05 to indicate good fit. These fit indexes indicate the extent to which the data is different from the model fitted. According to Cramer (2003, p. 28), "If the data support the model, the data will not differ significantly from the model." In other words, "A given model is considered properly specified when the true model (…that generated the data) is…consistent with the model being tested" (Phakiti, 2007, p. 48).

The South Australian Sample

The following sections present results of the CFA tests for the single factor model fitted into the data from the South Australian sample. These sets of data are the same as the ones used in the previous validation chapters. However, this time the section of the data concerning students' perceptions of their parents' (mother's and father's) support for their learning was used. Three CFA tests were carried out fitting separately a single factor model into data sets from samples of South Australian high school students, university students, and a data set combining the high school and university data sets.

South Australian High School Physics Students Sample

The results of fitting a single factor model into the data collected from a sample of South Australian high school Physics students are shown in Tables 9.2 and 9.3. Table 9.2 represents results pertaining to scale for perceived mother's support to her children's learning and Table 9.3 for perceived father's support to his children's learning.

An item loading onto a latent factor with a value below 0.40 shows poor item fit to the model. Looking at the second column of Table 9.2, loading values for all seven items loaded onto a latent factor that represents perceived mother's support for learning (PASPM) indicate at least a modest fit to the data. However, good factor loadings do not necessarily indicate good model fit. A number of goodness-of-fit criteria (represented by indexes) needs to be satisfied before a conclusion can be made about a model's fit to the data. These goodness-of-fit indexes, as mentioned above, are presented later.

Table 9.2. Factor loadings of the single factor model for perceived mother's support to her children's learning (South Australian sample: high school, university, and combined high school and university).

Variable	*Loadings (se)* † *PASPM (High School)*	*Loadings (se)* †† *PASPM (University)*	*Loadings (se)* ††† *PASPM (Combined)*
PASPM125	0.79(0.06)	0.73(0.14)	0.78(0.05)
PASPM126	0.49(0.06)	0.33(0.16)	0.44(0.06)
PASPM127	0.84(0.06)	0.78(0.13)	0.83(0.05)
PASPM128	0.70(0.06)	0.54(0.15)	0.68(0.06)
PASPM129	0.77(0.06)	0.74(0.14)	0.77(0.05)
PASPM130	0.77(0.06)	0.77(0.14)	0.77(0.05)
PASPM131	0.50(0.06)	0.55(0.15)	0.49(0.06)
	†*n=233*	†† *n=45*	††† *n=278*

The second column of Table 9.3 shows all seven items loading well onto a single latent factor that represents perceived father's support for learning (PASPF) when a single factor model was fitted to the South Australian high school data.

The single factor model showed all seven items have demonstrated satisfactory factor loadings when fitted to either the perceived mother's support for learning high school data or the perceived father's support for learning high school data. These results indicate that the set of items showed generally reasonable fit to a single latent perceived parental support for learning. However this conclusion only holds for the data where the data was fitted into. In addition, examination of the model's goodness-of-fit indexes was needed to confirm this.

Table 9.3. Factor loadings of the single factor model for perceived father's support to his children's learning (South Australian sample: high school, university, and combined high school and university).

Variable	*Loadings (se)* † *PASPF (High School)*	*Loadings (se)* †† *PASPF (University)*	*Loadings (se)* ††† *PASPF (Combined)*
PASPF136	0.79(0.06)	0.84(0.13)	0.80(0.05)
PASPF137	0.64(0.06)	0.27(0.16)	0.57(0.06)
PASPF138	0.80(0.06)	0.64(0.14)	0.78(0.05)
PASPF139	0.68(0.06)	0.88(0.12)	0.70(0.06)
PASPF140	0.86(0.05)	0.79(0.13)	0.84(0.05)
PASPF141	0.75(0.06)	0.93(0.12)	0.77(0.05)
PASPF142	0.62(0.06)	0.54(0.15)	0.60(0.06)
	†*n=231*	††*n=42*	†††*n=273*

The following section summarizes the results of the test of fitting a single factor model into the data collected from a sample of South Australian university Physics students.

South Australian University Physics Students

With reference to the third column of Tables 9.2 and 9.3, fitting the single factor model into the university data yielded results showing one misfitting item in both the scale for perceived mother's support for learning (item PASPM126 = 0.33 in Table 9.2) and the scale for perceived father's support for learning (item PASPF137 = 0.27 in Table 9.3). The poor loading of these items may be due to the small size of the university sample (with only 45 students). These items loaded adequately when the model was fitted to a set of data coming from a significantly bigger sample size. Furthermore, this observation has been demonstrated when the model was fitted to the combined high school and university data sets.

Combined South Australian High School and University Students Samples

Combining the data sets collected from the high school and the university samples was considered feasible by the author for a number of reasons. The average age difference between the high school and university student samples is around one year. In addition, the first year university student samples were just into their second week of university classes when they filled out the survey questionnaire. It was therefore assumed that student samples from both groups (high school and university) were likely to hold similar attitudes and perceptions towards things – like school subjects, for instance. .

Another reason is, based on the results of the CFA runs using the high school and university samples data, there is some degree of similarity in the pattern in terms of misfitting items. Lastly, combining the two sets of data significantly increases the sample size which makes SEM more fit for use (Thompson, 2000 in Phakiti, 2007).

Fitting the single factor model into the combined high school and university data sets yielded results showing all items at least adequately loading onto a single latent factor (see fourth column of Tables 9.2 and 9.3). Based on the results of fitting the single factor model to the different sets of data from the South Australian sample, it appears that small sample size had a significant effect on items PASPM126 and PASPF137. However, it was not sufficient to base a model's adequacy just on the loading figures. Some goodness-of-ft criteria needed to be examined to make judgements about the model fit's acceptability.

Fit Indexes of the Single-Factor Models (South Australian Sample)

Optimum values for the different fit indexes used in CFA for this study are presented above. Table 9.4 shows a summary of the different fit index values resulting from fitting the single factor measurement model into the different sets of data for the mother's support to learning collected from the South Australian sample. It appears that the model exhibits a more acceptable fit in the high school data and in the combined high school and university data, with the combined one showing better fit index values by a tiny margin. The model fitted to the university data shows the least acceptable fit.

Table 9.4. Goodness-of-fit index summary for the single factor model fitted to perceived mother's support to her children's learning data (South Australian sample).

	High School data *n=233*	University data *n=45*	Combined data *n=278*
Chi-Square	133.62	32.61	144.06
df	14	14	14
GFI	0.86	0.83	0.87
AGFI	0.72	0.65	0.74
PGFI	0.43	0.41	0.43
RMR	0.07	0.09	0.07
RMSEA	0.19	0.17	0.18

The resulting GFI values (0.86 and 0.87) for the model fitted to the high school and the combined data somehow reflect good fit as they are very close to the acceptable value of 0.90. The RMR values also indicate somewhat of a mediocre fit as they are between the range of 0.05 and 0.10. However, the rest of the fit indexes presented are showing poor model fit. The PGFI, for instance, indicate some model complexity with its low value. Moreover, all of the RMSEA values presented in the table indicate poor fit. However, the high RMSEA values may have resulted because of small degrees of freedom. Phakiti (2007) pointed out, larger degrees of freedom results to smaller RMSEA.

Table 9.5. Goodness-of-fit index summary for the single factor model fitted to perceived father's support to her children's learning data (South Australian sample).

	High School data *n=231*	University data *n=42*	Combined data *n=273*
Chi-Square	135.57	32.66	149.09
df	14	14	14
GFI	0.86	0.81	0.86
AGFI	0.71	0.63	0.73
PGFI	0.43	0.41	0.43
RMR	0.07	0.08	0.07
RMSEA	0.19	0.18	0.19

Fitting the single factor measurement model into the different sets of data for the perceived father's support to learning collected from the South Australian sample yielded results that can readily be observed in Table 9.5. The model fitted to the high school data and the combined high school and university data show equal fit index values that are better than those of the model fitted to the university data.

The Filipino sample

This section presents the results of fitting the single factor model into the data collected from a sample of high school and university Physics students in the Philippines. These sets of data are the same as the ones used in the previous two chapters. The section of the data that concerns students' perceived parental (mother's and father's) support for their learning was subjected to the analysis. Three CFA tests were carried out separately using data sets from Filipino high school students, university students, and a data set combining the high school and university data sets. The same set of fit indexes is reported.

Filipino High School Physics Students Sample

The results of fitting a single factor model into the data collected from a sample of South Australian high school Physics students are shown in Tables 9.6 and 9.7. Table 9.6 represents results pertaining to the scale for perceived mother's support to her children's learning and Table 9.7 for perceived father's support to his children's learning.

An item loading onto a latent factor with a value below 0.40 shows poor item fit to the model. Looking at the second column of Table 9.6, loading values for six items loaded onto a latent factor that represents perceived mother's support for learning (PASPM) indicate at least a modest fit to the data. One item (PASPM126=0.36) appears to misfit the model by loading poorly. However, good factor loadings do not necessarily indicate good model fit. A number of goodness-of-fit criteria (represented by indexes and their corresponding values) needs to be satisfied before a conclusion can be made about a model's fit adequacy to the data. These goodness-of-fit indexes, as mentioned above, are presented later.

The model fitted to the set of data concerning perceived father's support to learning yielded results presented in the second column of Table 9.7. All seven items loaded well to indicate good fit onto the latent factor PASPF.

Filipino University Physics Students Sample

When the single factor measurement model was fitted to the Filipino university sample data, resulting loading figures presented in the third column of Table 9.6 mirror a trend similar to that of the results fitting the same model into the high school data. Six items loaded satisfactorily but item PASPM126 (0.33) failed to load adequately (at least 0.40) onto the latent factor PASPM. This result negated this study's author's conjecture that items loading poorly may be due to the significant difference in sample sizes as exhibited earlier in the discussion of the results of fitting the model to the South Australian samples.

Table 9.6. Factor loadings of the single factor model for perceived mother's support to her children's learning (Filipino sample: high school, university, and combined high school and university).

Variable	*Loadings (se)* † *PASPM (High School)*	*Loadings (se)* †† *PASPM (University)*	*Loadings (se)* ††† *PASPM (Combined)*
PASPM125	0.70(0.05)	0.43(0.10)	0.64(0.05)
PASPM126	0.36(0.06)	0.33(0.11)	0.35(0.05)
PASPM127	0.59(0.06)	0.57(0.10)	0.60(0.05)
PASPM128	0.66(0.05)	0.70(0.09)	0.66(0.05)
PASPM129	0.82(0.05)	0.82(0.09)	0.82(0.04)
PASPM130	0.80(0.05)	0.91(0.08)	0.82(0.04)
PASPM131	0.69(0.05)	0.60(0.10)	0.65(0.05)
	†*n=305*	††*n=96*	†††*n=401*

With reference to the third column of Table 9.7, the results of fitting the single factor model to the university data show six items loading adequately and one item loading poorly (PASPF137=0.36) – a trend similar to the results from a number of the CFA runs carried out using the South Australian sample and the Filipino sample.

Combined Filipino High School and University Students Samples

The Filipino high school and university sample data sets were combined for the same reasons of feasibility stated above – that the average age difference between the high school and university student samples is around one year. In addition, the first year university student samples were just into their second month of university classes when they filled out the survey questionnaire. It was therefore assumed that student samples from both groups (high school and university) were likely to hold similar attitudes and perceptions towards things.

Fitting the single factor model into the combined high school and university data set for the perceived mother's support to her children's learning yielded results showing six items at least adequately loading onto a single latent factor and one misfitting item (PASPM126 = 0.35) (see fourth column of Tables 9.6). Fitting the model to the combined data sets for the perceived father's support to his children's learning yielded all seven items showing standardised loadings of at least 0.40 (see Table 9.7). Based on the results of fitting the single factor model to the different sets of data from the Filipino sample, it appears that small sample size had a significant effect on item PASPF137. However, this was not the case for item PASPM126 where it failed to load regardless of the sample size.

Table 9.7. Factor loadings of the single factor model for perceived father's support to his children's learning (Filipino sample: high school, university, and combined high school and university).

Variable	*Loadings (se)* † *PASPF (High School)*	*Loadings (se)* †† *PASPF (University)*	*Loadings (se)* ††† *PASPF (Combined)*
PASPF136	0.80(0.05)	0.64(0.10)	0.77(0.04)
PASPF137	0.59(0.05)	0.36(0.11)	0.55(0.05)
PASPF138	0.79(0.05)	0.69(0.09)	0.77(0.04)
PASPF139	0.79(0.05)	0.54(0.10)	0.74(0.04)
PASPF140	0.88(0.05)	0.90(0.08)	0.88(0.04)
PASPF141	0.82(0.05)	0.90(0.08)	0.83(0.04)
PASPF142	0.79(0.05)	0.70(0.09)	0.78(0.04)
	†*n=299*	†† *n=92*	†††*n=391*

Judging a model's fit based on item standardised loadings was considered not sufficient. Some goodness-of-ft criteria needed to be examined to make judgements about the overall model fit's acceptability.

Fit Indexes of the Single-Factor Models (Filipino Sample)

Optimum values for the different fit indexes used in CFA to indicate at least a good model fit are presented above. Table 9.8 shows a summary of the different fit index values resulting from fitting the single factor measurement model into the different sets of data for the perceived mother's support to her children's learning collected from the Filipino sample. It appears that the model exhibits a better fit in the high school data and in the combined high school and university data, with the high school data showing better fit index values by a tiny margin as seen in the GFI, AGFI, PGFI and RMSEA. The model fitted to the university data shows the worst fit among the three.

Table 9.8. Goodness-of-fit index summary for the single factor model fitted to perceived mother's support to her children's learning data (Filipino sample).

	High School data *n=305*	University data *n=96*	Combined data *n=401*
Chi-Square	231.67	147.71	349.37
df	14	14	14
GFI	0.82	0.69	0.80
AGFI	0.64	0.38	0.60
PGFI	0.41	0.35	0.40
RMR	0.10	0.15	0.10
RMSEA	0.23	0.32	0.24

The resulting GFI values (0.82 and 0.80) for the model fitted to the high school and the combined data somehow raises doubts about the model fit as they are not very close to the acceptable value of 0.90. The RMR values also indicate somewhat of a poor fit as indicated by a value of 0.10. In addition, the rest of the fit indexes presented are showing poor model fit. The PGFI, for instance, indicate some model complexity with its low value. Moreover, all of the RMSEA values presented in the table indicate poor fit. However, the high RMSEA values may have resulted because of small degrees of freedom. Phakiti (2007) pointed out, larger degrees of freedom results to smaller RMSEA.

Table 9.9. Goodness-of-fit index summary for the single factor model fitted to perceived father's support to her children's learning data (Filipino sample).

	High School data *n=299*	University data *n=92*	Combined data *n=391*
Chi-Square	207.84	93.57	268.56
df	14	14	14
GFI	0.83	0.77	0.84
AGFI	0.67	0.55	0.67
PGFI	0.42	0.39	0.42
RMR	0.06	0.10	0.06
RMSEA	0.22	0.25	0.22

Fitting the single factor measurement model into the different sets of data for the perceived father's support to his children's learning collected from the Filipino sample yielded results that are shown in Table 9.9. The model fitted to the high school data and the combined high school and university data show values better than those of the model fitted to the university data. The GFI and RMR values for the model fitted to the combined data indicate an acceptable fit. However, the AGFI, PGFI and RMSEA values indicate otherwise. Nevertheless, it shows the best model fit among the three.

Alternative model

A two-correlated factors model was used as an alternative model fitted to the sets of data collected from the South Australian and Filipino samples. The two latent factors correlated were the perceived mother's support for her children's learning (PASPM) and the perceived father's perceived support for his children's learning (PASPF). Although this was not necessarily postulated by the author of the PFCS, CFA was carried out to test whether the alternative model will give better fit to the different sets of data. The structure of the two-correlated factors model is shown in Figure 9.2.

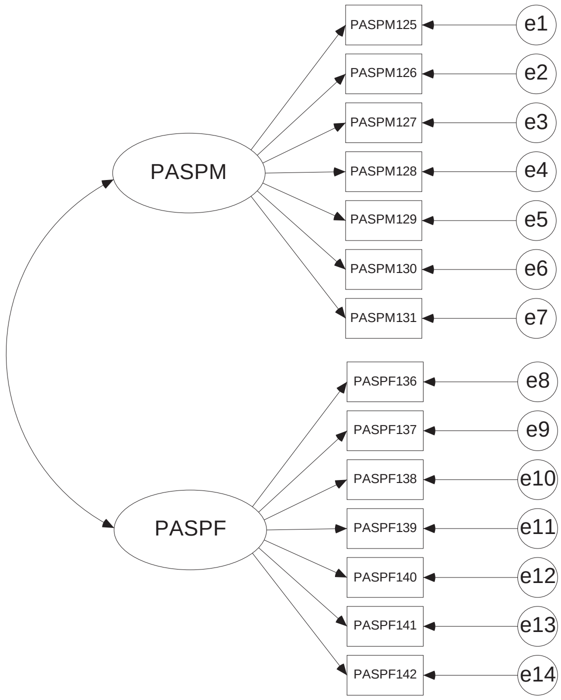


Figure 9.2. Structure of the Two-Correlated Factors Model for the PFCS.

Since the focus of this section is only to compare the model fit of the alternative model with the model fit of the measurement model, factor loadings are no longer presented. Only the summary of the fit indexes resulting from fitting the alternative model to the different sets of data from the South Australian and Filipino samples are presented in this section.

The summary of the fit indexes of the two-correlated factors model fitted to the South Australian data is shown in Table 9.10. The goodness-of-fit statistics for the two-correlated factors model fitted to the different sets of South Australian sample data clearly indicate poor model fit. In addition, the goodness-of-fit statistics of the single factor model fitted to any of the South Australian data sets (see Tables 9.4 and 9.5) show better fit when compared to the two-correlated factors model.

Table 9.10. Goodness-of-fit index summary for the two-correlated factors model (South Australian sample).

	High School data *n=231*	University data *n=42*	Combined data *n=273*
Chi-Square	950.97	155.46	915.15
df	76	76	76
GFI	0.66	0.64	0.67
AGFI	0.53	0.51	0.55
PGFI	0.48	0.47	0.49
RMR	0.10	0.14	0.10
RMSEA	0.21	0.16	0.20

The summary of the fit indexes of the two-correlated factors model fitted to the Filipino data is shown in Table 9.11. Similar to the South Australian sample data, the goodness-of-fit statistics for the two-correlated factors model fitted to the different sets of Filipino sample data clearly indicate poor model fit. In addition, the goodness-of-fit statistics of the single factor model fitted to any of the Filipino data sets (see Tables 9.8 and 9.9) show better fit when compared to the two-correlated factors model.

Table 9.11. Goodness-of-fit index summary for the two-correlated factors model (Filipino sample).

	High School data *n=299*	University data *n=92*	Combined data *n=391*
Chi-Square	1210.95	1111.04	1617.20
df	76	76	76
GFI	0.63	0.36	0.63
AGFI	0.49	0.11	0.49
PGFI	0.46	0.26	0.45
RMR	0.10	0.62	0.11
RMSEA	0.22	0.39	0.23
	n=299	*n=92*	*n=391*

The result of fitting the alternative model to the different sets of data has prompted the author of this study to use the single factor model in the succeeding analyses.

CFA was used to examine the structure of the model and its consistency with the collected data for this study. To add 'granularity' to the analysis and validation of the scales, Rasch modeling was also employed to examine the instrument at item-level. See Chapter 3 for more details of why CFA and Rasch modeling techniques were used in the analysis and validation of scales used in this study.

9.5. Rasch analysis

Rasch analysis enables for a more detailed, item-level examination of the structure and operation of the two sub-scales in the PFCS.

The data collected in this study concerning physics students' perception of their mother's and father's support for their learning were fitted to the rating scale model. All seven items from both the 'perceived mother's support to her children's learning' and the 'perceived father's support to his children's learning' were included in the initial analysis.

Item analysis with the Rating Scale Model

The seven items in each of the perceived family capital scales (i.e. perceived mother's and father's support for learning) were subjected to item analyses by fitting the South Australian and Filipino sample data on physics students' perceived parental (mother's and father's) support for their learning to the Rating Scale Model. This involved examining each item's fit statistics and item threshold values. More specifically, the infit mean square (INFIT MNSQ) statistic was used as a basis for the model fitting or non-fitting items. Similar to the validation of instruments discussed in the previous chapters, a range of 0.72 to 1.30 was used for the infit mean square to indicate good fitting items.

The combined high school and university sample data sets for the mother's and father's support for their children's learning (for both South Australia and the Philippines) were used in the Rasch analysis fitting the rating scale model. In addition to the reasons cited in the CFA section, combining the high school and the university data sets for each group of samples was considered in Rasch analysis for consistency in data handling regardless of using the infit statistics which is robust enough not to be affected by sample size (Adams & Khoo, 1993).

The analyses were carried out and results are presented in the following order:

- Combined samples of South Australian high school and university Physics students (no items removed from each scale)
- Combined samples of South Australian high school and university Physics students (misfitting items removed from each scale)
- Combined samples of Filipino high school and university Physics students (no items removed from each scale)
- Combined samples of Filipino high school and university Physics students (misfitting items removed from each scale)

The refinement process involved subsequent runs of the item analysis using ConQuest after removing items that did not fit the model. Misfitting items were removed one at a time. However, misfitting items were examined very carefully first before removal was decided. Items with infit mean square values outside the accepted range whose item deltas, which indicate the location of the response choices on a scale, exhibit order swapping were readily removed. When items show infit mean square values outside the range but exhibit item deltas in order, item statements were examined carefully as to whether or not they measure what was needed in this study. If deemed not to measure what was required in the study, then they were removed. Caution was strongly exercised in removing misfitting items as they may be valuable in providing other important information or finding that might arise in the study.

Tabulated results include item estimate, error and the unweighted fit statistics. The unweighted fit statistics include the infit mean square and the *t* value. The separation reliability index, chi-square test of parameter equality, degrees of freedom and significance level are also included. As defined by Adams and Khoo (1993), separation reliability index is an indication of the proportion of the observed variance that is considered true. There is generally a preference for high separation reliability index because this means that measurement error is smaller.

The South Australian sample

The data concerning the perceived mother's support to her children's learning collected from samples of South Australian high school and university students were fitted to the

Rasch Rating Scale model. Results are shown in Table 9.12. Two of the seven items yielded infit mean square values outside the accepted range (see Chapter 4) of 0.72 and 1.30. The misfitting items include PASPM126 (1.34) and PASPM131 (1.42). Examining each item's delta values revealed that PASPM126 exhibited order swapping while PASPM131 did not. Item PASPM126 was removed. Separation reliability index was very high (very close to 1.00) which indicates that a significant proportion of the observed variance was considered to be true.

Table 9.12. Table of response model parameter estimates of the PFCS (perceived mother's support for learning) for the South Australian sample (no items removed).

Variables	*Estimates*	*Error*	***Unweighted Fit***		
			INFIT MNSQ	*CI*	*t*
PASPM125	-0.112	0.053	0.83	(0.83, 1.17)	-2.1
PASPM126	1.688	0.052	1.34	(0.83, 1.17)	3.6
PASPM127	0.139	0.052	0.79	(0.83, 1.17)	-2.7
PASPM128	0.023	0.053	1.01	(0.83, 1.17)	0.2
PASPM129	-0.032	0.053	0.89	(0.83, 1.17)	-1.3
PASPM130	-0.977	0.058	0.81	(0.83, 1.17)	-2.4
PASPM131	-0.728*	0.131	1.42	(0.83, 1.17)	4.4

Separation Reliability = 0.996
Chi-square test of parameter equality = 1331.17
df =6 Significance Level = 0.000

Item analysis through data fitting to the rating scale model was carried out after the removal of Item PASPM126. The results showed (see Figure 9.13) that Item PASPM131 was out of range of the acceptable infit mean square values. However, this item was not removed because its item deltas did not exhibit order swapping.

Similarly, the data for the perceived father's support for his children's learning collected from the South Australian sample was fitted to the Rasch Rating Scale model. The results of this test presented in Table 9.14 shows that only one item did not fit the model. This item was PASPF137 with an infit mean square of 1.36 – just outside the upper end of the accepted range. However, examination of this item's delta values showed order swapping. Therefore, this item was removed and the analysis re-run.

Table 9.13. Table of response model parameter estimates of the PFCS (perceived mother's support for learning) for the South Australian sample (one item removed).

Variables	*Estimates*	*Error*	*Unweighted Fit*		
			INFIT MNSQ	*CI*	*t*
PASPM125	0.186	0.056	0.93	(0.83, 1.17)	-0.9
PASPM127	0.460	0.055	0.91	(0.83, 1.17)	-1.1
PASPM128	0.334	0.055	1.05	(0.83, 1.17)	0.6
PASPM129	0.273	0.055	1.01	(0.83, 1.17)	0.1
PASPM130	-0.762	0.061	0.80	(0.83, 1.17)	-2.5
PASPM131	-0.490*	0.126	1.48	(0.83, 1.17)	5.0

Separation Reliability = 0.987
Chi-square test of parameter equality = 300.74
df =4 Significance Level = 0.000

The results of the analysis after Item PASPF137's removal are shown in Table 9.15. It can be observed that Item PASPF142's infit mean square went up to 1.34. This prompted an examination of its item deltas. However, there was no swapping observed. Therefore, this item was kept.

Table 9.14. Table of response model parameter estimates of the PFCS (perceived father's support for learning) for the South Australian sample (no items removed).

Variables	*Estimates*	*Error*	*Unweighted Fit*		
			INFIT MNSQ	*CI*	*t*
PASPF136	-0.122	0.054	0.86	(0.83, 1.17)	-1.7
PASPF137	1.246	0.052	1.36	(0.83, 1.17)	3.9
PASPF138	0.124	0.054	0.87	(0.83, 1.17)	-1.6
PASPF139	0.040	0.054	1.08	(0.83, 1.17)	0.9
PASPF140	-0.062	0.054	0.75	(0.83, 1.17)	-3.3
PASPF141	-0.586	0.056	0.95	(0.83, 1.17)	-0.6
PASPF142	-0.640*	0.132	1.24	(0.83, 1.17)	2.7

Separation Reliability = 0.992
Chi-square test of parameter equality =691.46
df =6 Significance Level = 0.000

Out of the seven items in the scale, only one item was removed. Similar to the results presented above (Tables 9.12 and 9.13) there was only a very small drop in the separation reliability index after removing the misfitting item. The same argument as the one above could be made about this drop.

Table 9.15. Table of response model parameter estimates of the PFCS (perceived father's support for learning) for the South Australian sample (one item removed).

Variables	*Estimates*	*Error*	*Unweighted Fit*		
			INFIT MNSQ	*CI*	*t*
PASPF136	0.102	0.057	0.92	(0.83, 1.17)	-1.0
PASPF138	0.363	0.057	0.96	(0.83, 1.17)	-0.4
PASPF139	0.268	0.057	1.12	(0.83, 1.17)	1.4
PASPF140	0.157	0.057	0.85	(0.83, 1.17)	-1.9
PASPF141	-0.416	0.059	0.88	(0.83, 1.17)	-1.5
PASPF142	-0.473*	0.128	1.34	(0.83, 1.17)	3.6

Separation Reliability = 0.964
Chi-square test of parameter equality =123.07
df =4 Significance Level = 0.000

The sets of data collected from the Filipino sample were also fitted to the Rasch Rating Scale model.

The Filipino sample

This section reports on the results of fitting the Rasch Rating Scale model to the data concerning the perceived mother's support to her children's learning collected from samples of Filipino high school and university students. The results are shown in Table 9.16.

Table 9.16. Table of response model parameter estimates of the PFCS (perceived mother's support for learning) for the Filipino sample (no item removed).

Variables	*Estimates*	*Error*	*Unweighted Fit*		
			INFIT MNSQ	*CI*	*t*
PASPM125	0.160	0.049	0.89	(0.86, 1.14)	-1.5
PASPM126	1.594	0.048	1.24	(0.86, 1.14)	3.2
PASPM127	0.435	0.049	0.98	(0.86, 1.14)	-0.3
PASPM128	0.348	0.049	0.94	(0.86, 1.14)	-0.8
PASPM129	-0.233	0.051	0.87	(0.86, 1.14)	-1.9
PASPM130	-0.776	0.054	0.97	(0.86, 1.14)	-0.4
PASPM131	-1.529*	0.122	1.15	(0.86, 1.14)	2.1

Separation Reliability = 0.996
Chi-square test of parameter equality =1493.75
df =6 Significance Level = 0.000

Item analysis fitting the combined high school and university data from the Filipino sample to the rating scale model revealed no misfitting item. In addition, the separation reliability index was very high at a value very close to 1.00 indicating that a significant proportion of the observed variance was considered to be true.

Fitting the data concerning the perceived father's support to his children's learning to the rating scale model produced one misfitting item. This item was PASPF137 with an infit mean square value of 1.33 (see Table 9.17). This figure is just outside the desired upper limit of the infit mean square used in this study. However, the item was removed because its item deltas exhibited order-swapping. The analysis was re-run.

Table 9.17. Table of response model parameter estimates of the PFCS (perceived father's support for learning) for the Filipino sample (no item removed).

Variables	*Estimates*	*Error*	***Unweighted Fit***		
			INFIT MNSQ	*CI*	*t*
PASPF136	0.219	0.051	0.82	(0.86, 1.14)	-2.7
PASPF137	1.404	0.050	1.33	(0.86, 1.14)	4.2
PASPF138	0.538	0.050	0.90	(0.86, 1.14)	-1.4
PASPF139	0.253	0.051	0.99	(0.86, 1.14)	-0.1
PASPF140	-0.261	0.052	0.85	(0.86, 1.14)	-2.2
PASPF141	-0.795	0.054	1.00	(0.86, 1.14)	0.0
PASPF142	-1.359*	0.126	1.11	(0.86, 1.14)	1.5

Separation Reliability =0.995
Chi-square test of parameter equality =1197.25
df =6 Significance Level = 0.000

Removing Item PASPF137 and re-fitting the data into the model produced results shown in Table 9.18 including the items' infit statistics. Overall, only one item was removed and all the six remaining items have infit mean square within accepted range. Observed drop in the separation reliability is small given that only one item was removed.

Table 9.18. Table of response model parameter estimates of the PFCS (perceived father's support for learning) for the Filipino sample (one item removed).

Variables	*Estimates*	*Error*	***Unweighted Fit***		
			INFIT MNSQ	*CI*	*t*
PASPF136	0.495	0.053	0.95	(0.86, 1.14)	-0.7
PASPF138	0.844	0.053	0.98	(0.86, 1.14)	-0.2
PASPF139	0.533	0.053	1.11	(0.86, 1.14)	1.5
PASPF140	-0.029	0.055	0.86	(0.86, 1.14)	-2.1
PASPF141	-0.613	0.057	0.94	(0.86, 1.14)	-0.8
PASPF142	-1.230*	0.121	1.12	(0.86, 1.14)	1.6

Separation Reliability =0.991
Chi-square test of parameter equality =561.32
df =5 Significance Level = 0.000

In total, only one item was removed from the two scales fitted to the Filipino data. In contrast, a total of two items were removed when the South Australian data was used. This clearly indicates measurement variance which makes it difficult to compare the two groups of samples.

9.6. Model for the study

After examining and comparing the results of the CFA and Rasch analysis tests, it was decided that the following single factor models will be used in the subsequent analyses.

- For the South Australian sample, a single factor model without Item PASPM126 will be used for the scale mother's perceived support to her children's learning. A single factor model without Item PASPF137 will be used for the scale father's perceived support to his children's learning.
- For the Filipino sample, a single factor model keeping all items will be used for the 'mother' scale and a single factor model without Item PASPF137 will be used for the 'father' scale.

The reasons for this decision has been that the results of the Rasch analysis has demonstrated the unidimensionality of the items to measure a common construct, and thus resulting to a fitting parsimonious model which is more preferred (Thompson, 2000).

9.7. Summary

The Perceived Family Capital Scale developed by Marjoribanks (2002) was adapted for use in this study as part of the SUPSQ instrument to measure Physics students' perceived parental support for their learning. The PFCS was also used to collect information on the students' perceived parental educational and occupational aspirations for them. It consists of the perceived mother's support for her children's learning scale and the perceived father's support to his children's learning scale. Each scale consists of seven items using five Likert-type choice responses ranging from "strongly disagree" (1) to "strongly agree" (5).

As with the preceding five instrument validation chapters, the same sets of data collected from South Australian and Philippine high school and university Physics student samples were used. A section of the data sets that concern students' perceived parental support for their learning was analysed through CFA employing LISREL 8.80 software package to examine the structure of the whole PFCS. Rasch Modeling with ConQuest 2.0 (using the rating scale model) was used for item-level analysis to examine the unidimensionality of the instrument items to measure a common latent factor – perceived mother's (or father's) support for her (or his) children's learning.

The CFA part of instrument validation involved fitting the measurement and alternative models into the South Australian and Filipino data. The South Australian data consists of three different groups of samples: high school Physics students, university Physics students and combined high school and university Physics students. The Filipino data consists of the similar groups of samples. The measurement model was fitted in each of these sets or groups from each data set. As there were only seven items in each scale (therefore generating a small number of parameters) there were no issues encountered when the model was fitted to a set of data collected from a small sample (around 45) of South Australian university students. Hence, the results of fitting the model to the university data were used for comparisons with the other sets of data. The measurement model used was a single factor model consisting of seven observed variables loading onto a single latent factor. The model fitted in the South Australian data showed all of the seven items in each scale adequately fitting using the high school and combined high school and university data sets. However, items PASPM126 and PASPF137 showed misfit when the model was fitted to the South Australian university sample data.

Based on the goodness-of-fit statistics of the model fitted to the three different sets of South Australian sample data concerning the perceived mother's support to learning, the single factor model fitted to the high school data showed the best fit. The single factor model factor fitted to the combined high school and university data concerning father's support to learning demonstrated the best fit.

The model fitted in the Filipino data showed results a little different from the South Australian data. Item PASPM126 consistent failed to load adequately using any of the three data sets (i.e., high school data, university data, and combine high school and university data), while PASPF137 failed to adequately load only when the model was fitted to the university data. Based on the single factor model's goodness-of-fit statistics, a trend similar to the results of the South Australian sample is exhibited – high school data produced the best model fit for the perceived mother's support to learning, while combined data produced the best model fit for the perceived father's support to learning.

A two-correlated factors model was tested as an alternative model. This model included the two scales correlated within a single structure to test whether it will improve model fit. Running CFA with this model resulted in goodness-of-fit statistics worse than that of the single factor model for each scale. Therefore, the single factor model was used in the study's succeeding analyses. No items were removed when CFA was carried out. Items were removed when item-level analyses were carried out using Rasch modeling with the rating scale model.

To test the unidimensionality of the seven items to measure a common factor in the PFCS, the rating scale model was fitted to the data. Using the unweighted fit statistics, items were examined for their fit in the model. An item whose infit mean square statistic did not fall within the accepted range of 0.72 and 1.30 and whose item deltas exhibited order swapping was removed. For both the perceived mother's support to her children's learning and the perceived father's support to his children's learning scale, a total of two items were removed when the combined South Australian high school and university data was fitted to the rating scale model. Only one item was removed when the combined Filipino data was fitted to the rating scale model. This was a clear indication that the PFCS adapted for use in this study demonstrated measurement variance for the two different groups sampled.

The final model used in the succeeding analyses was the single factor model for both scales. Items in the model include the following:

For the South Australian sample

- Perceived mother's support to her children's learning:
  PASPM125, PASPM127, PASPM128, PASPM129, PASPM130 and PASPM131
- Perceived father's support to his children's learning:
  PASPF136, PASPF138, PASPF139, PASPF140, PASPF141 and PASPF142

For the Filipino sample

- Perceived mother's support to her children's learning:
  PASPM125, PASPM126, PASPM127, PASPM128, PASPM129, PASPM130, and PASPM131
- Perceived father's support to his children's learning:
  PASPF136, PASPF138, PASPF139, PASPF140, PASPF141, and PASPF142

All scales and instruments used in this study were examined using the same steps and techniques. A total of six different instruments were adapted for this study. These include:

1. The 'Attitudes towards Physics' scale developed by Redford (1976) (discussed in Chapter 4). This instrument was used to measure the students' attitudes towards physics in terms of its importance and practicability in the society. It was used to partly address research questions that concern student attitudes which, is the main focus of this study.
2. The 'Students' Motivation Towards Learning Science' scale by Tuan et al. (2005) (discussed in Chapter 5). In this study, this instrument was used to measure students' motivation to learn physics covering the domains of self-efficacy, active learning strategies, science learning value, performance goals, achievement goals, and learning environment stimulation. One of the factors examined in this study for its effects on students' attitudes towards physics, as advanced in the research questions, is motivation.

3. The 'Rosenberg Self-Esteem' scale by Rosenberg (1965) (discussed in Chapter 6). This is a short (10 items) instrument design to measure an individual's general self-esteem. This instrument was adapted in this study to provide answers to the research questions regarding self-esteem and its effects on a student's attitudes towards and motivation to learn physics.

4. The 'Computer Attitudes Scale' by Jones and Clarke (1994) (discussed in Chapter 7). In an attempt to examine how students' attitudes towards computers affect their attitudes towards physics, this instrument was adapted. It covers the three domains commonly covered in measuring attitudes: affective, behavioural, and cognitive.

5. The 'Individualised Classroom Environment Questionnaire' by Fraser (1990) (discussed in Chapter 8). The classroom environment effects on students' attitudes towards physics were examined using this instrument. It covers a number of important aspects of the classroom environment including: personalisation, participation, independence, investigation, and differentiation. This instrument also provides insights on how teachers in the physics classrooms conduct their classes as perceived by their students. Furthermore, insights on what students prefer to happen in their physics classrooms are also provided by this instrument.

6. The 'Perceived Family Capital Scale' by Marjoribanks (2002). This instrument was adapted in this study to measure parents' (father and mother) aspirations for their children and support for their learning as perceived by the students. It was also used to determine whether students' perceived parental aspirations for them could influence their subsequent decision to continue doing physics or physics-related courses.

The next chapter discusses how the data collected for this study was prepared for analysis. Some descriptive statistics will also be presented.

Chapter 10

Examining the Research Sample

10.1. Introduction

In this study, a model combining individual and school level factors influencing students' attitudes towards physics have been developed based on findings of previous studies (see Chapter 2). This model was developed to address the research questions advanced in Chapter 1. Broadly, the research questions advanced address two key aspects: the factors that affect high school and university level students' attitudes towards physics that could influence their choice of physics as a stand-alone subject/course in their course of study, and how these factors interact to influence students' attitudes towards physics. Individual level factors include gender, self-esteem, motivation towards learning physics, parents' aspirations for the children's education and support for their learning as perceived by the students, and student attitudes towards computers. School level factors include school curriculum and classroom climate (which reflects how physics teachers contribute in shaping it).

This chapter includes a description of the steps carried out in the data preparation and score transformation methods undertaken in this study. It describes the demographics of the samples taken from the two different groups – South Australian and Filipino students. It also describes the differences between raw scores, scaled scores and measures which provides a prelude to how the data used in this study was transformed from one form to another. This is followed by the scaling process carried out to transform raw scores into measures, and how missing data was addressed. The level of analysis employed in this study is also discussed. This chapter concludes with a summary.

10.2. The Sample: descriptive information

Gender distribution

Chapter 3 describes in detail the sample in this study. The sample is composed of Physics high school and university students from South Australia and the Philippines. More specifically, the participants in this study were Years 11 and 12 Physics high school students and First Year university Physics students from South Australia's metropolitan area, and Fourth Year high school and First Year university Physics students from Quezon City in the Philippines (see Table 3.1 in Chapter 3 for summary including the distribution of participants from each school type). A combined (high school and university) total of 306 students comprise the sample from South Australia and a combined total of 403 from Quezon City, Philippines. What was not included in Chapter 3 was the distribution of student gender. Gender is one of the factors considered to possibly have an effect on students' attitudes to, and uptake of, Physics. Therefore it is important that gender distribution be presented as well.

Table 10.1 and Table 10.2 show the gender distribution for the sample groups.

Table 10.1. Gender distribution for the South Australian sample.

	School Level			
Gender	**Year 11**	**Year 12**	**First Year Uni**	**Total**
Female	54	64	11	129
Male	78	65	34	177
Total	132	129	45	**306**

Table 10.2. Gender distribution for the Filipino sample.

	School Level		
Gender	**Fourth Year HS**	**First Year Uni**	**Total**
Female	206	47	253
Male	101	49	150
Total	307	96	**403**

An interesting fact that can be observed as far as the two sample groups are concerned is the contrast between the ratio of males to females in the South Australian sample and the Filipino sample, especially the university Physics students. The ratio of females to males in the South Australian sample is around 7:10, while the ratio of females to males in the Filipino sample is around 17:10. The South Australian ratio, while not very alarming, shows (and perhaps confirm) the trend of fewer females taking Physics as a subject or course compared to males, which is commonly observed and reported by Physics education researchers. This can be best described by a pictorial representation of the figures to get an easier grasp of the gender distribution for each sample group. Figure 10.1 shows the gender distribution for the South Australian sample and Figure 10.2 shows the distribution for the Filipino sample.

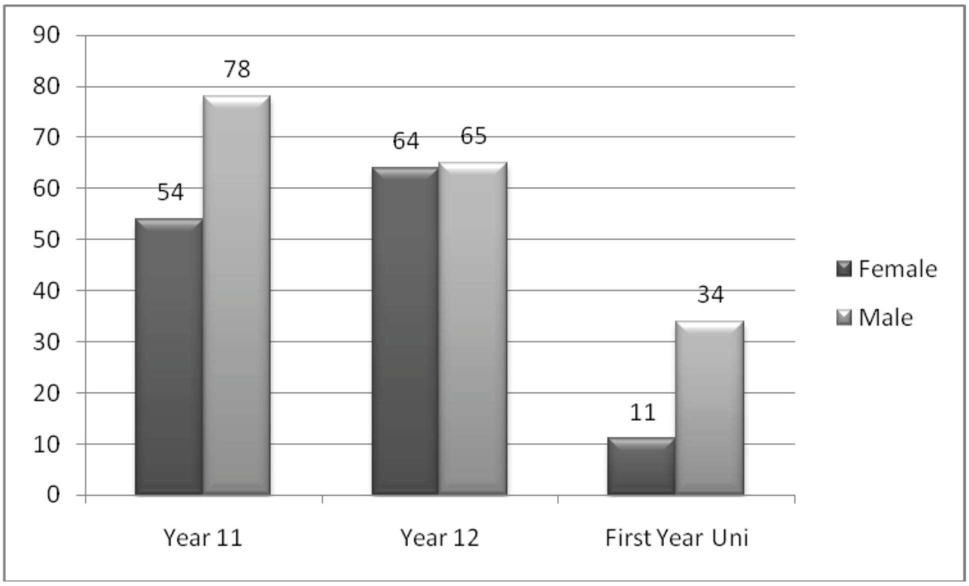


Figure 10.1. South Australian sample gender distribution.

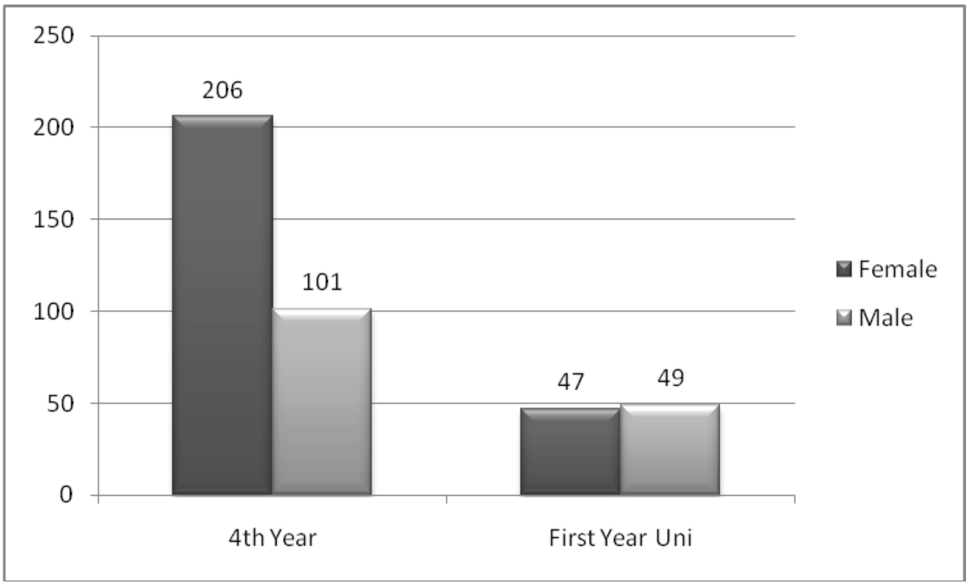


Figure 10.2. Filipino sample gender distribution.

The Students' Uptake of Physics Study Questionnaire (SUPSQ) was administered to both sample groups for the data needed in this study. This became the raw data for the study. The raw data collected contains participants' demographic information and data for each scale in the questionnaire as well as qualitative data for some open-ended question items.

School type distribution

Two educational sectors provide South Australia's school education – the government-owned and operated schools to provide public education, and the non-government-owned schools for private education. The Department of Education and Children's Services (DECS) administer the government-owned schools, and the Association of Independent Schools in South Australia (AISSA) and the Catholic Education Office (CEO) of South Australia govern private schools. Tertiary level education is provided by the government-owned and operated universities. The distribution of the South Australian sample by school type is shown in Table 10.3.

Table 10.3. Distribution of samples by school type.

School Type	Number of Schools	Number of Students
Adelaide, South Australia		
Government Schools	3	63
Private Schools		
(Independent Schools)		
- Coeducational School	4	93
- Boys' School	1	39
- Girls' School	1	25
(Catholic Schools)		
- Coeducational School	1	17
- Boys' School	1	24
- Girls' School	0	0
University		
- Government	1	45
Quezon City, Philippines		
Government Schools	6	169
Private Schools *(all coeducational)*	5	138
University		
- Government	1	32
- Private	1	64

Similarly, in the Philippines, the government and private education sectors provide primary, secondary and tertiary education. The chief government agency responsible for providing school education from elementary through to secondary schooling is the Department of Education (DepEd) which is also responsible in setting up and implementing the school curricula. Private schools, although privately-owned by business people and/or institutions, also follow the standards and the curricula prescribed by the DepEd. However, private schools have the option to add to or remove from the DepEd-prescribed curriculum depending on which will give their students what private schools administrators believe to be a 'high standard' education. The distribution of the Filipino sample by school type is shown in Table 10.3.

It should be noted, however, that opportunity or non-probability sampling had eventuated due to reasons beyond the control of the author. Therefore, generalisability of the results is limited to the study sample. Chapter 3 discusses the study sampling details.

As a prelude to the discussion on how the numerical (quantitative) data was 'processed' for the analysis, the following sections briefly discuss the concepts of raw score, scaled/transformed score, and measure.

10.3. The Data

Preparation of collected data

Data for this study was collected using paper questionnaires. The questionnaires were distributed to student and teacher participants to fill out. The questionnaire for students is different from the one distributed to the teachers. The student questionnaire, which is called the Student Uptake of Physics Study Questionnaire (SUPSQ), contains all the scales discussed in Chapters 4 to 9 in addition to the items used to collect the student participants' demographic information (Items 1 – 10; see Appendix A and B) and some open-ended question items (Items 18 and 19; see Appendix A and B) purposefully written to elicit some of their thoughts about Physics. The teacher questionnaire does not have any scale similar to the ones in the SUPSQ. It only contains open-ended question items purposefully written to collect answers that could be used to support some of the findings using the quantitative data from the SUPSQ. The open-ended question items in the SUPSQ and the teacher questionnaire compose the qualitative data for this study. Responses to these items and questionnaire have been entered and organised in a Microsoft Word document format.

Numerical data entry was carried out using Microsoft Excel. Texts from the open-ended question items (for both the SUPSQ and the teacher questionnaire) were saved as a separate text file using Microsoft Word. Data saved in the spreadsheet (using Excel) format was exported to SPSS for data 'tidying'. SPSS was also used to carry out descriptive statistics to gather descriptive information about the samples such as the ones presented above. The data saved in the SPSS format became the raw data for the study.

The data collected using the SUPSQ constitutes two parts: the nominal data from the items used to deduce descriptive information about the sample, and the ordered category data from the different rating scales (Masters, 1982) included in the questionnaire. Each item in each of the rating scales (which are Likert-type scales) is composed of a fixed set of ordered response alternatives. These constitute the students' raw scores. Raw scores are counts of observed events (Wright & Linacre, 1989). These raw scores represent the students' self-reports on their attitudes (Masters, 1982) for each of the scales' items. However, analysis cannot be carried out with these scores as they are not yet measures (Wright & Linacre, 1989), and that they have no standard starting point. According to Wright and Stone (1999), raw scores have a starting point at "none" and have units of more than one kind. Wright and Stone have also added that the term measurement (where measures are used) implies a count of "standard" units from a "standard" starting point that is necessary to anchor a scale. Wright and Linacre (1989) pointed out however that scores are an element essential for the construction of measures and that measurement is deduced from well-defined sets of scores. Therefore these scores need to be transformed to measures before analysis can be carried out.

The scaling process

Transforming raw scores (such as those collected in this study) into measures may be carried out using a variety of ability estimation methods. Several methods suggested by quantitative researchers include: Maximum Likelihood Estimate or MLE (Lord, 1980), Bayes modal estimation or BME (Mislevy, 1986), Expected A-Posteriori (EAP) method (Bock, 1983), and Marginal Maximum Likelihood estimation method (Bock & Aitkin, 1981). These estimation methods have been examined and were found to have their own strengths and weaknesses in terms of several attributes including their estimation biases (see e.g. Chen, Hou & Dodd, 1998; Junker, 1991; Warm, 1989). Warm (1989) has introduced an ability estimation technique that minimises estimation bias. He called this the Weighted Likelihood Estimation (WLE). Large-scale international studies such as the Programme for International Student Assessment (PISA) have used the WLE method (see Adams & Wu, 2002) as part of the data analysis techniques implemented. For these reasons, it was considered that the use of the WLE method will be advantageous for use in this study. Transforming raw scores to measures using the WLE was carried out using the ConQuest 2.0 computer program (Wu, Adams, Wilson & Haldane, 2007).

Measures derived from the WLE methods were further transformed to *W* scores (Woodcock, 1999). The scale was derived by Woodcock and Dahl in as early as 1971 and maybe expressed as a direct transformation of the Rasch logits scale as follows:

$$W = 9.1024 \text{ logits} + 500$$

The *W* formula implies that W scores are centred at 500. This represents the typical answer of the study respondents to a questionnaire item. This carries an advantage of creating an equal interval scale recommended for statistical analysis. In addition,, according to Woodcock (1999, p. 111), this scale has a number of advantages over the scales resulting from the earliest Rasch scaling program (see e.g. Wright & Panchapakesan, 1969):

1. Negative values are eliminated by setting the centering constant at 500. (This centering constant may be further adjusted to some meaningful point such as 500 set equal to beginning grade 5 *W* ability.)
2. The need for decimal values in many applications is eliminated by the multiplicative scaling constant of 9.1024.
3. The signs of the item difficulty and person ability scales are set so that low values imply either low item difficulty or low person ability. High values imply either high item difficulty or high person ability.
4. Distances along the *W* scale have probability implications that are more convenient to remember and to use than distances along the logits scale.

Transforming measures obtained from WLE method to W scale was a task performed by simply using the formula above in Microsoft Excel. The resulting data file in Excel was then exported to SPSS as data files ready for analysis.

Missing values and missing data: How they were addressed

In any fairly large-scale studies using survey instruments, it is almost inevitable to have missing data. In fact, this occurs in many areas of research (Kline, 1998). The data set for this study certainly have this. Missing data may be caused by at least one of the following reasons (Brick & Kalton, 1996):

- An element in the target population is not included on the survey's sampling frame (non-coverage).
- A sampled element does not participate in the survey (total non-response).
- A responding sampled element fails to provide acceptable responses to one or more of the survey items (item non-response).
- A responding sampled element fails to provide acceptable responses to a substantial number of survey items (partial non-response).

Missing values in data sets can affect inferences and reporting of studies. A number of sources (see e.g., Muthén, Kaplan, & Hollis, 1987; Arbuckle, 1996; Schafer & Graham, 2002) offer, and sometimes suggest some standard or 'more traditional' statistical techniques that can be used to handle data with missing values. Some of these include: complete case analysis approach (otherwise known as listwise deletion) which is widely used in social science research, available case methods approach (or casewise deletion), and filling in missing values with estimated scores (or imputation). With the listwise deletion method, Darmawan (2003) summarized some problems that may arise from using it. He pointed out that in multivariate settings where missing values occur in more than one variable, the loss in sample size can be considerable especially when the number of variables is large. This, he added, may result to the inefficiency due to the removal of large amounts of information. Nevertheless, the listwise deletion method is still used by other social science researchers because of its claimed proven usability in handling a variety of multivariate techniques such as multiple regressions and structural equation modeling (Myers, Gamst & Guarino, 2006). Allison (2002, p. 7), highly endorses this technique because, "…whenever the probability of missing data on a particular independent variable depends on the value of that variable (and not the dependent variable), listwise deletion may do better than maximum likelihood or multiple imputation." Maximum likelihood and multiple imputation techniques are considered contemporary techniques used to handle missing data.

Casewise methods and filling in missing values with estimated scores have their share of disadvantages as well. Casewise methods tend to increase sample size and are considered simple but sample base for each variable changes depending on missing value patterns (Darmawan, 2003). Filling in missing values (or imputation) involves assigning a value based on some values from other data cells or substituting a reasonable estimate for a missing data (Little & Rubin, 1989). Sometimes the mean is used to represent missing data. Although imputing the mean is easy to understand, this is not without a problem. According to Patrician (2002, p. 79), imputation

> …eliminates data that may be unique to a particular individual and ascribes the ``usual" to that person. The mean naturally depends on the study sample. The major problem with mean imputation is that nonresponse bias is ignored. There may be very distinct reasons why individuals do not respond to certain items.

Furthermore, Darmawan (2003) pointed out that using this technique distorts the covariance structure resulting to the estimated variance and covariance biasing towards zero.

Because of the disadvantages cited above, this study did not use any of the 'traditional' methods of handling missing data. Newer techniques have been considered instead, similar to what more recent researchers (such as Peugh & Enders, 2004) use as means of handling missing data including the maximum likelihood and multiple imputation techniques. This study particularly used the multiple imputation (MI) to handle missing values in the data sets. The multiple imputation was developed by Rubin (1977, 1987, as cited in Patrician, 2002) to address the problems encountered using single imputation methods. This is a predictive approach to handling missing data in a multivariate analysis (Patrician, 2002).

In the last two and a half decades, the MI methods have been progressively developed and utilised to handle missing values in data sets by social science researchers. A complete data set resulting from using MI methods allows a researcher to use standard complete-data procedures just as if the imputed data were the real data obtained from nonrespondents (Rubin, 2004).

The MI methods combine both the classical and Bayesian statistical techniques relying on iterative algorithms to create several imputations. The Bayesian statistical technique involves the Baye's Theorem which is a fundamental law of probability (Schafer, 1997). Because of this, it is required that a prior distribution for the parameters of the imputation model be specified. In addition, all the variables considered in the analysis and others predictive of the missing information should be included in the model. According to Schafer (1997), the multivariate normal is the most commonly used MI model. This model assumes that all variables are normally distributed and are linearly related (Allison, 2000, as cited in Patrician, 2002). The MI method used in this study was the Expectation – Maximisation (EM) algorithm and Data Augmentation (DA).

The EM algorithm is an iterative process to find maximum likelihood estimates in parametric models for data sets with missing values. This process cycles in two steps: the *expectation* step and *maximisation* step. Darmawan (2003, p. 74) provides a description of these two steps in his thesis:

(a) The Expectation or E-step: Replace missing sufficient statistics by their expected values given the observed data, using estimated values for the parameters; and
(b) The Maximisation or M-step: Update the parameters by their maximum-likelihood estimates, given the sufficient statistics obtained from the E-step.

The original EM algorithm, its basic properties and its applications can be found in Dempster, Laird, and Rubin (1977) where it was first formally introduced.

Data Augmentation (DA) is used by the EM algorithm to solve maximum likelihood problems. The DA method was popularised in Tanner and Wong's (1987) statistical literature. Van Dyk and Meng (2001, p. 1) describe this method as being used "for constructing iterative optimizations or sampling algorithms via the introduction of unobserved data or latent variables." Data augmentation consists of two steps alternately performed. These steps are summarised by Darmawan (2003, p. 75) as follows:

(a) The imputation or I-step: impute the missing data by drawing them from their conditional distribution given the observed data and assumed values for the parameters; and
(b) The posterior or P-step: simulate new values for the parameters by drawing them from the Bayesian posterior distribution given the observed data and the most recently imputed values for the missing data.

Multiple imputation was carried out in this study using built-in procedures in LISREL 8.80 (Jöreskog & Sörbom, 2006). The steps include importing the SPSS file into LISREL then converting the SPSS file into *.psj format which is a data file format in LISREL. After importing the data set into LISREL, a menu tab with 'multiple imputation' can be selected. MI using the EM algorithm is the default setting for LISREL 8.80. The imputed data is automatically generated and saved in *.psj format. A data file in this format can also be exported to more familiar formats such as SPSS and Excel.

Level of Analysis

The research questions advanced in Chapter 1 covered factors in both school and individual levels. Therefore, the collected data from the two sample groups contain information that includes two distinct levels – student level (individual level) and school level (organisational level). School level factors include school curriculum and classroom climate (including teachers), and individual level factors include gender, self-esteem, motivation, parents' aspirations as perceived by the students, and attitudes towards computers. Country as a third level was also considered. However, validation of the instruments demonstrated measurement variance between the two countries. Therefore, country level was not included. These different levels need special attention because problems in the interpretability of the results arise when data obtained at different levels are integrated into one model. These problems are discussed below.

To get a general picture of how a variable influences other variables (based on the theoretical model presented in Chapter 2), a single level (student or individual level) path analysis was undertaken. This involved the integration of the variables from two different levels. This can be done in two ways: aggregation of data from the individual level to the organisational level, and disaggregation of data from the organisational level down to the individual level. This study used the method of disaggregation of data at the student level for the single level path analysis. Within the context of this study, the single level path analysis is also the same as the student level path analysis. However, regardless of method used to combine data from different levels, potential problems arise when combining data from different levels.

Aggregation

Snijders and Bosker (1999) enumerated four potential errors resulting from aggregation of data which include:

1. *Shift of meaning* (cf. Hüttner, 1981, as cited in Snijders & Bosker, 1999), which happens when a variable that is aggregated to the macro-level refers to the macro-units, and not directly to the micro-units.
2. *Ecological fallacy* (Robinson, 1950, as cited in Snijders & Bosker, 1999), which states that a correlation between macro-level variables cannot be used to make assertions about the micro-level relations.
3. *Neglect of the original structure*, which happens when an inappropriate tests of significance are applied in the examination of the effects of sampling error.
4. *Prevention from examining potential cross-level interaction effects*, which means that there is a loss of cross-level interactions between a specified micro-level variable and yet to be specified macro-level variable.

Disaggregation

Disaggregation of data is no less problematic. Disaggregation of group level data results to some distorting effects which are otherwise known as disaggregation bias. Snijders and Boskers (1999, p. 15) pointed out that disaggregation results to

> … 'the miraculous multiplication of the number of units'…disaggregation and treating the data as if they are independent implies that the sample size is dramatically exaggerated. For the study of between-group differences, disaggregation often leads to serious risks of committing type I errors.

A type I error occurs when a statistical test incorrectly rejects a null hypothesis of no difference when the null hypothesis is true (Braun, Jenkins & Grigg, 2006).

In addition to the issues elaborated above, problems with aggregation and disaggregation include bias and incorrect estimates (Darmawan, 2003). For instance, the disaggregation method used in this study can exhibit greater measurement error and may introduce bias to the coefficient of input variables (Darling-Hammond & Youngs, 2002). Nevertheless, these problems were accounted for in the analysis.

Single level models are essentially structural equation models or SEMs (Rowe, 2005). Rowe (2005, p.109) pointed out

> ...SEM models assume *single-level* data...fitting any single-level model not only violates the assumptions of independence but gives rise to several problems affecting statistical conclusion validity, including misestimated parameters and their standard errors, with important ramifications for the substantive interpretation of findings.

To take into account the hierarchical structure of most data collected in social science research and to minimise the problems with single level path analysis which includes drawing wrong conclusions, it was necessary to carry out multi-level path analysis. In this study, the multilevel path analysis technique employed was the hierarchical linear modeling which is more commonly known as HLM. This will be discussed in detail in Chapter 12.

10.4. Summary

This chapter highlighted descriptive information about both groups of samples who participated in this study. The information includes distributions on gender and school type. Also highlighted in this chapter are the steps undertaken in the preparation of the study data that ranges from saving it as a spreadsheet of raw scores to transforming these raw scores to measures. Transforming raw scores to measures involved the use of weighted likelihood estimates (WLE) methods and the conversion of WLE to the *W* scale considering their advantages over other methods. The multiple imputation method was employed to handle missing data values. Level of analysis, which includes single (student) level analysis and multilevel analysis, was also discussed in this chapter since the data collected for this study contain information for two distinct levels. All of these procedures have been undertaken in an attempt to minimise errors, and eliminate biased and incorrect interpretation and reporting (Jöreskog & Sörbom, 2006; Rowe, 2005; Raudenbush & Bryk, 2002). The next chapter reports and discusses the results obtained using the single level (or student level) path analysis.

Chapter 11

What Impacts Students' Learning and Attitudes

11.1. Introduction

The following general and specific research questions were advanced in Chapter 1.

General research questions include:

a. What are the factors that affect high school and university level students' attitudes towards physics that could influence their uptake of physics as a stand-alone subject/course in their course of study?
b. How do these factors interact to influence students' attitudes towards physics?

These general questions lead to the following specific questions under 3 broad headings:

1. *School-level factors*
   a. What is the influence of school type (government or private, coeducational or single-sex) on students' attitudes towards physics?
   b. How does school curriculum influence classroom climate in the two sample groups?
   c. Does school curriculum have an influence on students' motivation to study physics?
2. *Classroom-level factors*
   a. How does classroom climate influence students' general self-esteem?
   b. How does classroom climate affect students' attitudes towards physics?
   c. How does classroom climate affect students' motivation to learn physics?
   d. What is the influence of teachers on the physics classroom climate that could affect students' attitudes towards physics?
   e. How do teachers' teaching methods impact on physics classroom climate?
3. *Individual-level factors*
   a. Do motivation and self-esteem affect students' attitudes towards physics?
   b. Does self-esteem affect students' motivation to learn physics?

c. Does gender have an influence on students' motivation to study physics? Does it influence their attitudes towards physics?
d. Is there a significant difference between genders towards their attitudes towards physics?
e. Does gender have an effect on general self-esteem?
f. Does the use of computers have a positive impact on students' attitudes towards physics?
g. How do parents' aspirations for their children affect students' attitudes towards and their choice of physics or physics-related courses?
h. How do parents' aspirations affect their children's general self-esteem?
i. What are the students' perceptions of physics and physics-related courses in terms of job availability, status of jobs related to these courses in the society, and financial security from these jobs?

The study sought to examine these factors that may have a significant effect on the attitudes of students towards physics that could influence their uptake of physics as a subject or course of a study. These factors are divided into two different levels: school (school-level and classroom-level) factors and individual-level factors. School-level factors include school type, school curriculum, and classroom climate. Individual-level factors include students' attitudes towards physics, students' motivation to learn physics, attitudes towards computers, student gender, parents' aspirations, and self-esteem. The Students' Uptake of Physics Questionnaire (SUPSQ) was used to obtain data from South Australian and Filipino senior high school and first year university physics student samples. A total of 306 South Australian and 403 Filipino senior secondary and first year university physics students participated in the study (See Chapter 3 for details).

This chapter reports on the processes carried for the student level path analysis in order to answer all research questions (RQ) except RQ3i (which will draw from the students' qualitative responses): The process of path analysis carried out in this study started with exploring the relationships of the different pairs of variables as advanced in the theoretical framework. Student level path analysis then proceeded to obtain an overview of the relationships and the interactions of the different variables examined in this study. The student level path analysis is also known as the single level analysis as mentioned in the previous chapter. Results following the different processes involved in carrying out path analyses are also presented and discussed. More specifically, the following sections discuss the results that address the different research questions enumerated above, which were advanced in Chapter 1. The chapter concludes with a summary.

11.2. The use of LISREL for student level path analysis

A number of statistical software packages that can handle single and/or multi-level path analysis are available. Some examples include PLSPath developed by Sellin (1989), AMOS by Arbuckle (2007), MPlus by Muthén and Muthén (2007), and LISREL by Jöreskog and Sörbom (2006). PLSPath and AMOS have been considered for use in path analyses in this study, however, according to Keeves and Cheung (1990, as cited in Darmawan, 2003, p. 84); some issues arise in single level analysis carried out with these software applications which include:

(a) Problems of aggregation of data from a lower to a higher level;
(b) Problems of disaggregation of data from a higher to lower level;
(c) Specification errors which arise when a variable measured at the lower level is permitted to account for variance that is more properly associated with the higher level such as climatic conditions in the classroom;
(d) Specification errors which arise when a variable measured at the higher level is not permitted to account for variance with which it is associated at the lower level, such as the variability of the regression slopes between groups; and
(e) Problems associated with the estimation of errors which arise with measures obtained under conditions involving two or more levels of sampling and measurement.

Aggregation and disaggregation, in lay terms, pertain to individual factors or entities that are grouped to provide a collective representation.

MPlus was also considered but its availability during the conduct of the study proved to be a challenge. Fortunately, LISREL was available during the phase of the study. This was considered good for a number of reasons; firstly, LISREL is the best known structural equation modeling package available. Since path analysis is essentially a structural equation modeling (SEM) technique, LISREL could easily handle it. Second, the use of LISREL in path analysis has already been demonstrated by a number of researchers such as Hennesy (1985), and Godin, Valois, Shephard and Desharnais (1987). Moreover, the online help and tutorials (http://www.ssicentral.com) provided directions for advanced analysis and the evidence through its documentation journal articles. Thus, in this study, LISREL (version 8.80) was used to carry out a single level path analysis to examine a series of dependence relationships simultaneously. This set of relationships is where structural equation modeling is based from (Hair et al., 1995).

There are two ways of running LISREL 8.80: using its Windows-based point-and-click graphical user interface (GUI) or using syntax (PRELIS) files (Jöreskog, 2005). With the Windows GUI, LISREL permits the user to create and specify a path diagram by simply dragging and dropping the variable names into a drawing panel. However, before this can happen, the user needs to import and convert a data file into a PRELIS system file data format (*.psf). LISREL is able to import and convert data sets from over 30 different formats including popular ones such as SPSS files (*.sav) and Excel files (*.xls). After converting a data file in the *.psf format and creating the model, a SIMPLIS syntax and project files which specify the structural equation model are generated. Using the generated SIMPLIS syntax file, LISREL then fits the specified model to the data corresponding to the created *.psf file. Pressing the 'run' button generates a path diagram including which is a graphics file with a PTH extension. The path diagram can either display the estimates or the standardised solutions. Easy as it may sound, this procedure of running LISREL was not used. Specifying the model parameters is rather restricted because it only uses its default settings. Although the SIMPLIS syntax generated with this procedure can be edited, this just adds complexity to the whole process of running LISREL. A less restrictive procedure of running the application to test models which was used in this study is by writing a PRELIS syntax file. Detailed examples on how this procedures are undertaken are available from http://www.ssicentral.com.

PRELIS is a 32-bit application that interfaces with LISREL. Du Toit, du Toit, Mels and Cheng (n. d., p. 1) describe PRELIS as an "…application for manipulating data, transforming data, generating data, computing moment matrices, computing asymptotic covariance matrices, performing multiple linear, censored, logistic and probit regression analyses, performing exploratory factor analyses, etc."

Testing models using PRELIS is generally composed of five steps. First, raw data (in popular file formats from SPSS and Excel) is converted to ASCII (or text) format. Second, a PRELIS2 (*.pr2) command file is created to read and transform the raw data. Correlation and/or covariance matrices can be produced from the PRELIS command file. Third, a model is specified by making a sketch of a diagram that shows the paths (discussed in more detail in the next section). Fourth is the creation of a LISREL syntax file (*.spl) that shows the relationships of variables based on the sketched diagram (the model of interest). This is where the modeling parameters are set and the desired outputs (such as path diagram) are requested. The fifth (final) step is the evaluation of the LISREL output file (*.out) for model fit to the data.

Models and representations in quantitative research

In quantitative research, a model is used to represent phenomena under examination. A model can either be in the form of a series of structural equations or in pictorial/graphical form to represent the causal processes under study. The graphical representation enables for a clearer understanding of the theory under study (Byrne, 2001; Jöreskog & Sörbom, 1993). Models in graphical form conventionally use the following shapes to represent something: ellipse (for latent variables), rectangle (for observed variables), straight single-headed arrows (to represent the impact of one variable to another variable), and double-headed arrows (to represent covariances or correlation between pairs of variables).

Generally, there are three steps in model building (Lohmöller, 1989). These are: specification, estimation, and evaluation. Model specification entails a careful definition of the phenomena under examination and explication. Estimation requires model to translate hypotheses into mathematical expressions which can be compared with a set of data (Neale, Heath, Hewitt, Eaves & Fulker, 1989). In other words, the hypothesised model can be tested statistically to determine the extent to which it is consistent with the data (Byrne, 2001). Through model evaluation, if the data are consistent with the model, then it can be concluded that the model fits well (i.e., the data provides support for the model) (Neale et al., 1989). Path models are a form of structural equation models that require the specification beforehand of the inter-variable relations based on established theories that can be used in the analysis of data for inferential purposes (e.g., answering research questions).

Model specification

Since this study did not use LISREL's Windows-based GUI to draw the path diagram for the single-level analysis, other ways of drawing it were explored. Simple diagrams can be neatly created using other applications such as Microsoft Publisher and Adobe Illustrator. Of course, path diagrams can also be hand-drawn for reference purposes.

Path model diagrams in most SEM applications contain at least two shapes; rectangles and ellipses. The rectangles (or boxes) represent the observed variables, and the ellipses represent the latent variables. The error terms in the diagram are drawn and represented as latent errors. Causal relationships are indicated by single-headed arrows and covariances that exist among the variables are indicated by curved double-headed arrows. A variable is called 'exogenous' when there is no arrow pointing towards it and only has a single-headed arrow departing from it. Otherwise, the variable is 'endogenous'.

Model trimming

Model trimming in LISREL involves removing the manifest variables and the latent variables, which do not show significant paths in the model. This is where the examination of the *t*-value and the regression coefficients (also known as the *beta* value) becomes valuable when deciding whether a path is significant or not. The critical *t*-value used in this study to signify a significant path is 2.0. Any value less than this were considered not significant. Non-significant paths were removed from the model.

This procedure was carried out separately for the South Australian and Filipino data sets. This is due to measurement variance exhibited, as has been shown and explained in the validation chapters (Chapters 4 to 9), by the questionnaire administered to the South Australian and Filipino samples.

Test for normality of data

Before further analyses were carried out, it was considered important to test whether the variables are normally distributed. Two characteristics of a distribution that need to be examined are skewness and kurtosis to tell whether it is normal or non-normal. Skewness informs a distribution's non-symmetry and kurtosis its 'flatness' or 'pointiness'. Graphically, normally distributed sample scores represent a bell-shaped curve. Numerically, in normally distributed sample scores, skewness and kurtosis values are close to zero. Critical (absolute) values for these characteristics have been suggested by Kline (1998); <3 for skewness and <8 for kurtosis. Graphically, data distribution can also be checked for normality by means of a histogram and normal probability plots.

The test for normality was carried out in SPSS. Both skewness and kurtosis values, plus the histogram, for each of all the variables in the study were obtained. None of the variables showed skewness greater than 3 and a kurtosis greater than 8. Therefore, all the data distributions for the variables can be considered normally distributed to a sufficient degree for further analysis to be carried out.

The following sections report on the results of the one-to-one variable analysis, and then followed by sections that report on the results of putting together all the variables following the research questions and the theoretical framework advanced in Chapter 2. The results of the analysis carried out for the South Australian data are reported separately from the results for the Filipino data.

11.3. Univariate regression analysis

Analysis using regression was carried out to get an overview of the relationship between the variables examined in this study. It was employed to estimate the regression equation and the relative explanatory power of the independent variable (X) or to identify the best predictors of the dependent variable (Y) (Jöreskog, & Sörbom, 1993) Analysis through regression follows the general linear equation of the form

$$Y = B_o + B_1X + B_2X_2 + ... + B_nX_n + e \quad (11.1)$$

Regression in represented in equation 11.1 is also called *univariate multiple* regression or simply *multiple regression* (Jöreskog, & Sörbom, 2006). Where Y is the dependent variable and X the independent variable, B_o is the constant, B_1, B_2 and B_n are the standardised regression coefficients (or the *beta* value) for the independent variables, and e is the residual (or error). In a simple regression, B_1 represents the gradient of the regression line. This gradient represents the change in the outcome (Y) resulting from a unit change in the predictor (X). If B_1 is zero, then the expected change in the outcome would be zero – meaning the model is *bad* (Field, 2005, p. 150).

The variables are clustered into school-level variables and individual-level variables. School-level variables include school level (SchLEVEL), school type (SchTYPE), school curriculum (SchCURR), teachers, and classroom climate. The data collected for the variable 'teachers' is qualitative and was intended to be used as a corroborating evidence (triangulation) (Creswell, 2005) for the quantitative findings. The variable 'classroom climate' is composed of two categories: the actual classroom climate and the preferred classroom climate. Each of these categories represents five dimensions of the classroom environment namely: Personalisation, Participation, Independence, Investigation and Differentiation. These have been demonstrated in Chapter 8 to exhibit independence from each other, thus, dividing classroom climate into five separate variables representing the five classroom environment dimensions. For the actual classroom climate category, the variables were designated as the following: CCAPersn (Personalisation), CCAParti (Participation), CCAIndep (Independence), CCAInves (Investigation), and CCADffer (Differentiation). The following represent the preferred classroom climate variables: CCPPrsn (Personalisation), CCPPrti (Participation), CCPIndp (Independence), CCPInvs (Investigation), and CCPDfer (Differentiation).

Individual-level variables include the following: gender (GNDR), self-esteem (SelfEstm), attitudes towards Physics (Attitude), parents' aspirations for their children [mother (ParentsMUM) and father (ParentsDAD)], motivation to learn Physics, and attitudes towards computers. Motivation covers six independent dimensions (see Chapter 5): achievement goal (MotiACHVG), active learning strategies (MotiALS), learning environment (MotiLERNV), performance goal (MotiPERFG), self-efficacy (MotiSLEFF), and science learning value (MotiSLVAL). The Attitudes towards computers variable covers 3 independent dimensions: affective (CompAFFC), behavioural (CompBEHV), and cognitive (CompCOGN) (see Chapter 7).

All regressions were carried out using LISREL 8.80. Resulting values reported are the standardised regression coefficients (B_1, explained above) to indicate the strength of relationship and *t*-values to indicate significance. The *t*-value (or the *t*-statistic) tests for the null hypothesis that the value of B_o is zero. If the *t*-value is significant ($t \geq \pm 2.0$ for $P<0.01$ or $P<0.05$), then this means that B_o is significantly different from zero and that the predictor (*X*) contributes significantly in estimating the value of the outcome (*Y*).

Results of the regression analysis

For each group of samples (i.e., South Australians and Filipinos), the results for the regression are presented. The results of testing the regression model for each group of samples were compared in order to see the similarities/difference in the relationship between variables. Each regression model (represented by a regression equation in equation 11.1) provides an idea of the predictive power of variables in the equation. Regression analysis seeks to predict an outcome variable (*Y*, or the dependent variable) from a single or multiple predictor variables (*X*, or the independent variable) (Field, 2005). A simple regression is generally represented by the equation:

$$\text{Outcome} = (\text{Model}) + \text{error} \tag{11.2}$$

The equation means that the outcome can be predicted by whatever model predicted to the data plus some error (Field, 2005). The 'Model' in the equation contains one or more regression coefficients for one or more predictor variables. Field pointed out that the error term represents the fact that the model will not fit perfectly the data collected.

In the present study, physics uptake is gauged by positive attitudes (Trumper, 2006; Osborne, 2003; Reid & Skryabina, 2002; Jones et al., 2000; Crawley & Black, 1992). Measurement of attitudes takes centrality in the discussions that follow.

School type and attitudes towards physics

The effect of school type on students' attitudes towards Physics using the South Australian and Filipino data sets was explored. This was carried out to answer Research Question (RQ) 1a advanced in Chapter 1: *What is the influence of school type (government or private, coeducational or single-sex, on students' attitudes towards physics?*

The South Australian Sample

In the South Australian cohort, school type has been defined as government or private (SchTYPE1), and coeducational or single-sex (SchTYPE2). Interestingly, both SchTYPE1 and SchTYPE2 yielded standardised regression coefficients and *t*-values (in parenthesis) of 2.50(2.89) and 3.67(4.24), respectively, suggesting that these variables have significant relationship (at $P<0.01$) with students' attitudes towards physics. The relationship between attitudes towards physics and school type is represented by the equation:

$$Attitudes = B_o + 2.50(SchTYPE1) + 3.67(SchTYPE2) + error \qquad (11.3)$$

The results of the initial regression analysis indicate that students' attitudes towards physics have positive relationship with the type of school they attend. This is indicated by the positive regression coefficients representing positive slopes (see equation 11.3).

The equation means that students' attitudes towards physics tend to be more positive in government schools (SchTYPE1) and in single-sex schools (SchTYPE2). The positive result of the effect of single-sex school on students' attitudes towards physics is consistent with the findings of researchers (Koppel et al., 2003; Haag, 2000) who undertook similar studies. However, this presents an interesting contrast with the finding that students' attitudes towards physics tend to be more positive in government schools since single-sex schools are typically private schools in Australia. This result cannot confirm any results from similar studies such as PISA 2006. This detail is not included in the OECD Australian report on the 2006 PISA (see, Thomson & De Bortoli, 2008). Testing the differences between the attitudes of students towards the science in government- and privately-owned schools could add value to large-scale studies such as the PISA.

The Filipino Sample

Only one school type variable (SchTYPE1) was used in the Filipino cohort. School type in the Philippines is either government-owned or privately-owned. A simple regression analysis was performed to explore the relationship between school type and students' attitudes towards physics for the Filipino sample. The resulting regression coefficient and *t*-value are -1.38 and -3.51, respectively, indicating that school type appears to have a significant relationship (at $P<0.01$) with students' attitudes towards Physics. In equation form, the relationship is represented by:

$$Attitudes = B_o - 1.38(SchTYPE1) + error \qquad (11.4)$$

Equation 11.4 indicates that school type has a negative relationship (indicated by the negative regression coefficient) with attitudes towards physics. This suggests that attitudes towards physics tend to be more negative in government schools than in private schools. A possible reason could be that private schools in the Philippines generally have better science teaching facilities than government schools (Orleans, 2007).

School Curriculum and Classroom Climate

The relationship of school curriculum and classroom climate was explored using multiple regression to address one of the research questions (RQ1b) presented in the Chapter 1. RQ1b asks*: How does school curriculum influence classroom climate in the two sample groups?*

The actual classroom climate and the preferred classroom climate, each consisting of five variables representing different dimensions, and school curriculum, were subjected to multiple regression in order to gain an overview of their relationships.

The South Australian Sample

A multiple regression for school curriculum and classroom climate using the South Australian data set yields results as shown in Table 11.1.

Table 11.1. Resulting standardised regression coefficients and *t*-values from the regression analysis carried out for school curriculum and classroom climate (actual and preferred).

School curriculum and Actual classroom climate					
	CCAPersn	CCAParti	CCAIndep	CCAInves	CCADffer
SchCURR	6.66(14.98)*	7.54(13.79)*	-0.16(-0.36)	3.56(8.46)*	-4.01(-9.09)*
School curriculum and Preferred classroom climate					
	CCPPrsn	CCPPrti	CCPIndp	CCPInvs	CCPDfer
SchCURR	1.69(3.15)*	0.07(0.082)	0.76(1.52)	-1.03(-1.68)	-2.62(-5.29)*

South Australian sample: N=306
$P<0.01$

In equation form, the significant relationships (with asterisks) between school curriculum and classroom climate are represented by:

$$CCAPersn = B_o + 6.66(SchCURR) + error \quad (11.5)$$

$$CCAParti = B_o + 7.54(SchCURR) + error \quad (11.6)$$

$$CCAInves = B_o + 3.56(SchCURR) + error \quad (11.7)$$

$$CCADffer = B_o - 4.01(SchCURR) + error \quad (11.8)$$

$$CCPPrsn = B_o + 1.69(SchCURR) + error \quad (11.9)$$

$$CCPDfer = B_o - 2.62(SchCURR) + error \quad (11.10)$$

Equations 11.5 to 11.8 represent the relationships between school curriculum and four different dimensions of the actual classroom climate, and 11.9 and 11.10 for school curriculum and two preferred classroom climate dimensions. Positive relationships are indicated between school curriculum and the following classroom climate dimensions: personalisation (CCAPersn), participation (CCAParti), and investigation (CCAInves). This might be interpreted as senior secondary school physics students experience more personalised (opportunities for individual students to interact with the teacher), participative and investigative teaching approaches than those who are doing university physics courses. However, physics students in first year university experience more differentiated (CCADffer) teaching approach than those in senior high school level. This might be indicative of teachers moving away from the more traditional approaches to teaching physics as many research findings on approaches to teaching science suggest that the tradition approach does not work (e.g., Perkins et al., 2006; Labudde et al., 2000).

With regards to students' preferred physics classroom climate, equation 11.9 indicates that senior secondary physics students would prefer to experience more personalised physics teaching approach (CCPPrsn) than do university physics students. This is indicated by the positive regression coefficient in the equation. A negative regression coefficient is shown in equation 11.10 which indicates that first year university physics students tend to prefer differentiated learning more than high school physics students.

The Filipino sample

The regression analysis involving school curriculum and classroom climate using the Filipino data set yields the following regression coefficients and *t*-values as shown in Table 11.1a. Values with an asterisk indicate significant relationship.

Table 11.1a. Resulting standardised regression coefficients and *t*-values from the regression analysis carried out for school curriculum and classroom climate (actual and preferred).

School curriculum and Actual classroom climate					
	CCAPersn	CCAParti	CCAIndep	CCAInves	CCADffer
SchCURR	-0.23(-0.60)	-0.27(-0.50)	-6.39(-25.62)*	-0.63(-1.45)	0.14(0.43)
School curriculum and Preferred classroom climate					
	CCPPrsn	CCPPrti	CCPIndp	CCPInvs	CCPDfer
SchCURR	-2.00(-5.01)*	-2.09(-3.79)*	-5.51(-17.4)*	-2.24(-4.46)*	0.31(0.88)

Filipino sample: N=403
$P<0.01$

Translating the results above into equation form gives the following:

$$CCAIndep = B_o - 6.39(SchCURR) + error \quad (11.11)$$

$$CCPPrsn = B_o - 2.00(SchCURR) + error \quad (11.12)$$

$$CCPPrti = B_o - 2.09(SchCURR) + error \quad (11.13)$$

$$CCPIndp = B_o - 5.51(SchCURR) + error \quad (11.14)$$

$$CCPInvs = B_o - 2.24(SchCURR) + error \quad (11.15)$$

For the Filipino sample, only one actual classroom climate dimension had a significant relationship with school curriculum (see equation 11.11). This is the 'independence' dimension (CCAIndep). The negative coefficient indicates that first year university students tend to experience more learning independence than fourth year high school physics students. This result could be suggestive of the minimal (or lack of) science teaching facilities and equipment in many high schools in the Philippines (Marinas, n.d.). For this reason, high school physics teachers might resort to simply 'feed' their students with information that are mostly abstract (and mathematical).

Indicated by the negative regression coefficients in equations 11.12 to 11.15, first year university physics students, more than high school students, would prefer a physics classroom where they could experience physics teaching approaches that are more personalised in the sense that they could individually interact with the teacher more (CCPPrsn), participative (CCPPrti), provide learning independence (CCPIndp) and investigative (CCPInvs). This could be interpreted as partly a result of first year university students being deprived of the educational tools (laboratory facilities and equipment) they needed to learn physics while in high school.

School curriculum and motivation

To address RQ1c advanced in Chapter 1, the relationship between school curriculum and motivation to learn physics was explored using regression analysis. RQ1c raises the question: *Does school curriculum have an influence on students' motivation to study physics?*

The regression analysis for these variables was carried out separately for the South Australian sample and the Filipino sample. In addition, the six motivation dimensions were used in the regression analysis. The use of these dimensions was based on the results of validating the motivation scale discussed in Chapter 5.

The South Australian Sample

The resulting standardised regression coefficients and *t*-values using the South Australian sample data set are presented in Table 11.2.

Table 11.2. Results of regression analysis for school curriculum and motivation to learn science/physics.

School curriculum and Motivation to learn Science/Physics						
	MotiACHVG	MotiALS	MotiLERNV	MotiPERFG	MotiSLEFF	MotiSLVAL
SchCURR	-0.13(-0.89)	-0.28(-0.43)	1.92(4.17)*	-1.87(-2.59)*	-1.45(-1.98)	-1.07(-4.67)*

South Australian sample: N=306

**P<0.05*

The significant relationships are represented by the following equations:

$$MotiLERNV = B_o + 1.92(SchCURR) + error \quad (11.16)$$

$$MotiPERFG = B_o - 1.87(SchCURR) + error \quad (11.17)$$

$$MotiSLVAL = B_o - 1.07(SchCURR) + error \quad (11.18)$$

The equations suggest that school curriculum (university or secondary school) indicates significant relationship with motivation through learning environment stimulation (MotiLERNV), performance goal (MotiPERFG), and science learning value (MotiSLVAL). As indicated by the positive regression coefficient, school curriculum has a positive relationship with learning environment stimulation. This means that senior high school physics students tend to get more motivated to learn physics with a good learning environment stimulation compared to university students. However, university students tend to have more performance goals and see more science learning values compared to high school students, as indicated by the negative regression coefficients.

The Filipino Sample

Similarly, the relationship of school curriculum and motivation was explored using the Filipino data. The regression analysis results are shown in Table 11.2a.

Table 11.2a. Results of regression analysis for school curriculum and motivation to learn science/physics.

School curriculum and Motivation to learn Science/Physics						
	MotiACHVG	MotiALS	MotiLERNV	MotiPERFG	MotiSLEFF	MotiSLVAL
SchCURR	-0.09(-0.70)	0.09(0.14)	-0.37(-0.68)	-2.54(-3.72)*	0.60(1.06)	0.17(0.85)

Filipino sample: N=403
P<0.01

The significant relationship is represented by the following regression equations:

$$MotiPERFG = B_o - 2.54(SchCURR) + error \qquad (11.19)$$

The equation indicates that school curriculum has a negative relationship with motivation to learn physics through performance goals. This result suggests that university physics students tend to have higher performance goals compared to high school physics students to motivate them to study physics. This might be due to university students having already decided on a future career path. In the context of this study, university students might have already decided to pursue a physics-related career.

Classroom climate and self-esteem

Important aspects of schooling experiences, particularly in physics, relating to students' classroom environment and how it relates their general self-esteem have been explored. Regression analysis was employed to explore these relationships. Results from this analysis address RQ2a advanced in Chapter 1: *How does classroom climate influence students' general self-esteem?*

The South Australian Sample

The results of the regression analysis showing the regression coefficients and the *t*-values using the South Australian sample are presented in Table 11.3. Values with asterisks indicate significant relationships.

Table 11.3. Resulting standardised regression coefficients and *t*-values from the regression analysis carried out for self-esteem and classroom climate (actual and preferred).

Self-esteem and Actual classroom climate					
	CCAPersn	CCAParti	CCAIndep	CCAInves	CCADffer
SelfEstm	-0.24(-2.09)*	-0.06(-0.62)	-0.095(-0.41)	-0.23(-1.88)	0.23(2.11)*
Self-esteem and Preferred classroom climate					
	CCPPrsn	CCPPrti	CCPIndp	CCPInvs	CCPDfer
SelfEstm	-0.22(-1.96)	-0.02(-0.21)	-0.12(-1.10)	0.05(0.52)	0.19(1.79)

South Australian sample: N=306
**P<0.01*

The following regression equation represents the significant relationships:

$$SelfEstm = B_o - 0.24(CCAPersn) + 0.23(CCADffer) + error \qquad (11.20)$$

Indicated in equation 11.20 is self-esteem's negative relationship with personalisation in the actual classroom, and its positive relationship with differentiation in the actual classroom. This means that students' self-esteem tends to drop as they experience more personalised teaching approach. This is an interesting finding that raises the question, "Why would a student's self-esteem drop when he/she is given the opportunity to interact more with the teacher?" Clearly, more investigation on this is needed. However, their self-esteem tends to increase as they experience more differentiated teaching in the classroom. Differentiated learning can be considered synonymous with individualised learning. Therefore, the initial analysis is consistent with research findings (e.g., Zollman, 1997; Mazur, 1997b; Yu & Stokes, 1998) differentiated learning's potential in transforming student learning in any classroom.

There appears to be no significant relationship between self-esteem and students' preferred physics classroom climate.

The Filipino Sample

Subjecting the variables self-esteem and classroom climate (both actual and preferred) to regression analysis using the data from the Filipino sample yields results shown in Table 11.3a.

Table 11.3a. Resulting standardised regression coefficients and *t*-values from the regression analysis carried out for self-esteem and classroom climate (actual and preferred).

Self-esteem and Actual classroom climate					
	CCAPersn	CCAParti	CCAIndep	CCAInves	CCADffer
SelfEstm	-0.043(-0.46)	-0.018(-0.26)	-0.11(-1.39)	-0.26(-3.32)*	-0.04(-0.43)
Self-esteem and Preferred classroom climate					
	CCPPrsn	CCPPrti	CCPIndp	CCPInvs	CCPDfer
SelfEstm	0.00084(0.009)	-0.035(-0.50)	-0.12(-1.67)	-0.16(-2.24)*	-0.045(-0.50)

Filipino sample: N=403
*$P<0.01$

Observed significant relationships (marked with asterisks) can be represented in the following equation form:

$$SelfEstm = B_o - 0.26(CCAInves) + error \quad (11.21)$$

$$SelfEstm = B_o - 0.16(CCPInvs) + error \quad (11.22)$$

Both equations reflect negative relationship between self-esteem and the investigation dimension of both the actual and preferred classroom climate. This is another interesting finding that deserves attention. It appears that the sample of Filipino physics students tend to have lower self-esteem the more physics investigation activities they experience in the classroom. The investigation dimension of the classroom climate (defined by Fraser [1990, p. 5], in his ICEQ), "concerns the skills and processes of inquiry and their use in problem solving and investigation." This might be the result of the physics teachers' approach in giving students investigation activities. There might be a minimal (or lack of) information about what the students are required to do or to come up with, and that students get frustrated when confronted with confusing investigative activities. Therefore, students appear to not prefer having more investigative activities in their preferred physics classroom, as reflected in equation 11.22.

Classroom climate and attitudes towards physics

The relationship between the classroom climate and students' attitudes towards physics was explored using regression analysis. This undertaking addresses RQ2b advanced in Chapter 1: *How does classroom climate affect students' attitudes towards physics?* This test of relationship partly addresses RQ2d, "*What is the influence of teachers on the physics classroom climate that could affect students' attitudes towards physics?*", and RQ2e, "*How do teachers' teaching methods impact on physics classroom climate?*"

The South Australian Sample

The standardised regression coefficients and *t*-values (in parenthesis) resulting from the regression analysis using the South Australian sample are shown in Table 11.4.

Table 11.4. Resulting standardised regression coefficients and *t*-values from the regression analysis of attitudes towards Physics and classroom climate (actual and preferred).

Attitudes towards Physics and Actual classroom climate					
	CCAPersn	CCAParti	CCAIndep	CCAInves	CCADffer
Attitudes	-0.09(-1.80)	-0.07(-1.51)	-0.12(-2.21)*	0.07(1.32)	-0.16(-3.28)*
Attitudes towards Physics and Preferred classroom climate					
	CCPPrsn	CCPPrti	CCPIndp	CCPInvs	CCPDfer
Attitudes	-0.12(-2.43)*	-0.24(-1.08)	-0.008(-0.17)	-0.11(-2.43)*	-0.13(-2.84)*

South Australian sample: N=306
**P<0.01*

The regression equation for these relationships can be written as:

$$Attitudes = B_o - 0.12(CCAIndep) - 0.16(CCADffer) + error \quad (11.23)$$

$$Attitudes = B_o - 0.12(CCPPrsn) - 0.11(CCPInvs) - 0.13(CCPDfer) + error \quad (11.24)$$

In the actual classroom climate (as perceived by the students), attitudes towards physics appears to have negative relationship with independence (CCAIndep) and differentiation (CCADffer). An interpretation of this would be, attitudes towards physics deteriorate with more independence and differentiation in the physics classroom. However, these results are not consistent with published reports on similar studies (e.g., Zollman, 1997; Mazur, 1997b; Yu & Stokes, 1998). This could be attributed to the teachers' approach to teaching physics in the classroom. A theme that resulted from the analysis of the transcriptions of the interview of South Australian physics teachers who participated in the study is their efforts to move away from traditional style of teaching. A few examples of their responses to the question, *"How do you teach physics in class?"* include:

> Physics Teacher 1: *We use a lot of demonstrations in class; get out there and take the students out; get them to bounce things; get 'em to do this. Probably, a bit of fun, bit of laughter, bit of joking involved. Also talk a bit about the…a bit of history; a bit of how physics influences people; how some of the great physics minds were not just involved in physics, but they did other things. Try to get students to see that there is physics everywhere that they look, and that they…you can't just say that, well, physics is this subject that we study at school and that it is outside.*

> Physics Teacher 3: *With a more contextual approach to show greater relevance; it's more humanistic; there's more social and environmental impact in it, and the physics in context means that there's greater relevance.*

> Physics Teacher 4: *I try to make it enjoyable to the kids. I try to mix up basic work ethics with a bit of fun. Consequently I also make my kids realise that when they first do physics they are the ones who pick up the subject even though it is considered to be one of the more extreme of the Year 12 subjects, it is one of the priority and also externally examined subjects making the kids keep in mind that they are ones who selected it and obviously a name in mind and if they want to continue at university level or some tertiary level and their aim is to be, whatever it may be, doctor, engineer, pilot…*

> Physics Teacher 5: *At Year 11 I try to make it as fun as possible, engaging students in demonstrations and activities such as dropping water bombs off our highest building, pulling table cloths out from under crockery, having lengthy discussions about "looking back in time", why we see colour and allowing students to pose their own theories and ask interesting questions.*

It can be observed in the teachers' responses above that, despite the efforts of teachers to make learning physics interesting, nothing about differentiated learning and students having greater control over their own learning and behaviour (CCAIndep) have been mentioned. Therefore, a more in-depth examination of these factors in a similar research is suggested.

With regards to students' preferred physics classroom climate, there exist negative relationships (indicated by the negative regression coefficients) between attitudes and three of the classroom climate dimensions namely: personalisation, investigation, and differentiation. This could be interpreted as students' attitudes towards physics deteriorate with more personalisation, investigation and differentiation which means that would prefer less of these in their preferred physics classroom. It could be assumed that this is based on their actual experiences in the physics classroom. Again, further investigation of these results is recommended.

The Filipino Sample

The relationship between attitudes towards physics and both the actual and students' preferred classroom climate was explored with regression analysis using the data from the Filipino sample. The results are shown in Table 11.4a.

Table 11.4a. Resulting standardised regression coefficients and *t*-values from the regression analysis of attitudes towards Physics and classroom climate (actual and preferred).

Attitudes towards Physics and Actual classroom climate					
	CCAPersn	CCAParti	CCAIndep	CCAInves	CCADffer
Attitudes	-0.09(-1.41)	-0.04(-0.80)	-0.045(-0.92)	-0.05(-0.90)	0.46(2.33)*
Attitudes towards Physics and Preferred classroom climate					
	CCPPrsn	CCPPrti	CCPIndp	CCPInvs	CCPDfer
Attitudes	-0.43(-3.85)*	0.70(3.06)*	-0.12(-2.74)*	-0.28(-6.58)*	0.03(0.64)

Filipino sample: N=403
**P<0.01*

The following regression equations represent the relationships between attitudes towards physics and classroom climate (actual and preferred).

$$Attitudes = B_o + 0.46(CCADffer) + error \quad (11.25)$$

$$Attitudes = B_o - 0.43(CCPPrsn) + 0.70(CCPPrti) - 0.12(CCPIndp) - 0.28(CCPInvs) + error \quad (11.26)$$

Equation 11.25 shows that attitudes towards physics of the Filipino sample tend to be more positive with more differentiated teaching approach as indicated by the positive regression coefficient. This result adds to the confirmation of research findings highlighted earlier in this section. In the other equation (11.26), attitudes towards physics shows positive relationship with participation (CCPPrti) and negative relationship with personalisation (CCPPrsn), independence (CCPIndp), and investigation (CCPInvs). It appears that students would prefer to have more participation in the physics classroom but less individual interaction with the teacher, less independent learning approaches, and less investigative activities in the physics classroom. This is despite the fact that Filipino physics teachers who participated in this study having put in great efforts to make physics learning more interesting. A few examples of their responses to the question, *"How do you encourage students to study physics? How do you deliver your physics classess?"* include:

> Physics Teacher 4: *Aside from using PowerPoint Presentations/Interactive CD's in computer in my lessons I also integrate sports, art and music for them to appreciate the relevance of Physics in their daily life.*

> Physics Teacher 5: *I try to develop activities where students can enjoy Physics and applying it to common situation. This allows them to be conscious of the preserve of Physics everywhere, and to realize the importance of the study of Physics. One of my aims is to remove the stigma of Physics being a difficult subject: rather that it is one which needs a certain discipline and awareness.*

> Physics Teacher 7: *I use of active learning techniques:*
> 1. *Cooperative problem-solving;*
> 2. *Interactive learning approaches;*
> 3. *Interactive lecture demonstrations (ILD);*
> 4. *Active laboratory activities;*
> 5. *Higher-ordered concept mapping;*
> 6. *Real time Physics*

Could the negative relationships be the result of students' actual experiences in the physics classroom despite the efforts of teachers to make physics learning more interesting and relevant, or just merely adapting what they got used to? Thus, further examination of this is warranted.

Classroom climate and motivation

In Chapter 1, RQ2c was advanced to explore the relationship between students' motivation to learn physics and the physics classroom climate. RQ2c asks: *How does classroom climate affect students' motivation to learn physics?* It also partly addresses RQ2d and RQ2e presented in the previous section.

To get an overview of this relationship, a regression analysis was carried out. Each variable has a number of dimensions that were found to have a significant degree of independence (see Chapter 5 and Chapter 8). Thus, the different dimensions in each variable were included in the regression analysis.

The South Australian Sample

The results of the regression analysis using the South Australian data set to explore the relationship between classroom climate and motivation to learn physics is shown in Table 11.5.

Using regression equations, the significant relationships (with asterisks) can be represented. The equations are grouped into two: actual classroom climate and preferred classroom climate.

- Actual classroom climate

$$MotiLERNV = B_o + 0.23(CCAPersn) + error$$
$$MotiPERFG = B_o - 0.24(CCAInves) + error \qquad (11.28)$$

Table 11.5. Resulting standardised regression coefficients and *t*-values from the regression analysis of motivation to learn science/physics and classroom climate (actual and preferred).

Motivation and Actual classroom climate					
	CCAPersn	CCAParti	CCAIndep	CCAInves	CCADffer
MotiACHVG	0.004(-0.27)	0.005(0.38)	(0.002)0.14	0.0001(0.007)	-0.001(-0.07)
MotiALS	0.09(1.03)	0.06(0.83)	-0.15(-1.65)	-0.05(-0.51)	-0.15(-1.87)
MotiLERNV	0.23(4.04)*	0.003(0.05)	-0.05(-0.81)	0.015(0.24)	0.05(0.95)
MotiPERFG	0.10(1.08)	0.10(1.31)	0.19(1.95)	-0.24(-2.43)*	-0.03(-0.39)
MotiSLEFF	0.02(0.23)	0.03(0.39)	-0.012(-0.13)	-0.09(-0.89)	-0.085(-0.94)
MotiSLVAL	0.08(0.85)	0.06(0.77)	0.10(1.04)	-0.09(-0.89)	0.06(0.63)
Motivation and Preferred classroom climate					
	CCPPrsn	CCPPrti	CCPIndp	CCPInvs	CCPDfer
MotiACHVG	0.001(0.10)	0.0008(0.08)	0.02(0.17)	0.01(0.78)	-0.002(-0.11)
MotiALS	0.06(0.70)	0.07(1.23)	-0.11(-1.42)	0.13(1.93)	-0-0.05(.60)
MotiLERNV	0.03(0.53)	0.07(1.81)	0.01(0.19)	0.07(1.51)	0.02(0.33)
MotiPERFG	0.22(2.45*)	0.03(0.49)	0.17(1.95)	-0.20(-2.62)*	0.016(0.20)
MotiSLEFF	0.045(0.50)	0.04(0.70)	0.05(0.56)	0.09(1.13)	0.085(0.99)
MotiSLVAL	0.10(1.14)	0.03(0.43)	-0.06(-0.72)	0.22(2.92)*	0.046(0.55)

South Australian sample: N=306
**P<0.01*

- Preferred classroom climate

$$MotiPERFG = B_o + 0.22(CCPPrsn) – 0.20(CCPInvs) + error \quad (11.29)$$

$$MotiSLVAL = B_o + 0.22(CCPInvs) + error \quad (11.30)$$

Based on what students perceive as what is really happening in their physics classroom, it appears that students' motivation to learn physics because of learning environment stimulation (MotiLERNV) has a positive relationship with personalisation (CCAPersn) (equation 11.27). This could be interpreted as teachers giving more opportunities in the physics classroom for individual students to interact with them provide positive learning environment stimulation that gives students more motivation to learn physics. However, students' motivation to learn physics because of performance goals (MotiPERFG) shows a negative relationship with investigation in the physics classroom (CCAInves) (equation 11.28). In other words, the more investigative activities physics teachers provide the students, the less they get motivated to learn physics. A reason might be that students do not see the 'connection with the real-life' of the activities they do in the physics classroom. Could it also be because the investigative activities provide the students with many tasks with instructions that are not very clear? This warrants further investigation.

When it comes to students' preferred physics classroom, a positive relationship is indicated between motivation to learn physics because of performance goals (MotiPERFG) and personalisation in the physics classroom (CCPPrsn), but negative with investigation (CCPInvs) (equation 11.29). A possible interpretation might be that as students get more motivated to learn physics because of set performance goals, they would prefer to have a physics classroom where they have more interaction opportunities with their physics teacher to keep their goals on track. However, in their preferred physics classroom, students would not prefer to have more investigative activities when they have already set goals to motivate them to learn physics. In equation 11.30, in their preferred physics classroom, students appear to prefer more investigative activities in order for them to see the value of learning physics which could increase their motivation to learn more about physics.

The Filipino Sample

A similar regression analysis was carried out using the data from the Filipino sample. The results are shown in Table 11.5a.

The following are the resulting regression equations to represent these significant relationships:

- Actual classroom climate

$$MotiALS = B_o + 0.17(CCAParti) - 0.26(CCAIndep) + 0.23(CCAInves) + error \quad (11.31)$$

$$MotiLERNV = B_o + 0.27(CCAPersn) + 0.15(CCAParti) + 0.26(CCAInves) + 0.63(CCADffer) \quad (11.32)$$

$$MotiPERFG = B_o - 0.20(CCAPersn) + 0.18(CCAParti) + 0.24(CCAIndep) - 0.17(CCAInves) - 1.52(CCADffer) + error \quad (11.33)$$

Table 11.5a. Resulting standardised regression coefficients and *t*-values from the regression analysis of motivation to learn science/physics and classroom climate (actual and preferred).

Motivation and Actual classroom climate					
	CCAPersn	CCAParti	CCAIndep	CCAInves	CCADffer
MotiACHVG	0.02(0.86)	0.02(1.32)	-0.02(-1.30)	0.02(1.17)	-0.07(-1.10)
MotiALS	0.11(1.17)	0.17(2.59)*	-0.26(-3.55)*	0.23(2.90)*	0.01(0.04)
MotiLERNV	0.27(3.62)*	0.15(2.79)*	0.05(0.81)	0.26(4.01)*	0.63(2.61)*
MotiPERFG	-0.20(-2.01*)	0.18(2.46)*	0.24(2.96*)	-0.17(-2.00)*	-1.52(-4.64)*
MotiSLEFF	0.18(2.09)*	0.02(0.30)	-0.07(-0.98)	0.13(1.86)	0.05(0.20)
MotiSLVAL	0.07(2.52)*	0.07(3.18)*	-0.05(-1.94)	-0.006(-0.23)	0.08(0.80)
Motivation and Preferred classroom climate					
	CCPPrsn	CCPPrti	CCPIndp	CCPInvs	CCPDfer
MotiACHVG	0.08(2.06)*	0.28(3.57)*	-0.01(-0.71)	0.003(0.23)	0.01(0.64)
MotiALS	0.54(2.96)*	-0.49(-1.31)	-0.12(-1.73)	0.32(4.59)*	0.007(0.09)
MotiLERNV	0.21(1.36)	-0.59(-1.83)	-0.11(-1.89)	0.38(6.33)*	0.10(1.35)
MotiPERFG	-0.21(-1.00)	0.90(2.16)*	0.26(3.27)*	-0.07(-0.85)	-0.40(-4.12)*
MotiSLEFF	0.13(0.76)	-0.23(-0.65)	0.01(0.17)	0.20(3.09)*	0.04(0.51)
MotiSLVAL	-0.06(-0.99)	0.44(3.71)*	-0.06(-2.52)*	0.07(3.13)*	0.02(0.81)

Filipino sample: N=403
$P<0.01$

$$MotiSLEFF = B_o + 0.18(CCAPersn) + error \quad (11.34)$$

$$MotiSLVAL = B_o + 0.07(CCAPersn) + 0.07(CCAParti) + error \quad (11.35)$$

- Preferred classroom climate

$$MotiACHVG = B_o + 0.08(CCPPrsn) + 0.28(CCPPrti) + error \quad (11.36)$$

$$MotiALS = B_o + 0.54(CCPPrsn) + 0.32(CCPInvs) + error \quad (11.37)$$

$$MotiLERNV = B_o + 0.38(CCPInvs) + error \quad (11.38)$$

$$MotiPERFG = B_o + 0.90(CCPPrti) + 0.26(CCPIndp) - 0.40(CCPDfer) + error \quad (11.39)$$

$$MotiSLEFF = B_o + 0.20(CCPInvs) + error \quad (11.40)$$

$$MotiSLVAL = B_o + 0.44(CCPPrti) - 0.06(CCPIndp) + 0.07(CCPInvs) + error \quad (11.41)$$

A number of relationships between the different dimensions of motivation to learn physics and the different dimensions of the classroom climate, both actual and preferred, can be observed. In the Filipino context, in the actual classroom climate, students' motivation to learn physics because of active learning strategies (MotiALS) has positive relationship with participation (CCAParti) and investigation (CCAInves), but negative with independence (CCAIndep) (equation 11.31). This result suggests that, more participation and investigation activities in the physics classroom increase students' motivation to learn physics. However, it appears that more independence in the classroom decreases motivation. Motivation because of learning environment stimulation (MotiLERNV) shows a positive relationship with personalisation (CCAPersn), participation (CCAParti), investigation (CCAInves), and differentiation (CCADffer) (equation 11.32). In other words, motivation to learn physics increases as more individualised teaching approaches (personalisation, participation, investigation and differentiation) are used in the physics classroom. Motivation to learn physics because of performance goals (MotiPERFG) appears to have positive relationship with participation (CCAParti) and independence (CCAIndep), but negative relationship with personalisation (CCAPersn), investigation (CCAInves) and differentiation (CCADffer) (equation 11.33). Motivation to learn physics increases when a student with a set of performance goals experiences more participation and learning independence in the classroom. However, this motivation appears to drop when a physics teacher uses more personalisation, investigation activities, and differentiation in the classroom. Students' motivation to learn physics because of self-efficacy (MotiSLEFF) shows a positive relationship with personalisation (CCAPersn) (equation 11.34). In other words, the more opportunities to interact with the teacher a physics teacher provides a student, the more motivated a student becomes to learn physics because of better self-concept. Motivation to learn physics because of its perceived science learning value (MotiSLVAL) indicates a positive relationship with personalisation (CCAPersn) and participation (CCAParti) in the physics classroom (equation 11.35). In other words, the more interaction and participation opportunities a teacher provides the students in the classroom, the more motivated they become to learn physics because they could see its value. This finding is consistent with many of the literature on physics teaching strategies cited in Chapter 2, including those reported in the PISA 2006 study result by Thomson and De Bortoli (2008).

With the students' preferred classroom climate, examination of the equations (11.36 to 11.41) suggests, in order to get motivated to learn physics, students in the Filipino sample would prefer not to experience more classroom learning differentiation (CCPDfer – see equation 11.39) and learning independence (CCPIndp – see equation 11.41). This is not consistent with findings of many similar research studies (e.g., Reid & Skryabina, 2002; Murphy & Whitelegg, 2006), and this study does not provide the evidence needed to support the reasons for this finding. In addition, complicated relationships (hence, spurious effects) are evident in the results of the regression between classroom climate and motivation. This was probably due to the fact that physics is compulsory in Philippine secondary schools which render the meaning of 'uptake' not applicable. In other words, physics uptake can only happen at university level. By combining the high school and the university samples together, a masking effect is possible making it not possible to observe how classroom climate affects motivation for the university sample. Further examination of these factors in a similar study at university level is therefore suggested.

Motivation and attitudes towards physics

The relationship between students' attitudes towards physics and their motivation was explored using regression analysis. This was to address the research question (RQ3a) advanced in Chapter 1: *Do motivation and self-esteem affect students' attitudes towards physics?*

The South Australian Sample

The results of the regression analysis using the South Australian data set are shown in Table 11.6. All the significant relationships are indicated by asterisks.

Table 11.6. Resulting standardised regression coefficients and *t*-values from the regression analysis carried of attitudes towards physics and motivation to learn science/physics.

Attitudes towards Physics and Motivation to learn Science/Physics						
	MotiACHVG	MotiALS	MotiLERNV	MotiPERFG	MotiSLEFF	MotiSLVAL
Attitudes	0.10(0.60)	0.03(0.66)	-0.06(-1.41)	-0.16(-5.98)*	-0.12(-3.62)*	-0.19(-6.11)*

South Australian sample: N=306
*$P<0.01$

A regression equation to represent the relationship was drawn from the results shown in Table 11.6.

$$Attitudes = B_o - 0.16(MotiPERFG) - 0.12(MotiSLEFF) - 0.19(MotiSLVAL) + error \quad (11.42)$$

It appears that with the South Australian sample, attitudes towards physics (Attitudes) have negative relationship with motivation to learn physics because of performance goals (MotiPERFG), self-efficacy (MotiSLEFF), and science learning value (MotiSLVAL). This suggests that as students' motivation to learn physics (because of performance goal, self-efficacy, and science learning value) increases; their attitudes towards physics tend to become more negative. This was a surprising result considering it was expected otherwise. This might suggest that other factors other than motivation play some role in increasing attitudes towards physics. Further examination of these factors in a similar study is needed to gather more evidence to make better and more meaningful interpretation of this result.

The Filipino Sample

Using the Filipino data set, the same regression analysis was carried out. The results appear in Table 11.6a.

Table 11.6a: Resulting standardised regression coefficients and *t*-values from the regression analysis carried of attitudes towards physics and motivation to learn science/physics.

Attitudes towards Physics and Motivation to learn Science/Physics						
	MotiACHVG	MotiALS	MotiLERNV	MotiPERFG	MotiSLEFF	MotiSLVAL
Attitudes	-0.02(-0.85)	-0.17(-4.60)*	-0.04(-0.86)	-0.04(-1.37)	-0.05(-1.18)	-0.03(-1.60)

Filipino sample: N=403
**P<0.01*

The resulting relationship expressed as a regression equation becomes:

$$Attitudes = B_o - 0.17(MotiALS) + error \qquad (11.43)$$

Attitudes towards physics appear to have a negative relationship with motivation to learn physics because of active learning strategies, as suggested by the results of this study. For the Filipino sample, as attitudes towards physics become more positive, the motivation to learn physics because of active learning strategies decreases. A possible interpretation of this might be that students who already have high interest in physics do not see active learning strategies as a motivating factor to learn physics. However, there is not enough evidence to support this. Thus, further research on this relationship is needed.

Self-Esteem and attitudes towards physics

A research question advanced in Chapter 1 was, *"Do motivation and self-esteem affect students' attitudes towards physics?"* (RQ3a). To address this question, a regression analysis to test the relationship between self-esteem and attitudes towards physics was undertaken.

Regression analysis was carried out separately for the South Australian sample and the Filipino sample.

The South Australian Sample

The resulting standardised coefficient and *t*-value from the simple regression are 0.013 and 0.55 (at $P<0.01$), respectively. This suggests that, in the South Australian sample, there is no significant relationship between general self-esteem and attitudes towards physics.

The Filipino Sample

When the Filipino data set was used in carrying out a simple regression for the variables 'Attitudes' and 'SelfEstm', the resulting regression coefficient and *t*-value are 0.10 and 3.29 (at $P<0.01$), respectively. In equation form, the relationship is shown as:

$$Attitudes = B_o + 0.10(SelfEstm) + error \qquad (11.43)$$

The relationship shown by the equation indicates that as students' general self-esteem increases, their attitudes towards physics also increase. This suggests that, for the Filipino sample, students who have high self-esteem tend to have more positive attitudes towards physics. This is consistent with the findings of similar studies such as Benke and Stadler's (2003), Reid and Skryabina's (2002), and Murphy and Whitelegg's (2006) reviewed in Chapter 2.

Self-Esteem and motivation

The relationship between a student's general self-esteem and his/her motivation to learn physics was explored using regression analysis to address the research question (RQ3b) advanced in Chapter 1: *Does self-esteem affect students' motivation to learn physics?*

.

The South Australian Sample

Table 11.7 shows the results, using the data from the South Australian sample, of the regression analysis carried out to explore the relationship between self-esteem and motivation to learn physics.

Table 11.7. Resulting standardised regression coefficients and *t*-values from the regression analysis of self-esteem and motivation to learn science/physics.

Self-esteem and Motivation to learn Science/Physics						
	MotiACHVG	MotiALS	MotiLERNV	MotiPERFG	MotiSLEFF	MotiSLVAL
SelfEstm	-0.15(-0.33)	-0.11(-1.06)	-0.23(-1.90)	-0.10(-0.14)	-0.31(-3.57)*	0.12(1.46)

South Australian sample: N=306
*$P<0.01$

The significant relationship is represented by the equation

$$MotiSLEFF = B_o - 0.31(SelfEstm) + error \tag{11.44}$$

The equation (11.44) indicates that as self-esteem decreases, the motivation to learn physics because of self-efficacy increases. A possible interpretation of this would be that students already having a high general self-esteem may not necessarily need to have high self-efficacy to develop motivation to learn physics. This result somehow also confirms the association (and the distinction) of self-esteem and self-efficacy as studied by other social science researchers (e.g. Chen, Gully & Eden, 2004).

The Filipino Sample

The resulting regression coefficients and *t*-values of the regression analysis to test the relationship between self-esteem and motivation to learn physics using the Filipino data set are shown in Table 11.7a.

Table 11.7a. Resulting standardised regression coefficients and *t*-values from the regression analysis of self-esteem and motivation to learn science/physics.

Self-esteem and Motivation to learn Science/Physics						
	MotiACHVG	MotiALS	MotiLERNV	MotiPERFG	MotiSLEFF	MotiSLVAL
SelfEstm	-0.03(-3.01)*	-0.27(-5.54)*	-0.21(-4.90)*	0.21(3.84)*	-0.37(-9.12)*	-0.09(-5.63)*

Filipino sample: N=403
*$P<0.01$

The following equations represent the relationship between self-esteem and motivation to learn physics:

$$MotiACHVG = B_o - 0.03(SelfEstm) + error \tag{11.45}$$

$$MotiALS = B_o - 0.27(SelfEstm) + error \tag{11.46}$$

$$MotiLERNV = B_o - 0.21(SelfEstm) + error \tag{11.47}$$

$$MotiPERFG = B_o + 0.21(SelfEstm) + error \tag{11.48}$$

$$MotiSLEFF = B_o - 0.37(SelfEstm) + error \quad (11.49)$$

$$MotiSLVAL = B_o - 0.09(SelfEstm) + error \quad (11.50)$$

The equations indicate that, for the Filipino physics students who participated in the study, self-esteem appears to have negative relationship with all the dimensions of the motivation to learn physics (11.45 to 11.50) except for the 'performance goal' dimension (equation 11.48). This excepted equation suggests that as the self-esteem of a student increases, the student's motivation to learn physics because of his/her performance goals also increases. The resulting relationships represented by the other five equations do not show consistency with findings of similar studies. The results, however, only show overall relationships between the different dimensions of motivation and self-esteem. Inferring from these results is difficult since this study does not provide enough evidence to support any inferences made. Therefore, further investigation of these motivation dimensions and self-esteem is necessary in order to surface more meaningful interpretations.

Gender and motivation

Gender, as a factor, has always been central to many studies pertaining to subject uptake, achievement, attitudes, and many others. In this study, the relationship between gender and motivation to learn physics was explored. Regression analysis was employed in the initial analysis to address RQ3c: *Does gender have an influence on students' motivation to study physics? Does it influence their attitudes towards physics?*

The South Australian Sample

To address the first part of the question, regression analysis using the South Australian data set was carried out to test the relationship between gender and motivation to learn physics. Results are shown in Table 11.8.

Table 11.8. Resulting standardised regression coefficients and *t*-values from the regression analysis of gender and motivation to learn science/physics.

Gender and Motivation to learn Science/Physics						
	MotiACHVG	MotiALS	MotiLERNV	MotiPERFG	MotiSLEFF	MotiSLVAL
GNDR	0.08(0.52)	0.57(0.87)	0.06(0.13)	-0.38(-0.52)	2.62(3.63)*	-0.16(-0.67)

South Australian sample: N=306
*$P<0.01$

Drawing from the results presented above, a regression equation showing the relationship of the variables can be written as:

$$MotiSLEFF = B_o + 2.62(GNDR) + error \tag{11.51}$$

Equation 11.51 indicates a positive relationship between motivation because of self-efficacy and gender. This suggests that males tend to have higher self-efficacy than females. In other words, boys have relatively higher self-efficacy that influences attitudes and affords positive motivation to want to study physics. This is consistent with numerous related studies involving gender as a factor (e.g., Jones et al., 2000; Reid & Skryabina, 2002; and Osborne, 2003).

The Filipino Sample

The same regression analysis was carried out using the Filipino data set. The results are shown in Table 11.8a.

Table 11.8a. Resulting standardised regression coefficients and *t*-values from the regression analysis of gender and motivation to learn science/physics.

Gender and Motivation to learn Science/Physics						
	MotiACHVG	MotiALS	MotiLERNV	MotiPERFG	MotiSLEFF	MotiSLVAL
GNDR	0.04(0.28)	1.43(2.2)*	0.02(0.03)	-2.17(-3.16)*	2.23(4.02)*	0.11(0.53)

Filipino sample: N=403
*$P<0.01$

In equation form, the relationships are presented as follows:

$$MotiALS = B_o + 1.43(GNDR) + error \tag{11.52}$$

$$MotiPERFG = B_o - 2.17(GNDR) + error \tag{11.53}$$

$$MotiSLEFF = B_o + 2.23(GNDR) + error \tag{11.54}$$

Gender appears to have a positive relationship with the active learning strategies (MotiALS – see equation 11.52) and self-efficacy (MotiSLEFF – see equation 11.54) dimensions of motivation. This suggests that for the Filipino sample, males compared to girls, tend to develop higher motivation to learn physics because of active learning strategies and higher self-efficacy. However, gender has a negative relationship with performance goals (MotiPERFG – see equation 11.53), which suggests that girls, more than boys, tend to have more motivation to learn physics based on performance goals.

This information adds value to the existing information about the relationship between gender and motivation in sciences published based on the results of similar studies (such as Jones et al., 2000; and Reid & Skryabina, 2002).

Gender and attitudes towards physics

The relationship between gender and their attitudes towards physics was explored using simple regression. This addresses the second part of the research question (RQ3c) advanced in Chapter 1: *Does gender have an influence on students' motivation to study physics? Does it influence their attitudes towards physics?* This simple regression also addresses RQ3d: *Is there a significant difference between genders towards their attitudes towards physics?* Regression analysis was carried out separately for the South Australian sample and the Filipino sample.

The South Australian Sample

The resulting regression coefficient and *t*-value is 0.69 and 1.68 (at $P<0.01$), respectively. This suggests that there is no significant relationship between gender and attitudes towards physics in the South Australian sample. In other words, gender does not make a significant contribution to predicting students' attitudes towards physics. This might be due to the fact that all students sampled elected to study physics and, presumably, the less interested girls did not choose physics. This would also explain the gender imbalance in enrolments (see Figure 10.1 in Chapter 10, p. 294).

The Filipino Sample

Compared to the South Australian cohort, the result of the simple regression using the Filipino data set suggests otherwise – that gender has a significant relationship with students' attitudes towards physics as indicated by the resulting regression coefficient (-1.22) and *t*-value (-3.06, at $P<0.01$). This relationship can be represented in the following equation form:

$$Attitudes = B_o - 1.22(GNDR) + error \qquad (11.55)$$

This means that in the sample of Filipino physics students, gender makes a significant contribution to predicting students' attitudes towards physics. An interpretation that can be extracted from this result is that females have more positive attitudes towards physics than males. This difference between males' and females' attitudes towards physics appears to be significant ($P<0.01$) as suggested by the *t*-statistic. This might be due to the fact that physics is compulsory in Philippine secondary schools and girls are showing more negative attitudes towards the subject. These findings are consistent with those reported in the 2006 PISA report (Thomson & DeBortoli, 2008).

Gender and self-Esteem

To address RQ3e (*Does gender have an effect on general self-esteem?*), a simple regression to test for the relationship between gender and self-esteem was undertaken. Simple regression was carried out separately for the South Australian sample and the Filipino sample.

The South Australian Sample

Performing a simple regression for self-esteem (SelfEstm) and gender (GNDR) using the South Australian sample yields a regression coefficient of 0.24 and a *t*-value equal to 0.26 (at $P<0.05$) which do not suggest a significant relationship. This suggests that, for the South Australian sample, gender is not a significant contributor in predicting self-esteem.

The Filipino Sample

Using the Filipino sample, resulting regression coefficient and *t*-value from the simple regression are -0.67 and -1.08 (at $P<0.05$), respectively. A similar interpretation could be made for the Filipino study sample; that gender does not make a significant contribution to predicting self-esteem.

Attitudes towards computers and attitudes towards physics

To date, no study has been carried out to examine the relationship between students' attitudes towards computers and their attitudes towards physics. This study explored this relationship. The idea that students' attitudes towards computers may have a significant contribution in predicting their attitudes towards physics was conceived based on Osborne's (2003) review of literature of students' attitudes towards science which highlighted students' association of science with technological advances around them such as computers, televisions, mobile phones, etc.

Regression analysis was undertaken separately for the South Australian sample and the Filipino sample to get an overview of the relationship between attitudes towards computers and attitudes towards physics. The attitudes towards computer variable consists of a number of different dimensions (CompAFFC, CompBEHV, and CompCOGN – see Chapter 7) and these were taken into account.

The South Australian Sample

The results of the simple regression using the South Australian data set are shown in Table 11.9.

Table 11.9. Resulting standardised regression coefficients and *t*-values from the regression analysis of attitudes towards physics and attitudes towards computers.

Attitudes towards Physics and attitudes towards computers			
	CompAFFC	CompBEHV	CompCOGN
Attitudes	-0.00016(-0.003)	-0.032(-0.53)	-0.19(-2.66)*

South Australian sample: N=306

**P<0.01*

In equation form, the relationship between attitudes towards physics and attitudes towards computers is represented as:

$$Attitudes = B_o - 0.19(CompCOGN) + error \qquad (11.56)$$

The results indicate that only the cognitive dimension of attitudes towards computers has a negative relationship with attitudes towards physics. In other words, as attitudes towards computers (considering attitude's cognitive domain) become more positive, attitudes towards physics become more negative. For the South Australian sample, this might be interpreted as students who have increased perceptions of the usefulness and importance of computers have more negative attitudes towards computers. There might be two reasons for this: firstly, students appear to display more interest in learning and acquiring computing and programming skills than to learn challenging sciences such as physics. This brings to the second reason that a student does not need to learn physics in order to learn and acquire computing skills.

The Filipino Sample

An interesting contrast can be observed in the results of the simple regression carried using the data set from the Filipino sample (Table 11.9a).

Table 11.9a. Resulting standardised regression coefficients and *t*-values from the regression analysis of attitudes towards physics and attitudes towards computers.

Attitudes towards Physics and attitudes towards computers			
	CompAFFC	CompBEHV	CompCOGN
Attitudes	0.18(3.13)*	-0.22(-4.17)*	-0.41(-5.57)*

Filipino sample: N=403
*$P<0.01$

Written in equation form, the relationship is represented by:

$$Attitudes = B_o + 0.18(CompAFFC) - 0.22(CompBEHV) - 0.42(CompCOGN) + error \quad (11.57)$$

Equation 11.57 suggests attitudes towards physics having a positive relationship with the affective domain of computer attitudes and negative relationship with the behavioural and cognitive domains of computer attitudes. In other words, the result suggests that, as a student's attitudes towards physics become more positive, feelings of how computers affect him/her also become more positive. The opposite happens with the cognitive and behavioural domains of computer attitudes when attitudes towards physics become more positive. The positive relationship between the affective component of computer attitudes and attitudes towards physics in the Filipino context might be because of the affordability of acquiring a computer for household use is relatively low in the Philippines (Rodrigo, 2003), especially in the rural areas, which might make using computers a little intimidating for students. It might also be that Filipino students associate computers with physics. However, there is little or lack of evidence in this present study to supports the latter statement. Thus, a more in-depth review of current literature and a study on attitudes of students towards computers in the rural and metropolitan areas is needed.

Parents' aspirations and attitudes towards physics,

Parents have always been a big interest for researchers carrying out studies on student attitudes. One of the factors examined in this study is parents' aspirations and support for learning as perceived by the students. To answer RQ3g (*How do parents' aspirations for their children affect students' attitudes towards and their choice of physics or physics-related courses?*), the relationship of parents' aspirations and students' attitudes towards physics was tested using regression analysis. Parents' aspirations included both the mother's aspirations (ParentsMUM) and father's aspirations (ParentsDAD). Regression analysis was undertaken separately for the South Australian sample and the Filipino sample.

The South Australian Sample

The resulting standardised regression coefficients and *t*-values (in parenthesis) from the regression analysis are -0.09(-2.08 at $P<0.01$) and -0.03(-0.78 at $P<0.01$) for ParentsMUM and ParentsDAD, respectively. The following equation represents the relationship between students' attitudes towards physics and parents' aspirations:

$$Attitudes = B_o - 0.09(ParentsMUM) + error \qquad (11.58)$$

Equation 11.58 states that, for the South Australian sample, students' attitudes towards physics have negative relationship with mothers' aspirations. The result suggests that as students' attitudes towards physics become more positive, mothers' aspirations for their child tend to decrease. This might be interpreted in two ways: one might be perhaps that mothers have different aspirations for their child besides physics or physics-related courses. The other reason might be that mothers themselves have negative attitudes towards physics especially when they were still in school. Nevertheless, the results are partly consistent with research findings reviewed in Chapter 2 such as those of Hill et al.'s (2004), Marjoribanks, (1991); and Teachman & Paasch, (1998). These researchers have highlighted that parental aspirations and involvement in their child's education have correlations with achievement and aspirations.

The Filipino Sample

Similarly, a regression analysis was undertaken using the Filipino sample. Following are the resulting regression coefficients and *t*-values from the regression analysis: mothers' aspirations (ParentsMUM) and attitudes towards physics; -0.05(-1.05 at $P<0.01$); and fathers' aspirations (ParentsDAD) and attitudes towards physics; -0.03(-0.88 at $P<0.01$). These results suggest that parents' aspirations in the Filipino sample do not significantly contribute to predicting students' attitudes towards physics.

The results of the regression analysis using the South Australian and the Filipino data sets only provide an overview of the relationship between the variables considered.

Parents' aspirations and Self-esteem

To address RQ3h (*How do parents' aspirations affect their children's general self-esteem?*) advanced in Chapter 1, the relationship between parents' aspirations (as perceived by their children) and students' self-esteem was tested. Regression analysis was employed. Regression analysis was undertaken separately for the South Australian sample and the Filipino sample.

The South Australian Sample

Using the South Australian data set a regression analysis was undertaken to test the relationship between parents' aspirations and self-esteem. The resulting regression coefficients and *t*-values (in parenthesis) for ParentsMUM and ParentsDAD are -0.07 (-0.72 at $P<0.01$) and -0.024(-0.26 at $P<0.01$), respectively. This suggests that parents' aspirations and support for their child's learning do not have significant contribution in predicting a student's general self-esteem. In other words, there is no significant relationship ($P<0.01$) between parents' aspirations perceived by the students, and their general self-esteem.

The Filipino Sample

A similar regression analysis using the Filipino data set was undertaken to test the relationship between parents' aspirations and self-esteem. The resulting regression coefficients and *t*-values (in parenthesis) for the variables ParentsMUM and ParentsDAD are -0.11(-1.47 at $P<0.01$) and -0.045(-0.92 at $P<0.01$), respectively. The results suggest that, for the Filipino sample, there is no significant relationship between parents' aspirations perceived by the students and their general self-esteem. In other words, parents' aspirations do not significantly contribute in the prediction of students' general self-esteem.

11.4. Student level path analysis

It has been mentioned in the previous chapter that a student (or a single) level path analysis was necessary to get an overview of the levels of interaction of the variables with the other variables based on the theoretical model shown in Chapter 2 (Figure 2.1). In other words, student level path analysis was carried out to see a 'flat' snap shot of the causal relationships of two or more variables. Student level path analysis was carried out using the statistical package LISREL 8.80 developed by Jöreskog and Sörbom (2006). The overall purpose of using the LISREL path analyses results was to identify possible patterns of relationships between the variables examined in this study.

Test for multicollinearity

Before carrying out the student level path analysis, it was necessary to test for multicollinearity. Multicollinearity (or collinearity) is a disturbance to and is very common in linear regression (Mason, 1987). This disturbance exists when two or more independent variables become highly correlated which result to regression estimates with inflated variances. When this happens, the resulting individual *t*-values from the regression become unreliable. Mason (1987, p. 88) cited Hocking and Pendleton's analogy using picket fences to represent independent variables:

> A picket fence (where each picket represents an independent variable), has even spaces between the pickets. Collinearity exists when pickets overlap. The Collinearity becomes more severe as individual pickets widen, and overlap other pickets, effectively hiding them from view. In other words, collinearity obscures the role of individual pickets (variables), and makes some pickets (variables) redundant.

A number of ways to diagnose multicollinearity have been suggested by experts. One of these is the examination of the variance inflation factors (VIF) value of each variable to be included in the regression. VIF provides a reasonable and intuitive indication of the effects of multicollinearity on the variance of the *i*th regression coefficient (O'Brien, 2007, p. 674). This can be easily carried out in SPSS. According to Mason (1987), values in excess of 10 indicate serious multicollinearity and that the variable is redundant. Thus, it has been suggested that, in order to reduce multicollinearity the model should be respecified by removing one or more variables that are highly correlated with other independent variables (see O'Brien, 2007). However, O'Brien suggested taking caution because this process may do more harm than good and that associated rules with the VIF should be interpreted in the context of other factors that influence the stability of the estimates of the *i*th regression coefficient.

Using the South Australian dataset, subjecting the variables used in this study to multicollinearity test using SPSS revealed that none of them demonstrates multicollinearity as indicated by the VIF values ranging from around 1.2 to 3.4. Values over 10 indicate serious multicollinearity (Mason, 1987). With the Filipino dataset, VIF values range from around 1.2 to around 2.99. Therefore, no variables were dropped and the student level path analysis proceeded.

Results of the single (student) level path analysis

It was discussed earlier why it was important to undertake a student level path analysis in this study despite its limitations. Path analysis was initially used to address the two main research questions advanced in Chapter 1: (RQ1) '*What are the factors that affect high school and university level students' attitudes towards physics that could influence their choice of physics as a stand-alone subject/course in their course of study?*'; and (RQ2) '*How do these factors interact to influence students' attitudes towards physics?*'

Path analysis is an extension of the regression model, and is considered closely related to the multiple regression (Stage, Carter & Nora, 2004). A path model can be seen as a representation of the relationships among a number of variables (or causal relationships). A path model is drawn to indicate independent, intermediary and dependent variables. In addition, its aim is to provide estimates of the magnitude and significance of the hypothesised variable interactions shown through a path diagram. This section will describe and discuss the results of this analysis. Results from using the South Australian data set are reported separately from the results using the Filipino data set.

The model

The model of single (student level) factors influencing students' attitudes towards Physics which was advanced as the theoretical framework in Chapter 2 consists of 10 latent variables hypothesised to have an influence on students' attitudes towards Physics.

These variables include gender (GNDR), general self-esteem (SelfEstm), parents' aspirations (ParentsMUM, ParentsDAD), motivation to learn science/physics (MotiACHVG, MotiALS, MotiLERNV, MotiPERFG, MotiSLEFF, MotiSLVAL), individual attitudes towards computers (CompAFFC, CompBEHV, CompCOGN), actual classroom climate (CCAPersn, CCAParti, CCAIndep, CCAInves, CCADffer), preferred classroom climate (CCPPrsn, CCPPrti, CCPIndp, CCPInvs, CCPDfer), school curriculum (SchCURR), school type (SchTYPE) and school level (SchLEVEL). Some of these variables consist of different dimensions. A concise summary of all the variables employed in this model, including their respective sub-dimensions, is given in Table 11.10.

Structural model results for the South Australian sample

A path analysis was carried out using the South Australian sample data set. The results are shown in Figure 11.2 and Table 11.11. It should be noted that only the significant paths (*P<0.01*) showing the standardised path coefficients and *t*-values (in parentheses) are included in the diagram presented. The flow of the diagram is read from left to right.

Table 11.10. Variables used in the single (student) level model.

Variable		Description
GNDR	Gender	Gender of participants – males or females
SelfEstm	Self-esteem	General self-esteem of participants
ParentsMUM ParentsDAD	Mother's aspirations Father's aspirations	Parents' aspirations and support for their child's education
MotiACHVG MotiALS MotiLERNV MotiPERFG MotiSLEFF MotiSLVAL	Motivation by achievement goals Motivation by active learning strategies Motivation by learning environment stimulation Motivation by performance goals Motivation by self-efficacy Motivation by science learning value	Motivation to learn Science/Physics
CompAFFC CompBEHV CompCOGN	Affective domain of attitudes Behavioural domain of attitudes Cognitive domain of attitudes	Attitudes towards computers
CCAPersn CCAParti CCAIndep CCAInves CCADffer	Personalisation in actual classroom Participation in actual classroom Independence in actual classroom Investigation in actual classroom Differentiation in actual classroom	Actual classrrom climate
CCPPrsn CCPPrti CCPIndp CCPInvs CCPDfer	Personalisation in preferred classroom Participation in preferred classroom Independence in preferred classroom Investigation in preferred classroom Differentiation in preferred classroom	Preferred classroom climate
SchCURR		School curriculum – secondary school or university
SchTYPE1		Government- or privately-owned school/university
SchTYPE2*		Co-educational or single-sex school
SchLEVEL		Level of schooling – high school or university

*For the South Australian sample only.

In the following discussion, the standardised coefficients, *t*-values and significance level are reported in parentheses. It should be noted that the standardised coefficients indicated in the path diagram are not the same as the regression coefficients (also known as the *beta* values). The regression coefficients are reported in Table 11.11. Output diagram from LISREL 8 is different from the output diagram from other statistical applications because it shows different parameters as shown in Figure 11.1 (Jöreskog & Sörbom, 2001).

NOTE:
This figure is included on page 347 of the print copy of the thesis held in the University of Adelaide Library.

Figure 11.1. Path diagram showing the path coefficients in Greek notation. (Adapted from Jöreskog & Sörbom, 2001)

For accuracy, the author of this study adapted Jöreskog and Sörbom's (2001, p.4) rules for drawing path diagrams to describe what Figure 11.1 means. These rules are easy enough to follow what the figure is trying to represent.

- The *x*- and *y*- variables enclosed in boxes are the observed variables.
- The latent variables ξ and η are enclosed in boxes.
- The unenclosed variables ε, δ, and ς are the error variables.
- A one-way arrow between two variables indicates a postulated direct influence of one variable on another. A two-way arrow between two variables indicates that these variables may be correlated without any assumed direct relationship. One-way arrows are drawn straight, while two-way arrows are generally curved.
- ξ-variables are independent variables, while η-variables are dependent variables. Variation and covariation in the dependent variables is to be accounted for or explained by the independent variables. In the path diagram this corresponds to

the statements: (1) no one-way arrow can point to a *ξ*-variable; (2) all one-way arrows pointing to an *η*-variable come from *ξ*- and *η*-variables.

- Associated with each arrow are the standardised coefficients.

Therefore, the model (Jöreskog & Sörbom, 2001, p.5) can be described as:

> The diagram shows there are seven *x*-variables as indicators of three latent *ξ*-variables...There are two latent *η*-variables each with two *y*-indicators. The five latent variables are connected in a two-equation interdependent system. The model involves errors in equations (the *ς*'s) and errors in variables (the *ε*'s and *δ*'s).

Direct effects on Attitudes towards Physics (Attitude)

In a path diagram, a direct effect is represented by a single-headed arrow between the variables concerned. A direct effect between two variables means that if one variable is changed, a change in the other variable is expected. Using the South Australia data set, there are eight factors that have direct effects on student attitudes towards physics (Attitude). Beginning with the leftmost factors in the diagram (Figure 11.2), school level (SchLEVEL, 0.19, t =3.08 at $P<0.01$) shows a significant positive influence on student attitudes (see Figure 11.2). The path coefficient (0.19) indicates the extent a change in 'SchLEVEL' is transmitted to 'Attitude'. Based on the results presented in the diagram and considering the factor coding of '0' for university students and '1' for high school students (*not* to be mistaken as a *dummy* variable coding), those who are doing physics at a high school level are likely to have more positive attitudes towards the subject.

Student gender (GNDR, 0.23, t =3.91 at $P<0.01$) also has a significant positive effect on attitudes towards physics. Based on the gender coding of '0' for females and '1' for males (again, *not* to be mistaken as *dummy* variable codings), the resulting positive coefficient indicates that male physics students have more positive attitudes towards Physics than female physics students. This result is generally consistent with findings of similar studies (e.g., Stokking, 2000; Jones et al., 2000; Reid & Skryabina, 2002) where males have more positive attitudes towards physics than females. However, independent samples *t*-test indicate that there is no significant difference between males and females in terms of their attitudes towards physics (t=-1.3, P<0.01).

Another factor that appears to have a significant influence on attitudes is the attitudes towards computers considering its affective domain (CompAFFC, -0.13, t =-2.24 at $P<0.01$). The negative coefficient (-0.13) suggests negative relationship between the two variables (Attitude and CompAFFC). The result suggests that students who have more positive attitudes towards computers (perceptions of feelings towards computers), tend to have a more negative attitudes towards physics. An interpretation of this result might be that students who get more interested in studying computers tend to have negative attitudes towards physics. This might be because a student does not need physics in order to learn how to use a computer.

With regard to physics students' preferred classroom, the investigation dimension (CCPInvs, -0.16, t =-2.75 at $P<0.01$) has a direct negative influence on student attitudes. The negative coefficient suggests that an increase in investigation activities in the physics classroom could cause a decrease in students' attitudes towards physics. Since this concern what students perceive as an ideal individualised classroom environment in terms of its 'investigation' dimension, the result might be interpreted as physics students preferring more group investigation (or collaborative work) rather than a more individualised investigation task. In other words, the more individualised work students have in a Physics classroom, the less they feel positively towards physics.

In an actual individualised classroom environment, the differentiation dimension (CCADffer, -0.13, t =-2.13 at $P<0.01$) appears to influence students' attitudes towards physics. The negative coefficient (-0.13) suggests a negative relationship between the two variables. This means that an increase in the teacher's classroom differentiation approach might cause students' attitudes towards physics to become more negative. In a classroom environment, differentiation emphasises the "selective treatment of students on the basis of ability, learning style, interests, and rate of working" (Fraser, 1982, p. 514). The result provides evidence, and thus suggests that too much differentiation in the physics classroom decreases students' attitudes towards physics.

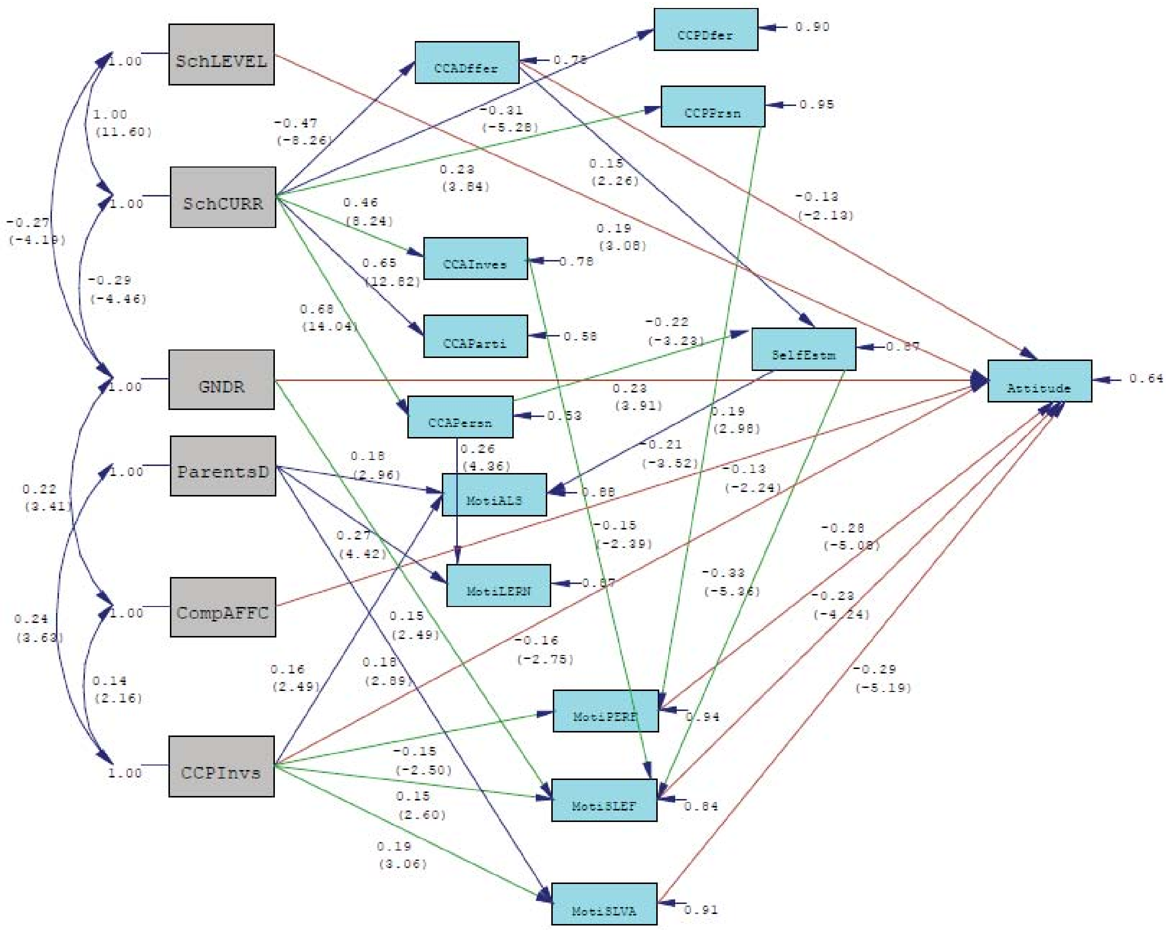


Figure 11.2. Student level factors influencing attitudes of students towards Physics of the total South Australia sample (N=306).

Three dimensions of the factor motivation to learn science/physics appear to have an impact on student attitudes towards Physics (refer to Figure 11.2). These are performance goal (MotiPERFG, -0.28, t =-5.08 at $P<0.01$), self-efficacy (MotiSLEFF, -0.23, t =-4.24 at $P<0.01$), and science learning value (MotiSLVAL, -0.29, t =-5.19 at $P<0.01$). The negative path coefficients (-0.28, -0.23, and -0.29) suggest negative relationship between attitudes towards physics and these three dimensions of motivation. In other words, an increase in motivation to learn physics by performance goals, self-efficacy, and science learning value, could result to more negative attitudes towards physics. An interpretation of this result would be students who constantly try to reach their performance goals and think about their self-worth and the value of learning science, tend to develop more negative attitudes towards physics. This might be attributed to the challenging nature of learning physics, especially the more advanced ones.

Equation 11.59 summarizes the direct effects in the path model for the South Australian sample shown in Figure 11.2.

$$Attitude = B_o + 0.19(SchLEVEL) + 0.23(GNDR) - 0.13(CompAFFC) - 0.16(CCPInvs) - 0.13(CCADffer) - 0.28(MotiPERFG) - 0.23(MotiSLEFF) - 0.29(MotiSLVAL) + error \quad (11.59)$$

Indirect effects on Attitudes towards Physics (Attitude)

The presence of indirect effect in evident when a variable affects another variable through intermediate variable(s). In order to obtain the effect of one variable on another variable through a third (or fourth, fifth, etc.) variable, the individual effects in this indirect path need to be multiplied. This is analogous to calculating the resultant of two or more vectors. This 'resultant' represents how many percent the indirect path explains the direct relationship between two variables in focus. The resulting figure from multiplying individual effects in an indirect path represents the proportion of variance explained by that path. With reference to the path diagram in Figure 11.2, it can be observed that student attitudes towards Physics can be indirectly influenced by a number of factors namely: school curriculum (SchCURR), father's support for learning and aspirations for his child (ParentsDAD), and the investigation dimension of the student's preferred classroom climate (CCPInvs). These factors affect attitudes through other factors.

School Curriculum (SchCURR). The school curriculum (SchCURR) factor can be observed in the diagram as having an indirect influence on students' attitudes towards physics through a number of factors. Firstly, as demonstrated in the Figure 11.2, SchCURR (-0.47 x -0.13 = 0.06) through the 'differentiation' component of the actual classroom climate (CCADffer) exhibits a positive relationship with students' attitudes towards Physics. This suggests that by providing enough differentiation in the physics classroom, school curriculum could positively have an impact on students' attitudes towards physics. This indirect path explains 6% of the direct relationship between school curriculum and attitudes towards physics. Secondly, school curriculum (0.46 x -0.15 x -0.23 = 0.02, or 2%), through the 'investigation' dimension of the actual physics classroom climate (CCAInves) and the 'self-efficacy' component of motivation to learn physics (MotiSLEFF), appears to have an indirect positive impact on students' attitudes towards Physics. This means that 'SchCURR' has a positive impact on 'CCAInve's, and 'CCAInves' has a negative impact on 'MotiSLEFF', and 'MotiSLEFF' has a negative impact on 'Attitude' (see Figure 11.2). However, by combining these effects, school curriculum turns out to have a positive influence on attitudes towards physics. This indirect path explains 2% of the direct relationship between school curriculum and attitudes towards physics. Thirdly, school curriculum (0.68 x -0.22 x -0.33 x -0.23 = -0.011, or 1.1%), through the 'personalisation' dimension of the actual Physics classroom climate (CCAPersn), self-esteem (SelfEstm), and the 'self-efficacy' component of motivation to learn Physics (MotiSLEFF) demonstrates indirect negative effect on students' attitudes towards physics (see Figure 11.2). This indirect path represents 1.1% of the explanation of the direct relationship between school curriculum and attitudes towards physics.

Gender (GNDR). Not only that gender directly impacts student attitudes towards physics, it also appears to have an indirect effect (0.15 x -0.23 = -0.035, or 3.5%) on student attitudes towards Physics through the self-efficacy dimension of the motivation to learn Physics (MotiSLEFF) factor (see Figure 11.2). Combining path coefficients of the direct effects of 'GNDR' to 'MotiSLEFF' (0.15) and 'MotiSLEFF' to 'Attitude' (-0.23), the resulting indirect effect path coefficient (-0.035) indicates a negative relationship between gender and attitudes towards physics. This figure accounts for 3.5% of the explanation of the direct relationship between gender and attitudes towards physics. This could be interpreted as females in the South Australian sample, considering their motivation to learn physics because of self-efficacy, have stronger attitudes towards physics than males. This result could also be interpreted as when students think more about their self-worth and abilities in Physics, the less motivated they become towards Physics (hence, the negative coefficient between 'MotiSLEFF' and 'Attitude'). This further highlights many students think of physics as a challenging subject and, often, the more they think about the academic demands of studying physics and compare it to their abilities to cope with it; they tend to be less motivated to study it. This statement takes into consideration the fact that all sampled participants were studying physics at the time data were collected. The significant direct positive effect of gender (GNDR, 0.15, t =2.49 at $P<0.01$) towards the self-efficacy dimension of motivation to learn Physics indicates that males have a higher motivation to learn Physics than girls.

Investigation in the Preferred Classroom Climate (CCPInvs). The 'investigation' dimension of the sampled South Australian students' preferred classroom climate, based on the diagram (Figure 11.2), appears to have indirect effects on their attitudes towards physics. These indirect effects are through the performance goal (MotiPERFG), self-efficacy (MotiSLEFF), and the science learning value (MotiSLVAL) dimensions of the motivation to learn Physics factor. Through 'MotiPERFG', 'CCPInvs' (-0.15 x -0.28 = 0.042, or 4.2%) has a positive indirect effect on students' attitudes towards physics. This means that, through students' motivation by their performance goals, students who have strong attitudes towards physics would prefer to have more investigation activities in their preferred classroom. This indirect path explains 4.2% of the direct relationship between 'CCPInvs' and 'Attitude'.

Through 'MotiSLEFF', 'CCPInvs' (0.15 x -0.23 = -0.035, or 3.5%) appears to have a negative impact on students' attitudes towards Physics. An increase in the investigation activities in the classroom could result to a decrease in attitudes towards physics because of a decrease in motivation due to self-efficacy. This means that students who would prefer to have more investigation activities in their preferred physics classroom might have a decrease in their attitudes towards physics because of lowered self-efficacy. Finally, through MotiSLVAL, it appears that CCPInvs (0.19 x -0.29 = -0.06, or 6%) has a negative impact on students' attitudes towards Physics. This means that an increase in investigation activities in the students' preferred physics classroom could increase their motivation to learn physics because of its science learning value. However, a decrease in the attitudes towards physics could result. A reason for this could be that even when students appreciate the value of learning physics because of more investigation activities in the classroom, they tend to develop a more negative attitude towards physics due to its perceived challenging nature. This indirect path explains 6% of the direct relationship between 'CCPInvs' and 'Attitude'.

Structural model results for the Filipino sample

Similarly, a path analysis was carried out using the Filipino data set. The results are shown in Figures 11.3 and 11.4, and Table 11.12. There are two path diagrams shown: one is a diagram showing the *t*-values significant at $P<0.01$ level (Figure 11.3), and the other diagram shows the standardised path coefficients (Figure 11.4). The *t*-values and the standardised coefficients should have been both included in only one diagram, however, doing this would result to a much more cluttered representation of the results. In the following discussion of results, the path coefficients and *t*-values at a specified significance level are included. Only the significant paths ($P<0.01$) are shown in the diagrams. The flow of the diagram is read from left to right.

Direct effects on Attitudes towards Physics (Attitude)

A direct effect is represented by a single-headed arrow between the variables concerned. A direct effect between two variables means that if one variable is changed, a change in the other variable is expected. Similar to the path diagram for the South Australian sample, the path diagram resulting from using the Filipino data also shows eight factors that appear to directly affect students' attitudes towards physics. Beginning with the upper left corner of the path diagram (Figure 11.4), school level (SchLEVEL, 0.75, t =10.65 at $P<0.01$) indicates a direct positive impact on students' attitudes towards Physics. Based on the school level coding of '0' for university level and '1' for high school level (*not* to be mistaken as a *dummy* variable coding), this could be interpreted as students physics who are at a high school level of study have more positive attitudes towards physics than those who are at a university level studies. The path coefficient (0.75) indicates the extent a change in 'SchLEVEL' is transmitted to 'Attitude'.

School type (SchTYPE1, -0.23, t =-5.33 at $P<0.01$) in terms of whether the school is government- or privately-owned appears to have a direct negative effect on students attitudes towards Physics. In other words, the 'more' government-owned a school becomes, a decrease in students' attitudes towards physics could be observed. The negative standardised coefficient could be interpreted as students in privately-owned schools are likely to have more positive attitudes towards physics than those who are in government-owned schools. This interpretation is based on the coding that was used in the data analyses: '0' for privately-owned schools, and '1' for government-owned schools. This coding should *not* be mistaken for a *dummy* variable coding.

The affective component (CompAFFC, 0.16, t =3.91 at $P<0.01$) and the cognitive component (CompCOGN, -0.19, t =-2.83 at $P<0.01$) of student attitudes towards computers appear to have significant impact on students' attitudes towards Physics (see Figures 11.3 and 11.4). The affective component of attitudes towards computers appears to have a positive relationship with attitudes towards physics. The affective component of attitudes encodes feelings towards attitude objects and the cognitive component pertains to the beliefs and perceptions held regarding this attitude object (Jones & Clarke, 1994). This means that the more positive students feel towards computers, the more positive they would feel about physics. However, a negative relationship between attitudes towards computers and the cognitive aspect of attitudes towards computers is suggested by the path coefficient between these two variables. In other words, the more students realise about the importance of computers, the more negative they become towards physics. This might be due to the reason that students do not need to learn physics in order to learn how to use the computer.

Table 11.11. Summary of direct effects on Attitudes, Self-esteem, Motivation and Classroom Climate of the South Australia total sample.

Direct Effects	*Attitude*	SelfEstm	MotiSLEFF	MotiALS	MotiSLVAL	MotiPERFG	MotiACHVG	MotiLERNV	CCAPersn	CCAParti	CCAIndep	CCADffer	CCAInves	CCPPrsn	CCPPrti	CCPIndp	CCPDfer	CCPInvs
SchLEVEL	1.27(3.1)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SchCURR	*	*	*	*	*	*	*	*	7.01(14.0)	7.88(12.8)	*	-4.04(-8.3)	3.79(8.2)	2.22(3.8)	*	*	-2.84(-5.3)	*
SchTYPE1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SchTYPE2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CCAPersn	*	-0.34(-3.2)	*	*	*	*	*	0.20(4.36)	*	*	*	*	*	*	*	*	*	*
CCAParti	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CCAIndep	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CCADffer	-0.10(-2.1)	0.27(2.3)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CCAInves	*	*	-0.23(-2.4)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CCPPrsn	*	*	*	*	*	0.25(3.0)	*	*	*	*	*	*	*	*	*	*	*	*
CCPPrti	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CCPIndp	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CCPDfer	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CCPInvs	-0.10(-2.8)	*	0.18(2.6)	0.17(2.5)	0.23(3.1)	-0.18(-2.5)	*	*	*	*	*	*	*	*	*	*	*	*
ParentsMUM	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
ParentsDAD	*	*	*	0.16(3.0)	0.17(2.9)	*	*	0.16(4.4)	*	*	*	*	*	*	*	*	*	*
GNDR	1.50(3.9)	*	1.93(2.5)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SelfEstm	*	*	-0.26(-5.4)	-0.15(-3.5)	*	*	*	*	*	*	*	*	*	*	*	*	*	*
MotiSLEFF	-0.12(-4.2)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
MotiALS	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
MotiSLVAL	-0.15(-5.2)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
MotiPERFG	-0.14(-5.1)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
MotiACHVG	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
MotiLERNV	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CompAFFC	-0.07(-2.2)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CompBEHV	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CompCOGN	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
TOTAL EFFCTS	8	2	4	3	2	2	0	2	1	1	0	1	1	1	0	0	1	0

Note: Regression Coefficient (*Beta*) – *values outside the parentheses*
T-values – *values inside parentheses*
N = 306; $P<0.01$

The 'independence' dimension of the actual classroom environment (CCAIndep, 0.45, t =6.83 at $P<0.01$) appears to have a significant influence on the students' attitudes towards physics (see Figures 11.3 and 11.4). This suggests that an increase in student independence for their learning makes them more positive towards physics. In the context of the Filipino sample, this result would be interpreted as a preference towards learning independence in a physics classroom would lead to more positive attitudes towards physics.

With regard to students' preferred physics classroom climate, the path diagram shows that the 'investigation' dimension (CCPInvs, -0.13, t =-2.91 at $P<0.01$) has a negative impact on students attitudes towards Physics. This means that an increase in the investigation activities in the physics classroom would result to a more negative attitude towards physics. It seems that students in their preferred Physics classroom would not want more classroom investigation work for them to have positive attitudes towards physics. This is an interesting result since it is contrary to the expected impact of the 'independence' dimension of the actual physics classroom climate. This might be a result of students' experience of receiving confusing physics activities where the expected outcome is not explicitly outlined, and, perhaps, lack of support from the physics teachers especially those who do not have the qualification to teach the subject. Since there little evidence in the present study to support this, further study is needed.

Two dimensions of the motivation to learn science/physics factor appear to have a direct impact on students' attitudes towards Physics. These are the learning environment (MotiLERNV, -0.18, t =-4.23 at $P<0.01$) and science learning value (MotiSLVAL, -0.16, t = -3.84 at $P<0.01$) dimensions. The negative sign suggests that, although significant, motivation to learn science/physics in terms of the learning environment stimulation and science learning value has a negative impact on students' attitudes towards physics. In other words, the more motivated a student becomes in learning physics because of learning environment stimulation and science learning value, the worse his/her attitudes towards physics becomes. This might be due to other factors playing a role in shaping students' attitudes. This was re-examined using multilevel analysis techniques. This will be presented in the next chapter.

Equation 11.60 summarizes the direct effects in the path model for the Filpino sample shown in Figure 11.3.

$$Attitude = B_o + 0.75(SchLEVEL) - 0.23(SchTYPE1) + 0.16(CompAFFC) - 0.19(CompCOGN) + 0.45(CCAIndep) - 0.13(CCPInvs) - 0.18(MotiLERNV) - 0.16(MotiSLVAL) + error \quad (11.60)$$

Indirect effects on Attitudes towards Physics (Attitude)

There is a presence of indirect effect when a path shows variable affecting another variable through intermediate variable(s). With reference to the path diagram in Figure 11.4, it can be observed that student attitudes towards physics appear to be indirectly influenced by a number of factors namely: school curriculum (SchCURR) and four dimensions of the actual physics classroom climate as perceived by the students. The four dimensions include differentiation (CCADffer), investigation (CCAInves), participation (CCAParti), and personalisation (CCAPersn).

School Curriculum (SchCURR). The resulting path diagram from using the Filipino data set exhibits school curriculum as having an indirect impact on students' attitudes towards Physics through a number of factors. These include the 'independence' dimension of the actual classroom climate (CCAIndep), the 'investigation' dimension of students' preferred Physics classroom (CCPInvs), the 'participation' dimension of students' preferred Physics classroom climate (CCPPrti), and the 'independence' dimension of students' preferred Physics classroom climate (CCPIndp). Through 'CCAIndep', the resulting path coefficient resulting from this indirect effect amounts to -0.79 x 0.45 = -0.36. In other words, the indirect path explains around 3.6% of the direct relationship between school curriculum and attitudes towards physics. The negative sign of the resulting path coefficient indicates negative relationship between school curriculum and attitudes towards physics. That is, students in high school tend to have more negative attitudes towards physics. Partly, this could be due to the 'independence' dimension of the actual classroom climate. In other words, this result could be interpreted as the likelihood that more independent work the students do in a high school physics classroom, the less positive they become towards physics. This is where physics teachers play a crucial role in properly shaping students' attitudes in taking responsibility for their learning by giving them clear instructions on how to carry out an assigned task and explicitly stating what is expected as an output at the end of the activity.

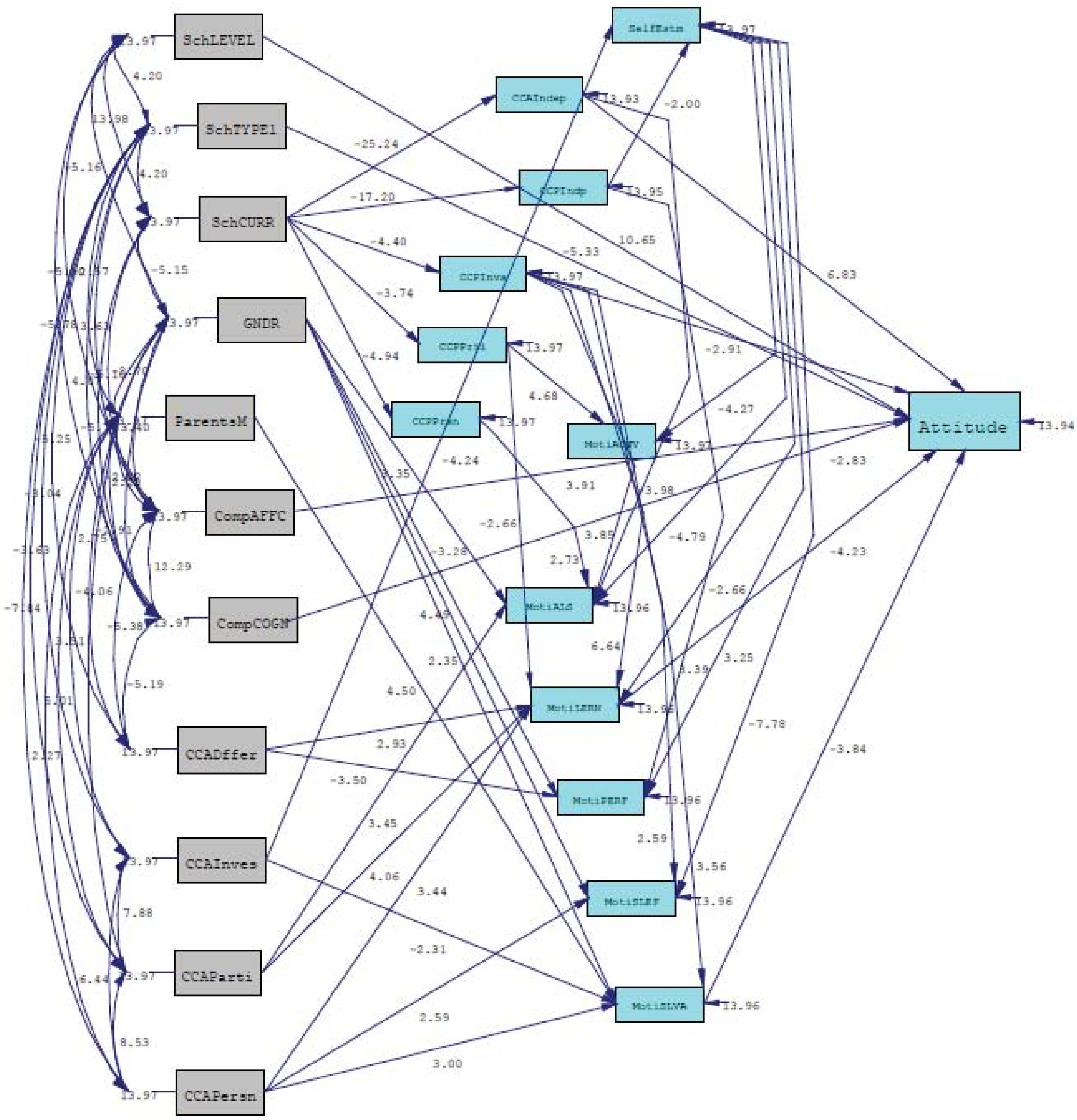


Figure 11.3. Student level factors influencing attitudes of students towards Physics of the total Philippine sample (N=403). *T*-values are shown.

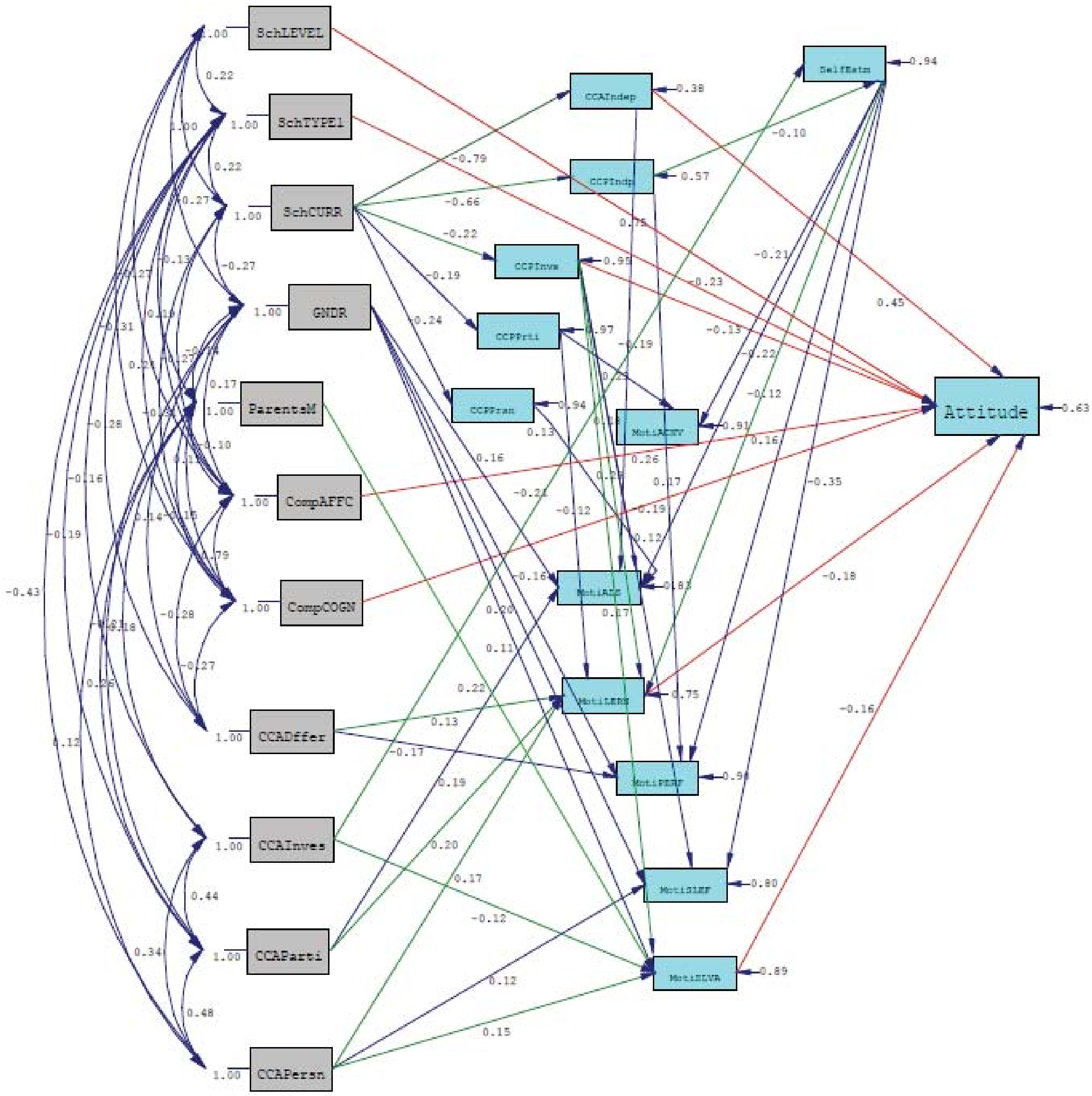


Figure 11.4. Student level factors influencing attitudes of students towards Physics of the total Philippine sample (N=403). Standardised coefficients are shown.

Through CCPInvs, the standardised coefficient resulting from this indirect effect amounts to -0.22 x -0.13 = 0.03, or 3%. This means that this indirect path explains 3% of the direct relationship between school curriculum and attitudes towards physics. This result could be an indication of the likelihood of students to have more positive attitudes towards physics as they prefer more investigative work in a physics classroom. Based on the path diagram, the indirect effect of school curriculum on attitudes towards physics not only goes through 'CCPInvs' but also extends through the learning environment stimulation component of motivation to learn Science/Physics (MotiLERNV). The resulting product of the path coefficients amounts to -0.22 x 0.18 x -0.18 = 0.007, or 0.7%. In other words, this indirect path only explains 0.7% of the direct relationship between school curriculum and attitudes towards physics. However, this is too small considering that it only explains the direct relationship between the two variables by less than a percent. Therefore, this indirect effect was disregarded.

The indirect effect of school curriculum towards students' attitudes in physics shown in the path that goes through CCPPrti and MotiLERNV yields a very small path coefficient (-0.19 x -0.12 x -0.18 = -0.004, or 0.4%) which accounts for less than a percent (0.4%) of the explanation of the direct effect between the two variables. Thus, this path indicating indirect effect was disregarded. Similarly, the path going through 'CCPIndp', 'SelfEstm', and 'MotiLERNV' indicating the indirect effect of school curriculum on students' attitudes towards physics was also disregarded because of a very small (less than a percent) path coefficient (-0.66 x -0.10 x -0.12 x -0.18 = 0.0014, or 0.14%).

Differentiation aspect of the Actual Classroom Climate (CCADffer). As shown in the path diagram in Figure 11.4, the actual classroom climate considering its teaching differentiation aspect (CCADffer) demonstrates an indirect effect on students' attitudes towards physics (Attitude). This indirect effect goes through the motivation to learn science/physics factor with a resulting path coefficient of 0.13 x -0.18 = -0.023. In other words, this indirect path explains 2.3% of the direct relationship between 'CCADffer' and 'Attitude'. An interpretation of this result would be the more differentiated the instruction approach in the physics classroom is, the higher the students' motivation to learn science/physics is likely to become. However, the more differentiated the teaching approach in a physics classroom becomes, the less likely that students will have positive attitudes towards physics. This is an interesting finding because the opposite was expected. Further research on teachers' differentiated approach to teaching physics will add value to this finding.

Investigation aspect of the Actual Classroom Climate (CCAInves). The actual classroom climate, considering its 'investigation' aspect, appears to indirectly influence students' attitudes towards physics. This indirect influence is observed in the path diagram to go through the 'science learning value' aspect of motivation to learn science/physics (MotiSLVAL). The product of path coefficients in the indirect path is, -0.12 x -0.16 = 0.02, or around 2%. In other words, this indirect path explains 2% of the direct relationship between 'CCAInves' and 'Attitude'. This indirect path also suggests that as investigation activities increase in the physics classroom, students' attitudes towards physics also increases. This result could be interpreted as the more investigation activities students experience in the physics classroom, the more positive they become about physics. This could be achieved through careful planning and development of investigation activities for the students in order for them to enjoy learning physics concepts and also be able to see how physics is applied in real life.

Participation aspect of the Actual Classroom Climate (CCAParti). It can be observed from the path diagram in Figure 11.4 that the 'participation' aspect of the actual classroom climate (CCAParti) appears to have an indirect influence on students' attitudes towards physics. The indirect effect can be traced with the path that goes through the 'learning environment' aspect of the factor motivation to learn science/physics (MotiLERNV). Multiplying the path coefficients in this path yields 0.20 x -0.18 = -0.036, or around 3.6%. This means that this indirect path explains around 3.6% of the direct relationship between 'CCAPart' and 'Attitude'. Considering the negative sign, this could be interpreted as student participation in the physics classroom having a negative effect on students' attitudes towards Physics. In other words, the more participation students are asked to do in the physics classroom, the more likely they become negative towards physics. This might be explained by the teaching approach employed by many physics teachers in the Philippines where they call on student names during discussion even when students do not raise their hands to indicate they want to participate in the discussion. However, the lack of evidence to support this suggests for a more in-depth examination of teaching approaches of physics teachers in the Philippines.

Personalisation aspect of the Actual Classroom Climate (CCAPersn). The path diagram in Figure 11.4 suggests evidence of CCAPersn's indirect influence on students' attitudes towards physics through the variable motivation to learn science/physics considering its 'science learning value' (MotiSLVAL) aspect. The resulting path coefficient from the product of the two path coefficients shown in the path in Figure 11.4 amounts to 0.15 x -0.16 = -0.024. This figure suggests that the indirect effect explains around 2.4% of the direct relationship between 'CCAPersn' and 'Attitude'. This result suggests some evidence that students are likely to develop negative attitudes towards physics when there is an increase on the emphasis to provide opportunities for individual students to interact with their teacher (the personalisation aspect in the actual physics classroom). This might be attributed to the approach employed by the physics teacher to encourage students to interact with him/her. It might be that the approach is not effective in showing concern for the individual student's personal welfare and social growth in the physics classroom. In other words, the teacher's approach to provide personalisation in the physics classroom might be developing hesitation among students to open up more about the challenges they are experiencing in trying to learn physics concepts. However, other factors might also be in play. Culture, for example, might play a role on this. Filipino students, especially those in high school, more often than not, are not comfortable interacting with their teachers about what they think and feel about a subject, especially when they are having difficulty learning it. This might be true with the Filipino physics students sampled in this study. However, very little evidence is provided in the present study to back up these statements, therefore, further research is recommended.

Table 11.12: Summary of direct effects on Attitudes, Self-esteem, Motivation and Classroom Climate of the Filipino total sample.

Direct Effects	*Attitude*	SelfEstm	MotiSLEFF	MotiALS	MotiSLVAL	MotiPERFG	MotiACHVG	MotiLERNV	CCAPersn	CCAParti	CCAIndep	CCADffer	CCAInves	CCPPrsn	CCPPrti	CCPIndp	CCPDfer	CCPInvs
SchLEVEL	5.81(10.6)	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
SchCURR	•	•	•	•	•	•	•	•	•	•	-6.39(-25.2)	•	•	-1.99(-4.94)	-2.09(-3.74)	-5.51(-17.2)	•	-2.24(-4.4)
SchTYPE1	-1.82(-5.3)	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CCAPersn	•	•	0.17(2.6)	•	0.51(3.0)	•	•	•	•	•	•	•	•	•	•	•	•	•
CCAParti	•	•	•	0.21(3.45)	•	•	•	0.22(4.1)	•	•	•	•	•	•	•	•	•	•
CCAIndep	0.43(6.8)	•	•	-0.29(-3.4)	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CCADffer	•	•	•	•	•	-0.39(-3.5)	•	0.24(2.93)	•	•	•	•	•	•	•	•	•	•
CCAInves	•	-0.30(-4.2)	•	•	-0.35(-2.3)	•	•	•	•	•	•	•	•	•	•	•	•	•
CCPPrsn	•	•	•	0.19(2.73)	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CCPPrti	•	•	•	•	•	•	0.34(4.7)	-0.12(-2.7)	•	•	•	•	•	•	•	•	•	•
CCPIndp	•	-0.15(-2.0)	•	•	•	0.29(3.4)	•	•	•	•	•	•	•	•	•	•	•	•
CCPDfer	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CCPInvs	-0.10(-2.9)	•	0.13(2.6)	0.21(3.85)	0.42(3.6)	•	•	0.34(6.64)	•	•	•	•	•	•	•	•	•	•
ParentsMUM	•	•	•	•	0.52(4.5)	•	•	•	•	•	•	•	•	•	•	•	•	•
ParentsDAD	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
GNDR	0.35(1.1)	•	2.30(4.5)	1.99(3.35)	2.93(2.4)	-2.39(-3.3)	•	•	•	•	•	•	•	•	•	•	•	•
SelfEstm	•	•	-0.32(-7.8)	-0.22(-4.8)	•	0.19(3.3)	-0.28(-4.3)	-0.11(-2.7)	•	•	•	•	•	•	•	•	•	•
MotiSLEFF	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
MotiALS	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
MotiSLVAL	-0.05(-3.8)	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
MotiPERFG	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
MotiACHVG	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
MotiLERNV	-0.12(-4.2)	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CompAFFC	0.18(3.9)	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CompBEHV	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CompCOGN	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
TOTAL EFFCTS	8	2	4	6	5	4	2	5	0	0	1	0	0	1	1	1	0	0

Note: Regression Coefficient (*Beta*) – *values outside the parentheses*
T-values – *values inside parentheses*
N = 403; $P<0.01$

11.5. Summary

This chapter highlights the results of the single-level (or student-level) path analyses undertaken using the computer program LISREL. This technique was carried out to examine the possible relationships of factors that could influence students' attitudes towards physics. This is with the assumption that each unit was independent of each other. Student-level analyses were carried out separately for the South Australian sample and the Filipino sample since the SUPSQ exhibited measurement variance between them.

The limitations of the single-level path analysis were discussed. This includes the over- or under-estimation of the path coefficients when this technique is used on a set of data that is hierarchical in nature. Nevertheless, this was carried out in order to obtain an overview of how the factors examined in this study relate to each other. The relationships tested were based on the research questions advanced in the first chapter (see below). Relationships between variables to address each question based on the results of the initial analyses are provided. Results for the South Australian (SA) sample are reported separately from the results for the Filipino (PH) sample.

a. What is the influence of school type (government or private, on students' attitudes towards physics?

- *SA*

School type 1 (government/private) and school type 2 (coeducational/single-sex) have positive relationship with students' attitudes towards physics.

- *PH*

School type (government/private) has a negative relationship with attitudes towards physics.

b. How does school curriculum influence classroom climate in the two sample groups?

- *SA*

School curriculum has a positive relationship with the following dimensions of the actual classroom climate: 'personalisation', 'participation', and 'investigation'. It has a negative relationship with 'differentiation'.

School curriculum has a positive relationship with the 'personalisation' dimension of students' preferred physics classroom. It has a negative relationship with the 'differentiation' dimension.

- *PH*

School curriculum has a negative relationship the 'independence' dimension of the actual physics classroom climate. In the students' preferred physics classroom, school curriculum has a negative relationship with the following dimensions: 'personalisation', 'participation', 'independence', and 'investigation'.

c. Does school curriculum have an influence on students' motivation to study physics?

- *SA*

School curriculum has a positive relationship with motivation to learn physics due to 'learning environment stimulation'. It has a negative relationship with motivation due to 'performance goals' and 'science learning value'.

- *PH*

School curriculum has a negative relationship with motivation due to 'performance goal'.

d. How does classroom climate influence students' general self-esteem?

- *SA*

Self-esteem has a negative relationship with the 'personalisation' dimension of the actual physics classroom climate, and positive relationship with the 'differentiation' dimension of the actual physics classroom climate.

- *PH*

Self-esteem has a negative relationship with the 'investigation' dimension of the actual physics classroom climate, and with the 'investigation' dimension of the preferred physics classroom climate.

e. How does classroom climate affect students' attitudes towards physics?

- *SA*

Students' attitudes towards physics have negative relationship with the following actual classroom climate dimensions: 'independence' and 'differentiation'. Attitudes have negative relationship the following dimensions of the preferred classroom climate: 'personalisation', 'investigation', and 'differentiation'.

- *PH*

Students' attitudes towards physics have positive relationship with the 'differentiation' dimension of the actual classroom climate, the 'participation' and 'investigation' dimensions of preferred classroom climate.

Attitudes have negative relationship with the 'personalisation' and 'independence' dimensions of the preferred classroom climate.

f. How does classroom climate affect students' motivation to learn physics?

Generally, significant relationships (P<0.01) between motivation and classroom climate have been observed for both the SA and PH samples.

g. What is the influence of teachers on the physics classroom climate that could affect students' attitudes towards physics?

- *This question was partly answered by the research question posted above in 'f', and was partly answered with the teacher interview transcripts.*

h. How do teachers' teaching methods impact on physics classroom climate?

- *This question was partly answered by the research question posted above in 'f', and was partly answered with the teacher interview transcripts.*

i. Do motivation and self-esteem affect students' attitudes towards physics?

- *SA*

Students' attitudes towards physics have negative relationship with motivation to learn science/physics due to 'performance goals', 'self-efficacy', and 'science-learning value'.

There was no relationship found between self-esteem and attitudes towards physics.

- *PH*

Students' attitudes towards physics have negative relationships with motivation to learn physics due to 'active learning strategies'.

Students' attitudes towards physics show a positive relationship with self-esteem.

j. Does self-esteem affect students' motivation to learn physics?

- *SA*

Self-esteem has a negative relationship with motivation to learn physics due to 'self-efficacy'.

- *PH*

Self-esteem has a positive relationship with motivation to learn physics due to 'performance goal'. However, it shows a negative relationship with motivation to learn physics due to 'achievement goals', 'active learning strategies', 'learning environment stimulation', 'self-efficacy', and 'science-learning value'.

k. Does gender have an influence on students' motivation to study physics? Does it influence their attitudes towards physics?

- *SA*

Gender has a positive relationship with motivation to learn physics due to 'self-efficacy'. However, no relationship between gender and attitudes towards physics was suggested in the analysis results.

- *PH*

Gender has a positive relationship with motivation to learn physics due to 'active learning strategies' and 'self-efficacy', but negative with 'performance goals'. Negative relationship between gender and attitudes towards physics was suggested by the results of the regression analysis.

l. Is there a significant difference between genders towards their attitudes towards physics?

There is no significant difference between males' and females' attitudes towards physics in the South Australian sample. However, it is evident in the Filipino sample that there is significant difference between males and females in terms of their attitudes towards physics.

m. Does gender have an effect on general self-esteem?

For both the South Australian and the Filipino samples, no relationship between gender and self-esteem was suggested using the results of the regression analysis.

n. Does the use of computers have a positive impact on students' attitudes towards physics?

- *SA*

Attitudes towards physics have negative relationship with the cognitive domain of attitudes towards computers.

- *PH*

Attitudes towards physics have positive relationship with the affective domain of attitudes towards computers. However, attitudes towards physics have negative relationships the behavioural and cognitive domains of attitudes towards computers.

o. How do parents' aspirations for their children affect students' attitudes towards and their choice of physics or physics-related courses?

- *SA*

Attitudes towards physics have a negative relationship with mother's aspirations for their education and support for their learning.

- *PH*

There is no relationship found between attitudes and self-esteem.

p. How do parents' aspirations affect their children's general self-esteem?

- *Parents' aspirations and self-esteem do not show significant ($P<0.01$) relationship for both the South Australian sample and the Filipino sample.*

A single-level path analysis was undertaken to address the following general research questions:

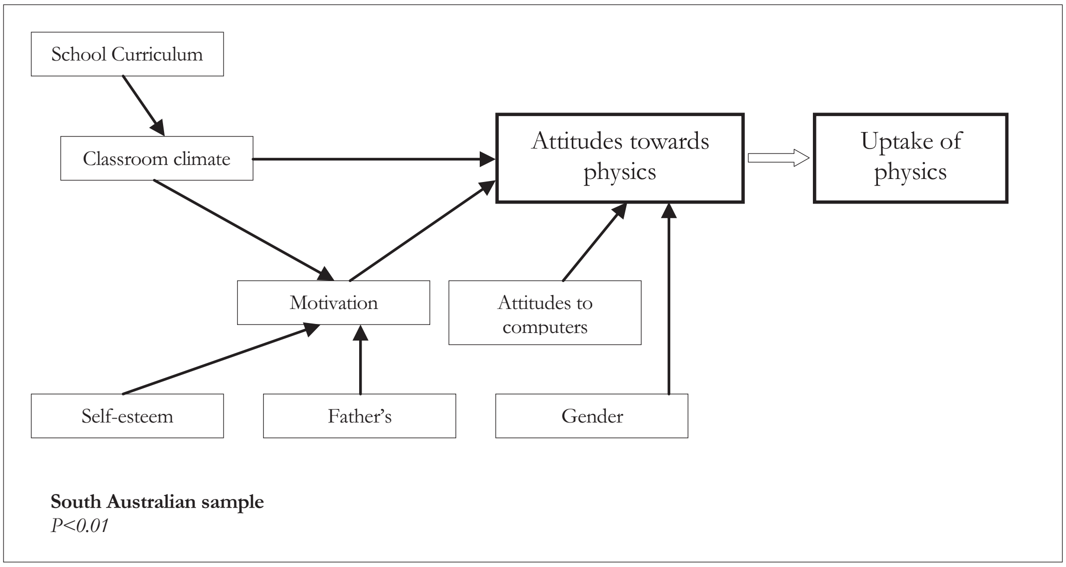
1. What are the factors that affect high school and university level students' attitudes towards physics that could influence their choice of physics as a stand-alone subject/course in their course of study?
2. How do these factors interact to influence students' attitudes towards physics?

For the South Australian sample, eight variables appeared to have direct influence (either positively [+], or negatively [-]) on students' attitudes towards physics that could influence their uptake of the subject/course. These included: school level (+), gender (+), the affective domain of attitudes towards computers (-), the 'investigation' aspect of preferred physics classroom climate (-), the 'differentiation' aspect of the actual physics classroom climate (-), and motivation to learn physics due to 'performance goals' (-), self-efficacy (-), and 'science-learning value' (-).

For the Filipino sample, on the other hand, there were also eight variables that appeared to directly influence students' attitudes towards physics. These included: school level

(+), school type – government/private (-), the affective (+) and cognitive (-) domains of attitudes towards computers, 'independence' in the actual physics classroom climate (+), 'investigation' in the preferred physics classroom climate (-), and motivation to learn physics due to 'learning environment stimulation' (-) and 'science-learning value' (-).

The structural equation modeling (SEM) analysis provided an 'aggregated' composite of the interaction between the identified variables. It was evident from the two separate analyses, the Philippines and South Australia, the following conceptual relationships operate. This was based on the conceptual framework advanced in Chapter 2 (see Figure 2.2, p. 57).



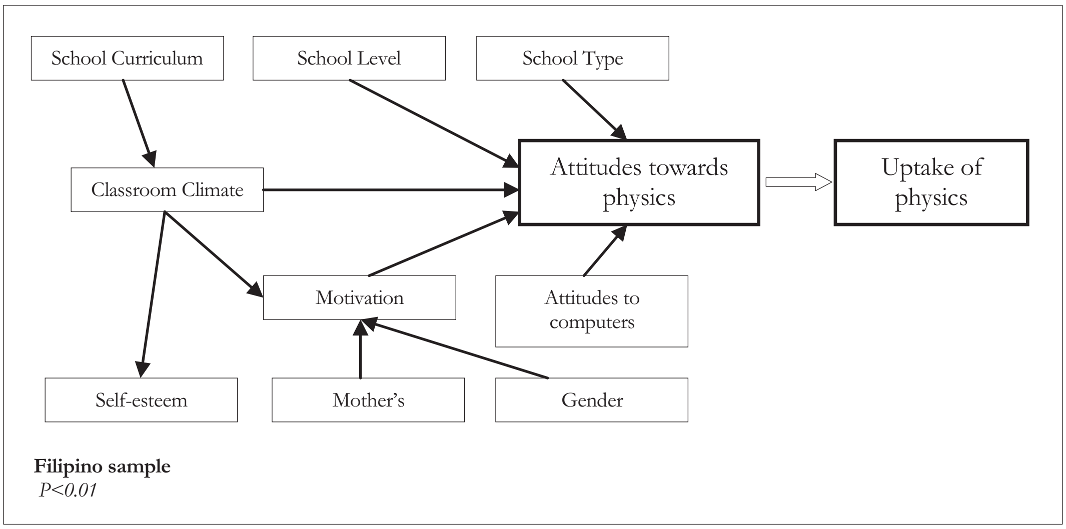


Figure 11.5. Conceptual relationships of variables for the South Australian and Filipino samples.

The results of the single-level path analyses, the summary of which is also represented in Figure 11.5, were used as a guide for carrying out multilevel analysis using the hierarchical linear modeling (HLM) technique. This technique takes into consideration the hierarchical nature of the data collected for this study. This technique also addresses the issues encountered using single-level path analysis techniques. Furthermore, HLM can be used to examine possible cross-level interaction effects between the variables at the school level and variables at the student level. Hierarchical linear modeling and the results obtained using this technique is discussed in the next chapter.

Chapter 12

What Accounts/Influences the Uptake of Physics

12.1. Introduction

The broad aim of the study was to examine how a number of variables affect students' attitudes towards physics, and thus, influencing their uptake of physics. Specifically, the study examined school curriculum, school level, school type, classroom climate (which includes teachers), gender, motivation to learn science/physics, general self-esteem, parental aspirations and support for their child's learning, and attitudes towards computers. Although studies have examined the influence of these variables, no research study had explored two educational systems (South Australia and Philippines) simultaneously. Senior high school and first year university physics students participated in this study. Data were collected using the Students' Uptake of Physics Questionnaire (SUPSQ).

In the previous chapter, single or student level path modeling was carried out to examine the effects of the different variables taken into account in this study on the students' attitudes towards physics as a subject or course of study. However, the data collected for this study has a structure that is considered multilevel or hierarchical, which is consistent with most data collected for social science and educational research. It has been shown in many research studies that analysing multilevel data with single-level procedures such as path analysis and structural equation modeling faced some issues resulting from the aggregation or disaggregation of data. Aggregation or disaggregation of data is needed before a multilevel dataset can be analysed using a single-level procedure. Issues include the loss of information due to the reduction of variance of lower level variables which often represent a considerable amount of variance (aggregation), and the violation of the assumption of the independence of observations due to the same value assigned to all the members in one group (disaggregation). Therefore, to overcome these problems, techniques such as the hierarchical linear modeling (HLM) was employed to analyse multilevel data. This procedure makes it possible to analyse variables at different levels simultaneously in order to determine which factors have an effect on the dependent (or outcome) variable – in this case, the students' attitudes towards Physics which is an influencing factor in their uptake of Physics. Moreover, the impact of individual and school/country levels was examined.

This chapter highlights the use of HLM in analysing this study's multilevel data set. The results of the analysis employing this procedure are also discussed. The chapter ends with a summary.

12.2. School and student samples

Between August 2007 and June 2008, a total of over 700 purposively-sampled Physics students participated in this study. These students came from the Adelaide metropolitan government, independent and catholic schools and a government-owned university in South Australia, and government- and privately-owned schools and universities in Quezon City in the Philippines. A total of 306 South Australian Physics students from 11 schools and one university, and 403 Filipino Physics students from 11 schools and two universities participated in the study. Tabulated details of the distribution of numbers of participating schools and students are provided in Chapters 3 and 10.

12.3. Overview of Hierarchical Linear Modeling (HLM)

According to Ma, Ma and Bradley (2008), multilevel modeling is an extension of multiple regression. It has been mentioned in a number of quantitative analysis books (e.g., Raudenbush & Bryk, 2002; Goldstein, 1999) that analysing a set of multilevel data using a single-level analysis technique has limitations in terms of estimating the interaction effects across different levels. This is therefore difficult to ignore if one is to meaningfully interpret the results. Ma et al. (2008) pointed out, that through multilevel modeling, the challenges in analysing hierarchical data are overcome since multilevel analysis accounts for correlated responses at levels where clustering occurs. Applied in the context of this study, Braun, Jenkins, & Grigg (2006, pp. 4-5) provided a simple and clear justification as to why HLM is needed to handle multilevel data:

Conventional regression techniques either treat the school as the unit of analysis (ignoring the variation among students within schools) or treat the student as the unit of analysis (ignoring the nesting within schools). Neither approach is satisfactory…In the former case, valuable information is lost, and the fitted school-level model can misinterpret the relationships among variables at the student level.

Furthermore, a consequence of ignoring the hierarchical nature of a multilevel data will generally cause standard errors of regression coefficients to be underestimated. To overcome these limitations, another technique designed to analyse a set of data that is hierarchical in nature was employed in this study. Data in hierarchy consists of *units* grouped at different *levels* (Goldstein, 1999). For example, students may be at level 1 units clustered within schools at level 2 units. It is no surprise then that the technique used to analyse multilevel data is called hierarchical linear modeling (HLM) (Raudenbush & Bryk, 2002). According to Braun, Jenkins, & Grigg (2006), hierarchical linear models are very flexible because they consist of two or more sets of linear regression equations that can incorporate explanatory variables at each level of the data structure. Moreover, the HLM approach provides both direct effects from various levels and the interaction effects between variables at different levels.

Thus, in this study, this technique was employed to: (a) improve estimation of individual effects; (b) model cross-level effects; and (c) partition variance-covariance components across levels in order to apply significance tests more appropriately (Raudenbush & Bryk, 2002).

However, like any other analytic techniques used to analyse a set of data, HLM is not without shortcomings. A perceived issue is that the HLM approach only allows for one dependent variable to be analysed at any one time. In addition, HLM is intended for observed and not latent variables, and, although HLM does allow for latent variables, it requires unrealistic assumptions about the measurement model (Scientific Software International, n.d.). However, this can be resolved by calculating using other applications such as SPSS, MS Excel and ConQuest the principal component scores (latent scores) for each construct involved in the models.

The different models tested are based on the path diagrams resulting from the single level analyses presented in Chapter 11.

Application software for HLM analysis

There are a number of software applications available that can be used to analyse multilevel data. Among these applications, HLM 6 (version 6.08) (Raudenbush, Bryk & Congdon, 2009) was employed to analyse the multilevel data in this study. Multilevel data are often associated with complex calculations inherent with fitting hierarchical linear models. With HLM 6, models can be fit to outcome variables that generate a linear model with explanatory variables that account for variations at each level, utilising variables specified at each level (Raudenbush, Bryk & Congdon, n.d.). Furthermore, Raudensbush, Bryk and Congdon (n.d.) also demonstrated that, HLM 6 not only estimates model coefficients at each level, but it also predicts the random effects associated with each sampling unit at every level.

In this study, HLM 6 was used to estimate the effects of student-level variables on an outcome variable (at the student level), and to estimate the effects of the school-level variables on the coefficients from the student-level analysis. It should be noted that in this chapter, the terms level 1, student-level, and single-level have the same meaning and that they are employed interchangeably. Similarly, the terms level 2 and school-level are used interchangeably.

Over the years HLM 6 has evolved in terms of its capabilities and functionalities. The latest version of this software works well with the latest Windows operating systems. Furthermore, since HLM 6 has to read data from an external source and format, its importing capabilities has also been enhanced by being able to read data not only from a plain text (ASCII) format but also from data saved in the latest SPSS/PASW and other statistical software.

12.4. HLM specifics

Model building

Analysing a multilevel set of data typically involves three broad steps: (a) importing into HLM 6 a set of data to create a multivariate data matrix (MDM) file, (b) executing the analysis based on this MDM file, and (c) evaluating the fitted model based on a residual file.

The MDM file is constructed from raw data saved in popular statistical package formats (e.g. from SPSS). Typically for a two-level HLM, two raw data files are required as input. However, recent improvements in HLM 6 enable it to produce an MDM file from a single raw data file containing both level-1 and level-2 variables although this is not suggested when the level-1 file is very large. The single data set is sorted by the level-2 ID variable (the school ID in this study). In this case, the single data file is used twice, once for level-1 and once for level-2.

The MDM file constructed is used as input in all subsequent analyses. The MDM file can be seen as a 'system file' in a standard computing package that contains both the summarised data and the names of all the variables.

A common sight in regression analysis equations is the *error* term. This is sometimes denoted by '*e*' or '*R*' in the regression equation. This *error* term is also called *residual*. The function of a residual is to express the part of the dependent variable '*Y*' that cannot be approximated by a linear function of that dependent variable (Snjider & Bosker, 1999). In other words, in multilevel modeling, residuals reflect the unexplained variability for each level of the model.

The fit of HLM is examined for tenability of assumptions by means of analyses of level-1 and level-2 residual files. Level-1 residual file includes: (a) the level-1 residuals which shows the discrepancies between the observed and the fitted values, (b) fitted values for each level-1 unit, (c) the observed values of all predictors included in the model, and (d) selected level-2 predictors useful in exploring possible relationships between such predictors and level-1 residuals. Level-2 residual file includes a number of important information which includes the fitted values for each level-1 coefficient which are the values predicted on the basis of the level-2 model. This residual file also includes information about the discrepancies between the level-1 coefficients and the fitted values using the ordinary least squares (OL) and the empirical Bayes (EB) estimates of the level-2 residuals.

Model Analysis

Analysis of hierarchical linear models is undertaken by initially running a model where no predictors of the outcome variable are specified at any level. This is called the fully unconditional means model, or more commonly, the *null* model. This is the simplest possible hierarchical linear model which is essentially equivalent to a one-way ANOVA with random effects (Raudenbush & Bryk, 2002). The purpose of running the null model is to obtain the estimates of the amount of variance available to be explained in the model (Raudenbush, Bryk,, Cheong & Congdon, 2004). In this model, the amount of variation in an outcome variable allocated across different levels is represented. In other words, the variability of the outcome variable at each level is provided by estimating the null model. Thus, the null model allows for the partitioning of the variance in the outcome variable in different levels (Raudenbush & Bryk, 2002). In this study, the null model was used to estimate the grand mean of 'attitudes towards physics' with adjustment for clustering of the students within schools and for the varying sample sizes across schools. It was also used to estimate the variance components at the student level and school level. The null model, containing only an outcome variable and no independent variable, (depicting a two-level model) is specified by the following equations.

Level-1model. The outcome variable is represented as a function of a predictor mean plus a random error. This is shown in the equation

$$Y_{ij} = \beta_{0j} + r_{ij} \qquad [12.1]$$

where:

Y_{ij} is the outcome variable *i* in organisation (school) *j*;

β_{0j} is the level-1 coefficient; and

r_{ij} is the level-1 random effect.

The indexes *i*, and *j* denote students and schools where there are

i=1, 2, ..., N_j students within schools; and

j=1, 2, ..., *J* schools.

Level-2 model. In this model the level-1 coefficient, β_{0j}, defined in the level-1 model becomes an outcome variable as depicted in the following equation.

$$\beta_{0j} = \gamma_{0o} + u_{0j} \qquad [12.2]$$

where:

γ_{0o} is a level-2 coefficient; and

u_{0j} is a level-2 random effect.

With level-1 and level-2 predictors included, the equations take the form of multiple linear regression equation where *Y* is the outcome (or dependent) variable and the *X*s are the predictors (or independent) variables.

Level-1 model. $$Y_{ij} = \beta_{0j} + \beta_{1j}X_{1ij} + \beta_{2ij}X_{2ij} + \ldots + \beta_{Qj}X_{Qij} + r_{ij}$$

$$= \beta_{0j} + \sum_{q=1}^{Q} \beta_{qj}X_{qij} + r_{ij} \qquad [12.3]$$

where:

β_{qj} (q = 0, 1,..., Q) are level-1 coefficients;

X_{1ij} , X_{2ij} , X_{Qij} are level-1 predictors for case *i* in unit *j*; and

r_{ij} is the level-1 random effect

Level-2 model. $$\beta_{oj} = \gamma_{o0} + \gamma_{o1}W_{1j} + \gamma_{o2}W_{2j} + \ldots + \gamma_{oS_o}W_{S_oj} + u_{0j}$$

$$= \gamma_{o0} + \sum_{s=1}^{S_o} \gamma_{os}W_{sj} + u_{0j} \qquad [12.4]$$

where:

γ_{os} (o = 0, 1,..., S_o) are level-2 coefficients;

W_{sj} are level-2 predictors; and

u_{0j} is a level-2 random effect.

The following sections illustrate these level-1 and level-2 equations applied to the hierarchical linear models tested in this study.

Variables in the model

In this study, the principal component scores were calculated for each construct variable using ConQuest (for the WLE scores) and MS Excel (for the *W*-scores). The conversion of WLE scores to *W*-scores is discussed in Chapter 10. Therefore, most variables were in standardised forms. This allowed for the direct comparison of coefficients of the different variables within the model except for the categorical variables (gender, school level, school type, and school curriculum). The variable gender (GNDR) was a categorical variable within which was originally coded as females=0 and males=1. The school level (SchLEVEL) variable was coded '0' for 'university-level' and '1' for 'high school level'. A similar coding of 1s and 0s were used for the variables school type (SchTYPE1 [Government/Private] or SchTYPE2 [Coeducational/Single-sex]) and school curriculum (SchCURR).

However, in carrying out the HLM analysis, the importance of creating *dummy variables* for the categorical variables was realised. But, firstly, what is a *dummy variable*? It is a dichotomous variable created by the researcher from an originally qualitative variable (Hardy, 1993). Dummy variables use binary coding (0 and 1) with '1' meaning respondents are members of a particular category and '0' meaning respondents do not belong to that particular category. For example, a dummy variable can be created for the nominal variable 'Gender'. This dummy variable can either be 'Boy' or 'Girl'. A male respondent ("Boy") receives a code '1' and a female respondent (NOT "Boy") receives a code '0'. If 'Girl' is used as a dummy variable for 'Gender', the female respondents receive a code '1' and male respondents (NOT "Girl") receive a code '0'. This coding could be compared to a computer 'switch' where '1' means 'on' and '0' means 'off'. Hardy (1993, p. 2) pointed out that

> When independent variables of interest are qualitative (i.e., "measured" at only the nominal level), we require a technique that allows us to represent this information in quantitative terms without imposing unrealistic measurement assumptions on the categorical variables…Defining a set of dummy variables allows us to capture the information contained in a categorization scheme and then to use this information in a standard estimation. In fact, the set of independent variables specified in a regression equation can include any combination of qualitative and quantitative predictors.

Using dummy variables in the analysis could be of benefit to the interpretation of the results. In addition, the dataset used in this study is a cross-sectional data. Cross-sectional data are often associated with heteroscedasticity (residuals at each level of the predictors have very unequal variances). Dummy variables can be used in cross-sectional research data to estimate differences between groups and to evaluate whether group membership moderates the effects of other independent variables (Hardy, 1993). Thus, in multilevel analysis, using dummy variables would allow a separate level 1 variance for the nominal/categorical variable from which they were created (Goldstein, 1999).

It is clear that combining and analysing information from different levels is central to multilevel modeling. This is where the idea of *centering* becomes an important issue as it has implications on the interpretation of the analysis results. Considering its advantages, Cronbach (in Hox, 1995) has suggested that individual scores be expressed as deviations from their respective group means (a procedure later became known as *group centering*). Hox (1995, p. 4) pointed out the benefits of group centering procedure to multilevel analysis:

> Centering around the group means makes very explicit that the individual scores should be interpreted relative to their group's mean. Another advantage of centering around the group means is that the group-centered individual deviation scores have a zero correlation with the disaggregated group means, which has statistical advantages.

Therefore, considering the benefits of using dummy variables and group-centering the scores for each variable around its means, this study employed these procedures. In the HLM analysis carried out in this study, dummy variables were created from the nominal variables gender (from GNDR to BOY or GIRL), school level (from SchLEVEL to SCHLVLHS), school type (from SchTYPE1 [government or private] to SCTYPGOV; from SchTYPE2 [single sex or coeducational] to STYPSSEX), and school curriculum (from SchCURR to CURSACE or CURDEPED).

All the level-1 (individual- or student-level) variables and level-2 (school-level) variables that were examined are listed in Table 12.1. For the HLM analyses results reported in this chapter, the variable names were given in uppercase. A suffix '_2' was added to variables measured at level-1 and aggregated to the school level to represent the organisational climate that may affect the outcome variable.

Table 12.1. List of variables used in the Two-Level HLM Models.

Individual Level	School Level	Description
School-Level Factors		
	SCHLVLHS*	School level: High School/University
	SCTYPGOV*	School type1: Government/Private
	STYPSSEX* (S. Australia only)	School type2: Single Sex/Co-ed
	CURSACE* (S. Australia only)	School Curriculum
	CURDEPED* (Philippines only)	School Curriculum
	CCADFFER	Actual Classroom Climate (Differentiation)
	CCAINDEP	Actual Classroom Climate (Independence)
	CCAINVES	Actual Classroom Climate (Investigation)
	CCAPARTI	Actual Classroom Climate (Participation)
	CCAPERSN	Actual Classroom Climate (Personalisation)
	CCPDFER	Preferred Classroom Climate (Differentiation)
	CCPINDP	Preferred Classroom Climate (Independence)
	CCPINVS	Preferred Classroom Climate (Investigation)
	CCPPRTI	Preferred Classroom Climate (Participation)
	CCPPRSN	Preferred Classroom Climate (Personalisation)
Individual-Level Factors		
BOY*	BOY_2*	Male student
GIRL*	GIRL_2*	Female student
ATTITUDE	ATTITUDE_2	Students' attitudes towards Physics
SELFESTM	SELFESTM_2	General self-esteem
PARENTSMUM	PARENTSMUM_2	Mother's aspirations and support
PARENTSDAD	PARENTSDAD_2	Father's aspirations and support
COMPAFFC	COMPAFFC_2	Attitudes to computers (affective)
COMPBEHV	COMPBEHV_2	Attitudes to computers (behavioural)
COMPCOGN	COMPCOGN_2	Attitudes to computers (cognitive)
MOTIACHVG	MOTIACHVG_2	Motivation to learn Physics (achievement goal)
MOTIALS	MOTIALS_2	Motivation to learn Physics (active learning strategies)
MOTILERNV	MOTILERNV_2	Motivation to learn Physics (learning environment)
MOTIPERFG	MOTIPERFG_2	Motivation to learn Physics (performance goal)
MOTISLEFF	MOTISLEFF_2	Motivation to learn Physics (self-efficacy)
MOTISLVAL	MOTISLVAL_2	Motivation to learn Physics (science learning value)

*Dummy variables

The outcome variable examined in this study is the students' attitudes towards Physics. A conceptual model of the two-level hierarchical linear model of factors influencing students' attitudes towards Physics is shown in Figure 12.1.

Level-1 predictor variables were group-centred and Level-2 predictor variables were grand-centred (i.e., the variable scores were centred at the mean over all individual students in the population).

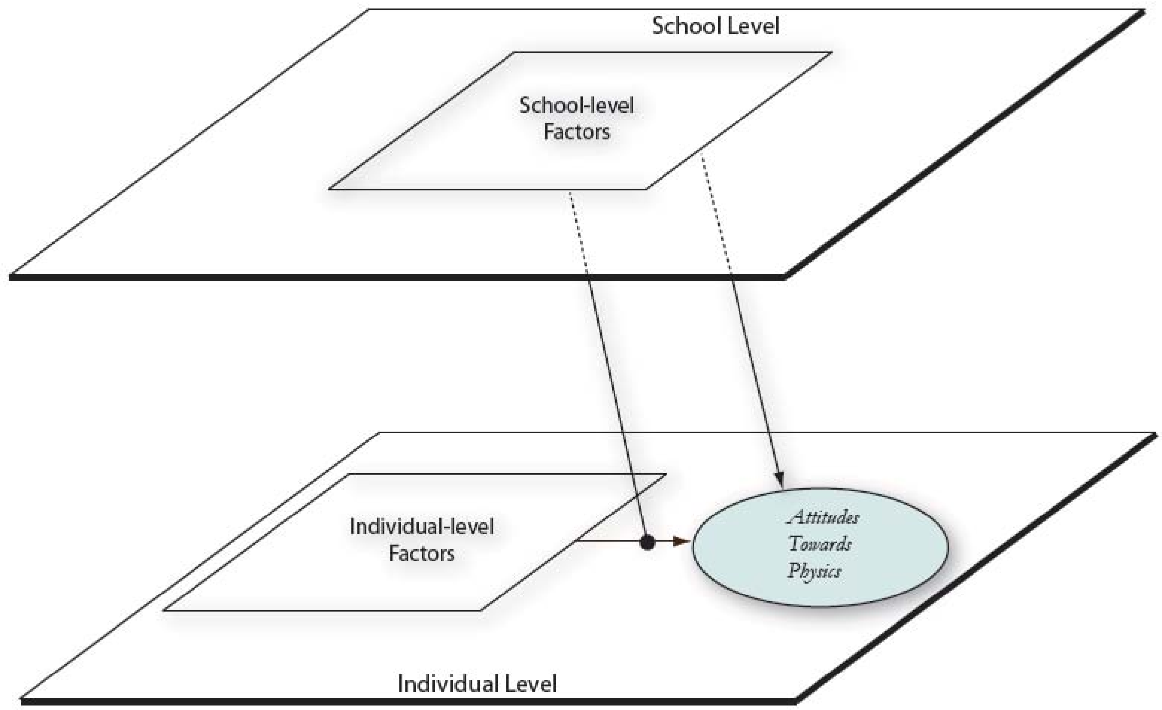


Figure 12.1 Two-Level Model of Students' Attitudes Towards Physics

12.5. Two-level model results

As discussed above, nested data analysed using single-level approaches proves to be problematic. Therefore, to avoid problems, a multilevel approach (using HLM) was employed to examine the variability simultaneously at different levels as well as variability in the cross-level interactions.

In addition, this study used data sets coming from two different groups of samples. It has been shown in the validation chapters (Chapters 4 to 9) that the scales used in this study exhibited significant measurement variance between the two groups of samples.

Therefore, similar to how the student-level path analyses were carried out, HLM analyses were conducted separately for the South Australian sample and Filipino sample. Because of this, the presentation of the analysis results was also prepared separately. The results of the HLM analyses using the South Australian sample are presented first followed by the results for the Filipino sample.

The initial step undertaken in the analysis of the two-level model HLM was running the fully unconditional model (the *null model*). The purpose of this model was mentioned earlier. The fully unconditional model in the analysis of the South Australian and Filipino data sets is specified by the following equations.

Level-1 Model. With reference to equation 12.1, the erceived student attitudes towards physics for each student is modelled as a function of the school mean plus a random error:

$$Y_{ij} = \beta_{0j} + r_{ij}$$

where:

Y_{ij} is the perceived student attitudes towards physics i in school j;

β_{0j} is the mean perceived student attitudes towards physics in school j; and

r_{ij} is the level-1 random effect or so-called 'student effect' (i.e. the deviation of student ij's score from the school mean).

In the above equation, the indexes i, and j denote students and schools where

$i = 1, 2, ..., N_j$ students within schools; and

$j = 1, 2, ..., J$ schools.

Level-2 model. With reference to equation 12.2, each school mean, β_{0j}, is viewed as varying randomly around a grand mean across all schools:

$$\beta_{0j} = \gamma_{0o} + u_{0j}$$

where:

γ_{0o} is the grand mean student attitudes towards physics in school j; and

u_{0j} is the random school effect (i.e., the deviation of school j's mean from the grand mean).

This is under the assumption that the random effect associated with school j, u_{0j}, has a normal distribution with a mean of zero and variance τ_π.

Estimating the null model creates a point estimate and confidence interval for the grand mean, γ_{0o}. This procedure also yields information about the variability of the outcome at each level. Variability at each level is represented by the following parameters: σ^2 for level-1, and τ_π for level-2 (Raudenbush & Bryk, 2002). The null models also allows for the estimation of the proportions of variations that are within schools, and among schools, as represented by the following mathematical expressions, respectively:

$\sigma^2/(\sigma^2 + \tau_\pi)$ the proportion of variance within schools [12.5]

$\tau_\pi/(\sigma^2 + \tau_\pi)$ the proportion of variance among schools [12.6]

The average reliability for the least squares estimates for each level-1 coefficient across a set of level-2 units (Raudenbush et al., 2004), is an indicator that could be used to assume (or not assume) the presence of random effect for a particular coefficient. The reliability represents the degree to which the school-level units can be discriminated between using the ordinary least squares estimates of β_{0j} (Raudenbush & Bryk, 2002). Furthermore, reliability measures the ratio of the true score (parameter variance) relative to the observed score (total variance of the sample mean) (Raudenbush & Bryk, 2002). The reliability estimate for the student sample mean for each school can be calculated using the following equation:

Reliability $(\beta_{0j}) = \tau_\pi/[\tau_\pi + \sigma^2 / n_{jk}]$ [12.7]

Based on Equation 12.7, the average of the reliabilities across schools may be viewed as measures of reliability of the school means (Raudenbush et al., 2004). A 'no random effect' is assumed for a particular coefficient when reliability falls below 0.05.

The following sections discuss the results for the null model using the South Australian and Filipino data sets.

The South Australian sample

The HLM results for the null model using the data collected from the South Australian sample are presented in Table 12.2. Similar to the Trends in International Mathematics and Science Study (TIMSS) (Thomson & Buckley, 2007), the present study used scales with 500 points as the mean (see Chapter 10 for discussion on this). The South Australian sample demonstrated mean attitudes towards physics of around 494. Since the scales used 500 points as the mean and 100 points as the standard deviation, South Australian students' attitudes towards physics are marginally below the average. In this study, the word 'average' connotes 'neutral' attitudes towards physics. Therefore, considering the null model model results, the South Australian samples have slightly negative attitudes in relation to the average. The between-school variance shows statistical significance (u_{0j} = 2.27, Chi-sq = 25.08, *P<0.01*) indicating that average attitudes towards physics varied across the South Australian sample schools. Intraclass correlation was calculated to determine the extent to which the total variance in students' attitudes towards physics is attributable to schools. That is, 2.27/(2.27+44.88) = 0.0481, or 4.81% of the total variance in students' attitudes towards physics is attributable to schools, while 95.19% (i.e., 100% - 4.81%) is attributable to students. This is an indication that a relatively small amount (only 4.81%) of variation lies between schools.

Table 12.2. Null Model results for the Two-Level Model for Students' Attitudes Towards Physics (South Australian sample).

Final estimation of fixed effects:						
Fixed Effect		Coefficient	Standard Error	T-ratio	Approx. DF	P-value
For INTRCPT1, B0						
INTRCPT2, G00		493.96	0.61	815.28	11	0.000
Final estimation of variance components:						
Random Effect	Reliability	Standard Deviation	Variance Component	DF	Chi-square	P-value
INTRCPT1, U0	0.52	1.51	2.27	11	25.08	0.009
level-1, R		6.70	44.88			

The reliability indicates the extent to which the average attitudes towards physics can be discriminated among schools. According to Ma et al. (2008, p.78), in a null model, "the reliability is a good indicator of how well each school's sample mean estimates the unknown parameter, β_{0j}." This means that a low reliability would suggest difficulty in discriminating among schools on the basis of their attitudes towards physics. Considering that the reliability coefficient ranges from 0 to 1, 0.52 indicates an average reliability.

The two-level HLM for the South Australian sample that was examined was based on the results of the student-level path analysis carried out using LISREL. However, there was a risk of model misspecification due to the limitations inherent in single-level analysis approach. Nevertheless, this was considered to be an appropriate step due to the complexity of the model.

Building up the final model consists of entering into the equation the variables that were found to influence student attitudes towards physics directly at the student-level LISREL path analyses. These variables were entered into the equation one at a time beginning with the one with the strongest path. This process has been suggested by Raudenbush and Bryk (2002) so that the variance explained by each individual predictor can be examined. Predictors that were found to be non-significant (based on the *t*-ratios) were removed from the model with the next potential predictor filling in the spot of the one removed. The equation was then re-analysed. Predictors with *t*-ratios greater than two were included in the model. This process was repeated until only the significant effects were left in the equation. This was done without the school-level predictors.

A similar process was carried out for the school-level predictors. School-level predictors were added to the equation one at a time and examined for significance. Non-significant predictors were removed from the model. This process was repeated until only all significant predictors were left in the equation.

In the HLM analysis, school level (SchLEVEL – high school- and university-level) and school curriculum (SchCURR – high school- and university-curriculum) were considered the same. The rationale for this was, high school-level students use only the high school curriculum, and university-level students use only the university curriculum. This renders the two variables practically the same. Thus, only one of them was used in the two-level model.

One final model is presented. This is specified by the following equations:

Two-Level Model (using the school-level variable school level – SCHLVLHS)

Level-1 Model

$$Y_{ij} = \beta_{0j} + \beta_{1j}(MOTIPERFG) + \beta_{2j}(MOTISLEFF) + \beta_{3j}(MOTISLVAL) + r_{ij} \qquad [12.8]$$

Level-2 Model

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(SCHLVLHS) + u_{0j} \qquad [12.9a]$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(CCPINVS) + u_{1j} \qquad [12.9b]$$

$$\beta_{2j} = \gamma_{20} + u_{2j} \qquad [12.9c]$$

$$\beta_{3j} = \gamma_{30} + u_{3j} \qquad [12.9d]$$

The final model is represented by the equation resulting from substituting Equations 12.9a to 12.9d into Equation 12.8:

$$\begin{aligned} Y_{ij} &= \gamma_{00} + \gamma_{01}(SCHLVLHS) + \gamma_{10}(MOTIPERFG) \\ &+ \gamma_{11}(CCPINVS)(MOTIPERFG) + \gamma_{20}(MOTISLEFF) + \gamma_{30}(MOTISLVAL) \\ &+ u_{0j} + u_{1j}(MOTIPERFG) + u_{2j}(MOTISLEFF) \\ &+ u_{3j}(MOTISLVAL) + r_{ij} \end{aligned}$$

[12.10]

The final Two-Level Model represents four main effects, one cross-level interaction effect and a random error. Four variables were found to be statistically significant ($P<0.05$) to influence students' attitudes towards physics (see Table 12.3). The term 'main effect' denotes the direct effect of a single or multiple independent variables at different levels on the dependent variable (Y). These variables representing the main effects are: school level (SCHLVLHS, γ_{01}) at level-2, and three level-1 variables namely: motivation to learn science/physics in terms of performance goal (MOTIPERFG, γ_{10}), motivation to learn science/physics in terms of self-efficacy (MOTISLEFF, γ_{20}), and motivation to learn science/physics in terms of science learning value (MOTISLVAL, γ_{30}). The cross-level interaction involves the investigation aspect of students' preferred physics classroom climate (CCPINVS) and MOTIPERFG (γ_{11}). The random error is represented in the equation by the terms "$u_{0j} + u_{1j}(MOTIPERFG) + u_{2j}(MOTISLEFF) + u_{3j}(MOTISLVAL) + r_{ij}$". Figure 12.2 shows these relationships.

Cross-level interaction effect generally involves three variables. These include the outcome variable, a level-1 (student-level) predictor, and a level-2 (school-level) predictor that is considered to have an influence on the effect of the level-1 predictor on the outcome variable. In the HLM results shown above, it can be observed that the variables MOTIPERFG and CCPINVS demonstrate this interaction effect. In order to show this in detail, a part of the final model equation is taken by setting the remaining terms to zero. The equation is as follows:

$$Y_{ij} = \gamma_{00} + \gamma_{10}(MOTIPERFG) + \gamma_{11}(CCPINVS)(MOTIPERFG) + r_{ij} \qquad [12.11a]$$

where γ_{00} = 494.11, γ_{10} = -0.13, γ_{11} = -0.01.

Thus, the cross-level interaction equation becomes

$$Y_{ij} = 494.11 - 0.13(MOTIPERFG) - 0.01(CCPINVS)(MOTIPERFG) + r_{ij} \qquad [12.11b]$$

Table 12.3. Two-Level Model 1 results: Student Attitudes Towards Physics (South Australian sample).

Final estimation of fixed effects:					
Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. DF	P-value
For INTRCPT1, B0					
INTRCPT2, G00	494.11	0.39	1259.09	10	0.000
***SCHLVLHS*, G01**	4.56	1.10	4.14	10	0.002
For MOTIPERFG Slope, B1	-0.13	0.03	-3.91	10	0.003
INTRCPT2, G10	-0.01	0.002	-2.32	10	0.042
CCPINVS, G11					
For MOTISLEFF Slope, B2	-0.12	0.05	-2.39	11	0.036
INTRCPT2, G20					
For MOTISLVAL Slope, B3	-0.18	0.04	-4.35	11	0.001
INTRCPT2, G30					

Final estimation of variance components:						
Random Effect	Reliability	Standard Deviation	Variance Component	DF	Chi-square	P-value
INTRCPT1, U0	0.341	0.76	0.580	9	15.21	0.085
MOTIPERFG Slope, U1	0.340	0.07	0.004	9	11.45	0.246
MOTISLEFF Slope, U2	0.618	0.14	0.018	10	32.48	0.001
MOTISLVAL Slope, U3	0.459	0.10	0.010	10	18.52	0.046
level-1, R		5.33	28.45			

This equation can be used to calculate school-level coordinates to obtain a graphical representation of the cross-level interaction effect. The coordinates calculated for schools were:

(a) One standard deviation above the average on MOTIPERFG and CCPINVS (i),

(b) One standard deviation above the average on MOTIPERFG and 100 standard deviations below the average on CCPINVS (ii),

(c) One standard deviation below the average on MOTIPERFG and 100 standard deviations above the average on CCPINVS (iii),

(d) One standard deviation below the average on MOTIPERFG and 100 standard deviations below the average on CCPINVS (iv),

(e) Average on MOTIPERFG and one standard deviation above the average on CCPINVS (v),

(f) Average on MOTIPERFG and one standard deviation below the average on CCPINVS (vi).

Using the above as a guide, the coordinates calculated were:

(i) High investigation (preferred Physics classroom) and high motivation (performance goal) (MOTIPERFG=100; CCPINVS=100)

$$Y(ATTITUDE) = 494.11 - 0.13(100) - 0.01(100)(100) = 381.11$$

(ii) High investigation and low motivation (MOTIPERFG=-100; CCPINVS=100)

$$Y(ATTITUDE) = 494.11 - 0.13(-100) - 0.01(-100)(100) = 607.11$$

(iii) Low investigation and high motivation (MOTIPERFG=100; CCPINVS=-100)

$$Y(ATTITUDE) = 494.11 - 0.13(100) - 0.01(100)(-100) = 581.11$$

(iv) Low investigation and low motivation (MOTIPERFG=-100; CCPINVS=-100)

$$Y(ATTITUDE) = 494.11 - 0.13(-100) - 0.01(-100)(-100) = 407.11$$

(v) Average investigation and high motivation (MOTIPERFG=100; CCPINVS=0)

$$Y(ATTITUDE) = 494.11 - 0.13(100) - 0.01(100)(0) = 481.11$$

(vi) Average investigation and low motivation (MOTIPERFG=-100; CCPINVS=0)

$$Y(ATTITUDE) = 494.11 - 0.13(-100) - 0.01(-100)(0) = 507.11$$

Figure 12.3 shows the result of graphing these coordinates. The same procedure was employed to generate the cross-level interaction graph for the Filipino sample.

Considering the differences between schools, it appears that the impact of school level or school curriculum (SCHLVLHS/CURSACE, 4.56) towards students' attitudes towards physics is significant (*P<0.01*) at the between schools level. Based on the coding used for 'university level' equal to '0' and 'high school level' equal to '1', this finding may suggest that students at the high school level/high school curriculum have more positive attitudes towards physics.

At the student-level, three variables appear to have a significant influence (all at *P<0.05*) on attitudes towards physics. All are within the dimensions of motivation to learn science/physics. These are: performance goal (MOTIPERFG, -0.13), self-efficacy (MOTISLEFF, -0.12) and science learning value (MOTISLVAL, -0.18).

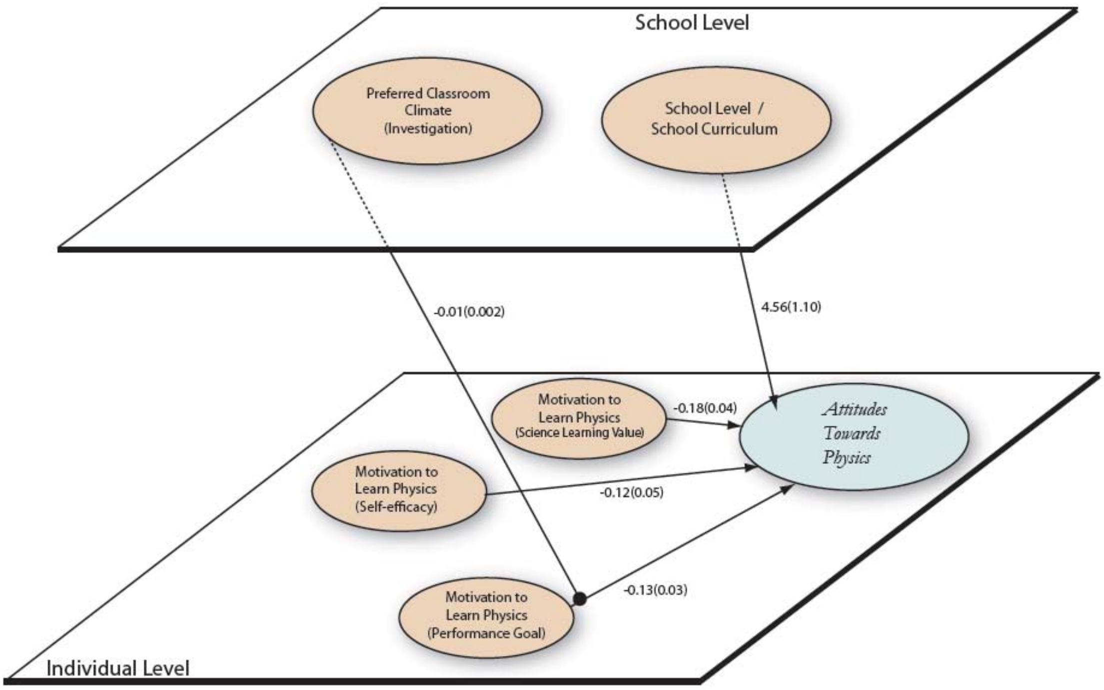


Figure 12.2. Two-Level Model of Students' Attitudes Towards Physics for the South Australian sample.

With reference to Figure 12.2 and Table 12.3, the resulting negative sign for the self-efficacy aspect of motivation to learn science/physics suggests a negative impact towards attitudes towards physics. In other words, the result suggests that a student who gains some motivation to learn physics because of his/her self-efficacy do not necessarily have positive attitudes towards physics. It might be that other factors are in play in this situation, their career preference, for instance. For example, a student might be motivated to learn physics because he/she needs to do physics as a pre-requisite subject towards obtaining a degree in engineering. This present study provides some evidence to support this through student responses to the open-ended questions of the study questionnaire. These questions are the following: Item 18 (*What are your perceptions of physics in terms of job availability and job status in the society?*) and Item 19 (*Do you think you will pursue a career in physics or anything related to physics?*). More than half of the respondents who have indicated positive perceptions of physics said that they study physics as a pre-requisite to other related course. A few examples of these responses are as follows:

> Student 7
>
> *18. Very available due to the amount of engineering courses and demand for engineers.*
>
> *19. Yes. I'm interested in how physics affects lives.*

> Student 8
>
> *18. Physics is an important feature of engineering. Therefore, many jobs are available that require physics.*
>
> *19. Yes. I enjoy building/designing structures and want to become an engineer.*

> Student 54
>
> *18. Physics is a prerequisite for many engineering university courses. There are many engineering jobs awaiting.*
>
> *19. Yes. I like it.*

> Student 91
>
> *18. Important to achieve a very successful and high-paid occupation such as engineering and aviation.*
>
> *19. Yes. Because it is required and good basic knowledge to have also.*

The student might be interested in engineering or related courses; however, he/she does not necessarily hold positive attitudes towards physics per se. The negative sign for the regression coefficient of the performance goal aspect of motivation may suggest that students do physics not because they would like people to think they are smart, nor they just would like to be competitive with other students and get the attention of their teacher. For example, students might enrol in physics subjects purely for the purpose of getting them be qualified to enrol in some courses, such as aviation and engineering. As for the negative coefficient between the science learning value aspect of motivation and attitudes towards physics, this may suggest that students who perceive science or physics as being importance do not necessarily have positive attitudes towards Physics.

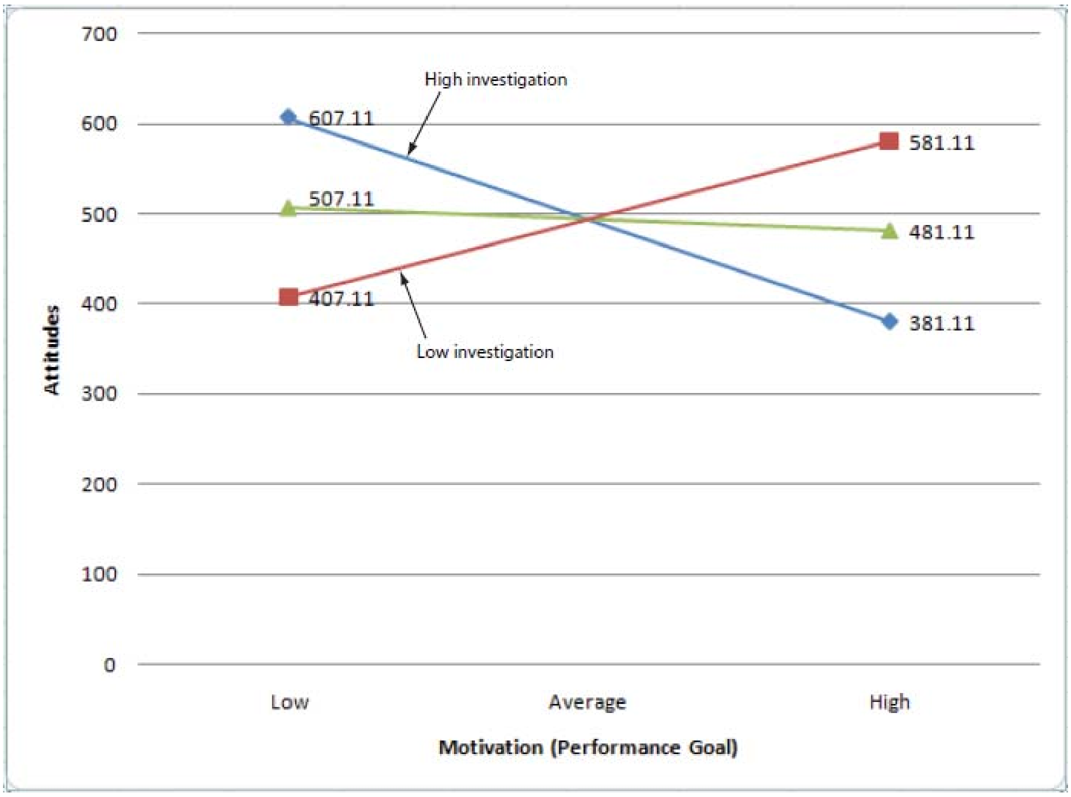


Figure 12.3. Cross-level interaction effect of Average Investigation (Preferred Physics Classroom Climate) on the Slope of Motivation (Performance goal) on Attitudes.

These results obtained by employing multilevel modeling techniques is consistent with the results obtained with structural equation modeling (SEM) in Chapter 11 where the data was aggregated to the student level. Thus, in this study, within the South Australian sample, motivation to learn science/physics, through self-efficacy, performance goals and science learning value, has a negative influence on students' attitudes towards physics.

As shown in Table 12.3 of HLM analysis using the South Australian data, there is a cross-level interaction effect involving the investigation dimension of the preferred physics classroom (*CCPInvs*, -0.01) and the performance goal aspect of motivation to learn science/physics (*MotiPERFG*, -0.13). This is illustrated in Figure 12.3. It can be observed in this figure that there are three lines with different slopes. Each line represents the investigation aspect of students' preferred classroom. The negative slope of the line for 'high investigation' in the students' preferred classroom suggests that students would not prefer relatively high amount of investigation activities. Too much investigation activities in the physics classroom could cause a drop in students' motivation to learn physics and their attitudes towards physics. In contrast, the line with positive slope representing 'low investigation' in the preferred physics classroom suggests that motivation to learn physics and attitudes towards physics increase when there is relatively few investigation activities in the physics classroom. This may be interpreted as: students prefer to have a few quality investigation activities that they fully understand what the desired outputs are, compared to having to undertake a large number of investigation activities that they barely understand which could well be the source of their frustration towards physics. The middle line represents the 'average investigation in the preferred physics classroom'. Its almost horizontal slope suggests that an average amount of investigation activities could maintain students' motivation to learn physics.

These two variables, *CCPInvs* and *MotiPERFG*, are also included in the final path model for the South Australian sample (see Chapter 11). However, the interaction between these two variables and how they influence students' attitudes towards physics was not evident since the data was analysed on a single level which resulted in a loss of information such as this interaction effect.

Table 12.4. Estimation of Variance Components: Attitudes Towards Physics (South Australian sample).

Model	Estimation of Variance components Between students (n=306)	Between Schools (n=12)
Null Model	44.88	2.27
Final Model	28.45	0.58
Variance at each level		
Between students	44.88/(44.88 + 2.27) = 0.9519 = 95.19%	
Between schools	2.27/(44.88 + 2.27) = 0.0481 = 4.81%	
Proportion of variance explained by final model		
Between students	(44.88 – 28.45)/44.88 = 0.3661 = 36.61%	
Between schools	(2.27 – 0.58)/2.27 = 0.7445 = 74.45%	
Proportion of total available variance explained by final model		
(0.3661 x 0.9519) + (0.7445 x 0.0481) **= 0.3843 = 38.43%**		

Based on the results of the calculations for variance at each level in the null model (see second panel of Table 12.4), it can be observed that most of the variance (95.19%) was attributable with the responding students. Only a small amount of variance (4.81%) is attributable to schools. Both of these values were shown and discussed earlier. In comparison to the null model, the final model, which constitutes the inclusion of the predictors of attitudes towards Physics at all levels, explained 36.61% of the variance at the student level (level 1) and 74.45% at the school level (level 2).

Considering the amount of variance explained by the final model at each level in relation to the amount of available variance to be explained at that level, the total variance explained by the final model amounted to 38.43%.

Similar studies, such as the Programme for International Student Assessment (PISA), employed the same multilevel analysis techniques using HLM. The 2006 PISA analysis results focusing on students 'science choice and performance obtained figures that are different to what were obtained in this study (variance explained at school level was around 50%, and variance explained at student level was around 5%). Factors such as sample size, number of levels in the model and number of factors included in the model have to be taken account for the differences. All the PISA analysis results using multilevel modeling techniques can be accessed at www.pisa.oecd.org.

The Filipino sample

The HLM results for the null model using the data collected from the Filipino sample are presented in Table 12.5. The Filipino sample demonstrated mean attitudes towards physics of around 495 – almost the same as the South Australian sample. Since the scales used 500 points as the mean and 100 points as the standard deviation, Filipino students' attitudes towards physics are marginally below the average which means that the attitudes are a little to the negative side. The between-school variance shows statistical significance (u_{0j} = 7.91, Chi-sq = 65.06, $P<0.01$) indicating that average attitudes towards physics varied across the Filipino sample schools. Intraclass correlation was calculated to determine the extent to which the total variance in students' attitudes towards physics is attributable to schools. That is, 7.91/(7.91+57.02) = 0.1218, or 12.18% of the total variance in students' attitudes towards physics is attributable to schools, while 87.82% (i.e., 100% - 12.18%) is attributable to students.

This is an indication that a relatively large portion (12.18%) of variation lies between schools although the majority of the variation in attitudes lies between students. This is a good indication of the existence of school effects (Ma et al., 2008) on attitudes towards physics.

As mentioned earlier, reliability indicates the extent to which the average attitudes towards physics can be discriminated among schools. Considering that the reliability coefficient ranges from 0 to 1, 0.79 indicates a high reliability.

Similar to the null model for the South Australian sample, at each level, part of the variability can be explained by measured variables which suggest that individual and organisational characteristics can be used as predictors. This yields to the examination of the conditional model leading to the creation of the final model.

Building up the final model consists of entering into the equation the variables that were found to influence student attitudes towards Physics directly at the student-level LISREL path analyses. The process employed to specify the final model for the Filipino sample was exactly the same process employed to specify the model for the South Australian sample.

Table 12.5. Null Model results for the Two-Level Model for Student Attitudes Towards Physics (Filipino sample).

Final estimation of fixed effects:						
Fixed Effect		Coefficient	Standard Error	T-ratio	Approx. DF	P-value
For INTRCPT1, B0						
INTRCPT2, G00		494.64	0.88	562.13	12	0.000
Final estimation of variance components:						
Random Effect	Reliability	Standard Deviation	Variance Component	DF	Chi-square	P-value
INTRCPT1, U0	0.79	2.81	7.91	12	65.06	0.000
level-1, R		7.55	57.02			

In the HLM analysis, school level (SchLEVEL – high school- and university-level) and school curriculum (SchCURR – high school- and university-curriculum) were considered the same. The rationale for this was, high school-level students use only the high school curriculum, and university-level students use only the university curriculum.

This renders the two variables practically the same. Thus, only one of them was used in the two-level model. Therefore only one table of results (Table 12.6) is presented. The dummy variable 'BOY' was used for the variable GNDR.

Similar to the South Australian sample, one final model is presented for the Filipino sample; the one including school level (SCHLVLHS). The final model is specified by the following equations:

Two-Level Model (using the school-level variable school level – SCHLVLHS)

Level-1 Model

$$Y_{ij} = \beta_{0j} + \beta_{1j}(COMPAFFC) + \beta_{2j}(COMPCOGN) + \beta_{3j}(MOTILERNV) + \beta_{4j}(MOTISLVAL) + r_{ij} \qquad [12.11]$$

Level-2 Model

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(SCHLVLHS) + \gamma_{02}(SCTYPGOV) + u_{0j} \qquad [12.12a]$$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + u_{2j}$$

$$\beta_{3j} = \gamma_{30} + u_{3j}$$

$$\beta_{4j} = \gamma_{40} + \gamma_{41}(CCAINVES) + u_{4j} \qquad [12.12e]$$

The final model is represented by the equation resulting from substituting Equations 12.12a to 12.12e into Equation 12.11:

$$Y_{ij} = \gamma_{00} + \gamma_{01}(SCHLVLHS) + \gamma_{02}(SCTYPGOV) + \gamma_{10}(COMPAFFC) + \gamma_{20}(COMPCOGN) + \gamma_{30}(MOTILERNV) + \gamma_{40}(MOTISLVAL) + \gamma_{41}(CCAINVES)(MOTISLVAL) + u_{0j} + u_{1j}(COMPAFFC) + u_{2j}(COMPCOGN) + u_{3j}(MOTILERNV) + u_{4j}(MOTISLVAL) + r_{ij}$$

[12.13]

It can be observed that the final Two-Level Model for the Filipino sample represents six main effects, one cross-level interaction effect and a random error. The six main effects (or variables having direct influence on the dependent variable '*ATTITUDE*') are the following: school level (SCHLVLHS, γ_{02}) and school type (SCTYPGOV, γ_{01}) at level-2, and four level-1 variables namely: the affective aspect of attitudes towards computers (COMPAFFC, γ_{10}), the cognitive aspect of attitudes towards computers (COMPCOGN, γ_{20}), motivation to learn science/physics in terms of learning environment (MOTILERNV, γ_{30}), and motivation to learn science/physics in terms of science learning value (MOTISLVAL, γ_{40}). The cross-level interaction involves the investigation aspect of the actual physics classroom climate as perceived by the students (CCAINVES) and MOTISLVAL (γ_{41}). The random error is represented in the equation by the terms "u_{0j} + u_{1j}(*COMPAFFC*) + u_{2j}(*COMPCOGN*) + u_{3j}(*MOTILERNV*) + u_{4j}(*MOTISLVAL*) + r_{ij}". It can be observed in Table 12.6 that the enumerated four level-1 variables that demonstrated direct effects influenced students' attitudes towards physics. Two level-2 variables that had an influence on students' attitudes towards physics were school type and either school level or school curriculum. In addition, the investigation aspect of students' perception of the actual physics classroom climate interacted with the science learning value aspect of motivation to learn physics. Figure 12.4 shows these relationships.

The cross-level interaction effect illustrated in Figure 12.4 can be shown in detail employing the same procedures followed to show the cross-level interaction effect exhibited in the model for the South Australian sample.

Table 12.6. Two-Level Model 1 results (SCHLVLHS included): Student Attitudes Towards Physics (Filipino sample).

Final estimation of fixed effects:					
Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. DF	P-value
For INTRCPT1, B0					
INTRCPT2, G00	494.99	0.50	984.39	10	0.000
***SCHLVLHS*, G01**	6.67	0.99	6.69	10	0.000
SCTYPEGOV, G02	-2.03	0.83	-2.69	10	0.023
For COMPAFFC Slope, B1					
INTRCPT2, G10	0.16	0.08	2.00	12	0.056
For COMPCOGN Slope, B2					
INTRCPT2, G20	-0.25	0.10	-2.60	12	0.024
For MOTILERNV Slope, B3	-0.14	0.06	-2.26	12	0.044
INTRCPT2, G30					
For MOTISLVAL Slope, B4					
INTRCPT2, G40	-0.16	0.04	-3.87	11	0.003
CCAINVES, G41	-0.01	0.001	-5.57	11	0.000

Final estimation of variance components:						
Random Effect	Reliability	Standard Deviation	Variance Component	DF	Chi-square	P-value
INTRCPT1, U0	0.524	1.37	1.870	10	26.90	0.003
COMPAFFC Slope, U1	0.515	0.22	0.049	12	23.97	0.020
COMPCOGN Slope, U2	0.463	0.25	0.063	12	26.89	0.008
MOTILERNV Slope, U3	0.575	0.18	0.032	12	22.50	0.032
MOTISLVAL Slope, U4	0.531	0.12	0.013	11	21.14	0.032
level-1, R		6.08	36.99			

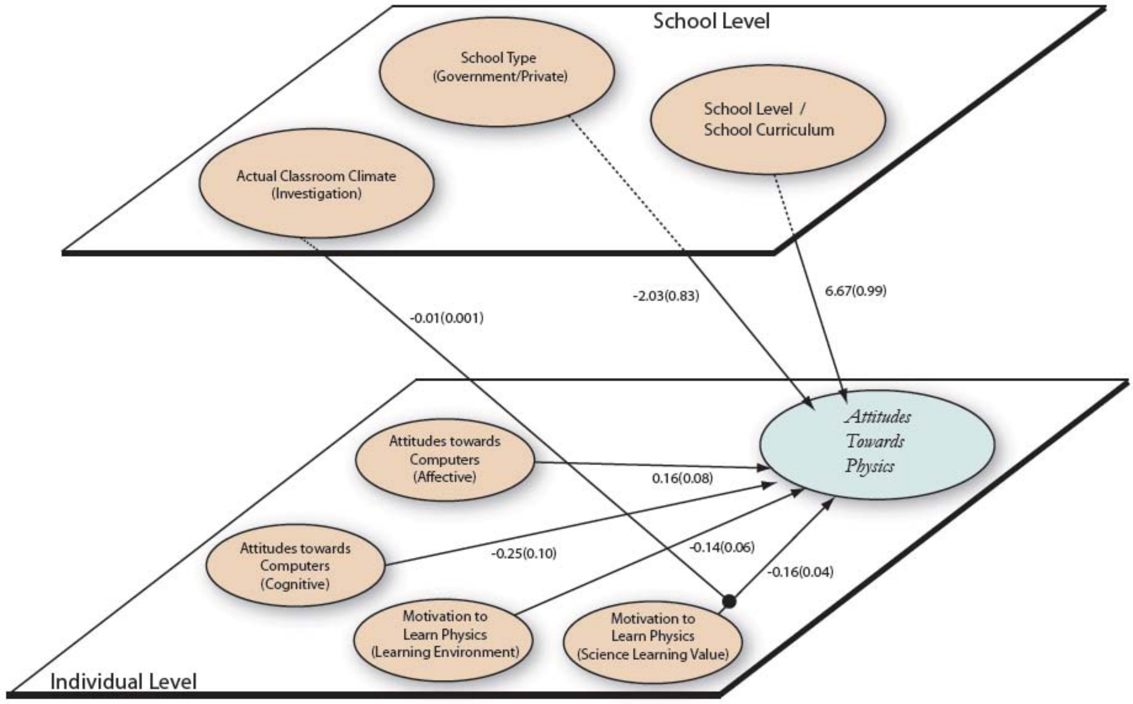


Figure 12.4. Two-Level Model of Students' Attitudes Towards Physics for the Filipino sample.

The part of the final equation for the final model taken to represent the cross-level interaction effect is as follows:

$$Y_{ij} = \gamma_{00} + \gamma_{40}(MOTISLVAL) + \gamma_{41}(CCAINVES)(MOTISLVAL) + r_{ij} \qquad [12.14a]$$

where γ_{00} = 494.99, γ_{40} = -0.16, γ_{41} = -0.01.
Substituting these values into Equation 12.14a yields to

$$Y_{ij} = 494.99 - 0.16(MOTISLVAL) - 0.01(CCAINVES)(MOTISLVAL) + r_{ij} \qquad [12.14b]$$

Equation 12.14b can be used to calculate school-level coordinates to obtain a graphical representation of the cross-level interaction effect. The coordinates calculated for schools were:

(a) One standard deviation above the average on MOTISLVAL and CCAINVES (i),

(b) One standard deviation above the average on MOTISLVAL and 100 standard deviation below the average on CCAINVES (ii),

(c) One standard deviation below the average on MOTISLVAL and 100 standard deviation above the average on CCAINVES (iii),

(d) One standard deviation below the average on MOTISLVAL and 100 standard deviation below the average on CCAINVES (iv),

(e) Average on MOTISLVAL and one standard deviation above the average on CCAINVES (v),

(f) Average on MOTISLVAL and one standard deviation below the average on CCAINVES (vi).

Using the above as a guide, the coordinates calculated were:

(i) High investigation (actual Physics classroom) and high motivation (science learning value) (MOTISLVAL=100; CCAINVES=100)

$$Y(ATTITUDE) = 494.99 - 0.16(100) - 0.01(100)(100) = 378.99$$

(ii) High investigation and low motivation (MOTISLVAL=-100; CCAINVES=100)

$$Y(ATTITUDE) = 494.99 - 0.16(-100) - 0.01(-100)(100) = 610.99$$

(iii) Low investigation and high motivation (MOTISLVAL=100; CCAINVES=-100)

$$Y(ATTITUDE) = 494.99 - 0.16(100) - 0.01(100)(-100) = 578.99$$

(iv) Low investigation and low motivation (MOTISLVAL=-100; CCAINVES=-100)

$$Y(ATTITUDE) = 494.99 - 0.16(-100) - 0.01(-100)(-100) = 410.99$$

(v) Average investigation and high motivation (MOTISLVAL=100; CCAINVES=0)

$$Y(ATTITUDE) = 494.99 - 0.16(100) - 0.01(100)(0) = 478.99$$

(vi) Average investigation and low motivation (MOTISLVAL=-100; CCAINVES=0)

$$Y(ATTITUDE) = 494.99 - 0.16(-100) - 0.01(-100)(0) = 510.99$$

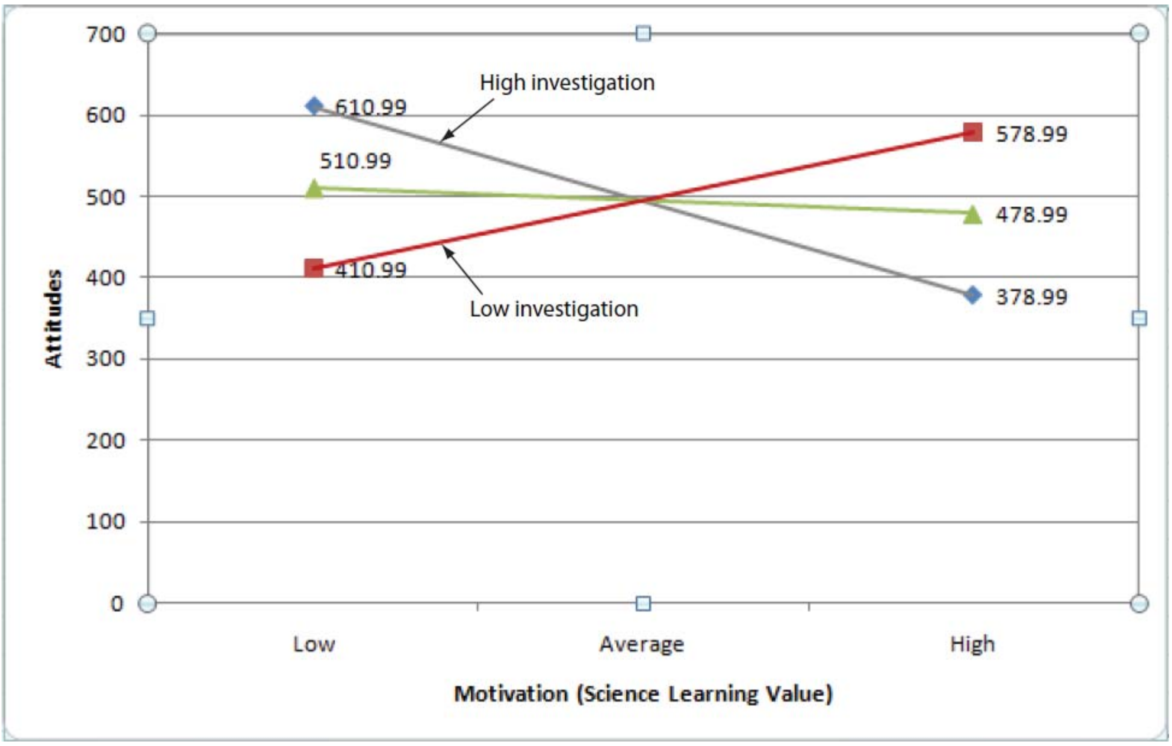


Figure 12.5. Cross-level interaction effect of Average Investigation (Actual Physics Classroom Climate) on the Slope of Motivation (Science Learning Value) on Attitudes.

Considering the differences between schools, it appears that the impact of school level or school curriculum (SCHLVLHS/CURDEPED, 6.67) towards students' attitudes towards physics is significant (*P<0.01*) at the between-schools level. This finding may suggest that students at the high school level/high school curriculum have more positive attitudes towards Physics. This is based on the coding used for high school level ('1'), and university level ('0'). In addition, school type (SCTYPEGOV, -2.03), whether a school or university is government- or privately-owned, appears to significantly (*P<0.05*) affect students' attitudes towards physics. The negative sign suggests that students coming from privately-owned schools/universities may hold more positive attitudes towards physics. These results (school level and school type having an influence on attitudes towards physics) are similar to those found using path analysis in Chapter 11.

At the student-level, four variables were found to have a significant impact on students' attitudes towards Physics. These include: the affective (COMPAFFC, 0.16) and cognitive (COMPCOGN, -0.25) domains of attitudes towards computers, and the learning environment stimulation (MOTILERNV, -0.14) and science learning value

(MOTISLVAL, -0.16) aspects of motivation to learn science/physics. With the exception of COMPAFFC, all of them have negative coefficients. The affective component of attitudes towards computers (COMPAFFC) shows a significant (*P<0.05*) positive influence on students' attitudes towards physics. This suggests that within the bounds of the sample, Filipino students who have positive attitudes towards computers (computers are considered important) tend to have positive attitudes towards physics. On the other hand, the cognitive aspect of attitudes towards computers (COMPCOGN) shows a negative influence on attitudes towards physics. This suggests that the more positive students become towards computers, the more negative they become towards physics. A possible explanation might be that students enjoy using computers more than studying physics. In addition, this might also be because students who are really interested in computers do not need to study physics in order for them to learn how to use and manipulate a computer. These results are consistent with the single level path analysis results presented in Chapter 11.

Two aspects of motivation to learn science/physics are shown to have a significant (*P<0.05*) influence on students' attitudes towards physics. One of these aspects is the learning environment stimulation which shows a negative effect on attitudes towards Physics. This could be interpreted consequentially. An interpretation of this negative effect would be that physics teachers in schools who try to provide learning environment stimulation might be affecting the students the opposite way. And, for students who already have positive attitudes towards physics, they would not really care if the teacher uses a variety of teaching methods or whether the teacher pays attention to them in class. The other aspect of motivation shown to have a significant (*P<0.01*) influence on attitudes towards physics is the science learning value. The negative relationship exhibited, similar to the finding with the South Australian sample, may be interpreted as students who perceive physics as being important do not necessarily have positive attitudes towards physics. Perhaps students need to study physics as a pathway to other courses, such as engineering. To provide evidence for this, a few examples of Filipino students' responses to Item 18 (*What are your perceptions of physics in terms of job availability and job status in the society?*) and Item 19 (*Do you think you will pursue a career in physics or anything related to physics?*) of the study questionnaire are as follows:

Student 99

18. I think physics has a great importance in terms of job availability. It also helps us become aware of the different phenomena around us and how they came about.

19. Because I want to become a successful nurse someday and I think physics plays a significant role in that field.

Student 107

18. For me physics is very valuable. Physics can be applied to many things. Airplanes are a result of knowledge in physics.

19. Because my dream is to become a pilot, and we need a lot of physics knowledge in navigating, flying, etc.

Student 229

18. Physics is very important not only in machines, of course, but also very important because it can be applied everywhere.

19. Since I will take up civil engineering I will have to do some physics courses.

More detailed discussion of this is provided in Chapter 13. These results are consistent with the results obtained from the single level path analysis in Chapter 11.

As shown in the table of results of HLM analysis using the Filipino data (Table 12.6), there is a cross-level interaction effect involving the investigation dimension of the actual Physics classroom climate and the science learning value aspect of motivation to learn Science/Physics. This is illustrated in Figure 12.5. At a glance it appears that student attitudes towards Physics drop as motivation and investigation activity levels in the Physics classroom go up. However, this is not the case. Interpretation needs a careful examination of the figure. It should be noted that the graph was 'amplified'; in other words, it was scaled up to show more clearly if there was any major interaction effect between the three variables mentioned. The scaling up should clearly be noticed by taking note of the very small divisions on the vertical axis. In whole number terms, the graph of the three lines should appear to be horizontal and that the lines should appear overlapping (on top of each other). In other words, it is likely that there is no major change in the attitudes of students towards Physics with varying motivation to learn the subject and with varying investigation activities put forward by the teacher in a Physics classroom.

Table 12.7. Estimation of Variance Components: Attitudes Towards Physics (Filipino sample).

Model	Estimation of Variance components Between students (n=403)	 Between Schools (n=13)
Null Model	57.02	7.91
Final Model	36.99	1.87
Variance at each level		
Between students	57.02/(57.02 + 7.91) = 0.8782 = 87.82%	
Between schools	7.91/(57.02 + 7.91) = 0.1218 = 12.18%	
Proportion of variance explained by final model		
Between students	(57.02 – 36.99)/57.02 = 0.3513 = 35.13%	
Between schools	(7.91 – 1.87)/7.91 = 0.7636 = 76.36%	
Proportion of total available variance explained by final model		
(0.3513 x 0.8782) + (0.7636 x 0.1218) **= 0.4015 = 40.15%**		

Based on the results of the calculations for variance at each level in the null model for the Filipino sample (see second panel of Table 12.7), it can be observed that majority of the variance (87.82%) was attributable with the responding students. Only a relatively small portion of variance (12.18%) is attributable to schools. Both of these values were shown and discussed earlier in the presentation of the results using the Filipino sample. In comparison to the null model, the final model, which constitutes the inclusion of the predictors of attitudes towards Physics at all levels, explained 35.13% of the variance at the student level (level 1) and 76.36% at the school level (level 2).

Considering the amount of variance explained by the final model at each level in relation to the amount of available variance to be explained at that level, the total variance explained by the final model amounted to 40.15%.

The PISA study employed the same multilevel analysis technique used in this present study. The results (for the variance explained at both school and student levels) obtained in this study are higher than those from the PISA study. However, factors such sample size, number of levels, and number of parameters to be estimated should be taken into account for the difference.

12.6 Summary

This chapter highlights the two-level analysis undertaken for a model that was based on the results of the single level path analysis presented in the previous chapter. This model represents the view that students' attitudes towards physics that could influence uptake of physics can be seen as the outcome of different factors at the student- and school-level. The analysis using hierarchical linear model techniques was undertaken to examine the direct effects and the cross-level interaction effects that might be present.

Similar to the previous analyses, two sets of data were subjected to HLM analyses. These are the data from a sample of South Australian and a sample of Filipino senior high school, and First Year university Physics students. The results reveal some differences between the factors that affect students' attitudes towards physics for the South Australian sample and the Filipino sample. These results can be utilised to further the knowledge of the relationships between variables in how they affect students' attitudes towards Physics, and consequentially, their decision to further study Physics. Interestingly, the factors that were found in HLM to have statistically significant influence on students' attitudes towards physics are consistent with many of those that were found to be significant using single level path analysis (see Chapter 11). For the South Australian sample, as a result of using both single level path analysis and HLM, factors showing significant influence on students' attitudes include: school level, motivation to learn physics through performance goals and science learning value, and the investigation component of students' preferred physics classroom. However, the influence cannot be seen as all positive. Only school level has a positive influence on attitudes which suggests that high school students have more positive attitudes towards physics compared to university students. As indicated in the HLM results, the investigation component of students' preferred physics classroom and, at the individual level, motivation to learn physics through performance goals and science learning value, all show negative effect on attitudes

For the Filipino sample, factors showing significant influence on students' attitudes in both the single level path analysis and HLM include: school level, school type, the affective and cognitive components of attitudes towards computers, and motivation to learn physics through learning environment stimulation and science learning value. At the school level, the factor 'school level' shows positive effect on attitudes which suggests that high school students hold more positive attitudes towards physics than university students. Also at the school level, school type and the investigation component of the actual classroom climate show negative effects on attitudes. The former suggests that students from private educational institutions exhibit more positive attitudes towards physics compared to students attending government-owned schools/institutions. At the individual level, only the affective component of the attitudes towards computers shows positive influence on attitudes towards physics. The cognitive component of the attitudes towards computers, and the learning environment stimulation and science learning value components of motivation to learn physics exhibited negative influence on students' attitudes towards physics. These results support some of the relationships (between students attitudes and school level, school type, motivation and attitudes towards computers) shown in the conceptual framework advanced in Chapter 2 (Figure 2.2, p. 57).

The next chapter discusses the results of the HLM analyses followed by a brief conclusion for this study including the some theoretical and methodological implications, and limitations and recommendations.

Chapter 13

Conclusion

13.1 Introduction

It can be argued that the importance of Physics in our society cannot be underestimated. Yet, as research on Physics education reveals, the number of students who are doing Physics courses at high school and university level studies appears to be continuously dwindling, especially in the Western world. Many studies have examined a number of possible causes of this reduction; however, a great majority of these have been undertaken within the context of the Western society. There is very little research on students' uptake of physics carried out in the Eastern/Asian societies.

13.2 The design of the study

The research study described in this thesis was aimed at identifying the various factors, and their interrelationships, which make a contribution to a positive set of attitudes towards physics, and its study, at upper high school and university levels. A number of factors were examined for the influence on attitudes that contributed to the uptake of physics. These factors were gauged through carefully selected and validated scales and instruments. The appropriateness of the scales was based on the objectives of the study and the research questions advanced in Chapter 1. The scales include the *Attitudes towards Physics Scale* by Redford (1976), Tuan et al's (2005) *Students' Motivation Toward Science Learning Scale,* the *Rosenberg Self-Esteem Scale* by Rosenberg (1965), the *Computer Attitude Scale for Secondary Students* by Jones and Clarke (1994), the *Individualised Classroom Experience Questionnaire* by Fraser (1990), and the *Perceived Family Capital Scale* by Marjoribanks (2002). All of the scales provided input to the the present study's *Students' Uptake of Physics Study Questionnaire (SUPSQ).* The scales' validity and consistency were established using structural equation modeling (SEM) through confirmatory factor analysis (CFA) and Rasch scaling. LISREL 8.80 (Jöreskog & Sörbom, 2006) was used for the CFA, and ConQUEST 2.0 (Wu, Adams, Wilson & Haldane, 2007) was used for Rasch scaling. Each scale was validated for each group of samples – the South Australian sample and the Filipino sample. This was undertaken to test for each scale's measurement invariance to determine whether the two groups of samples could be compared with each other.

The study acknowledges the implications of aggregation of data from the individual level to the organisational level, and disaggregation of data from the organisational level down to the individual level. Thus, structural equation modeling and hierarchical linear modeling were utilised for aggregated and disaggregated data, respectively, to answer the research questions on causal relationships for the positive attitudes and thus the uptake of physics.

The research questions advanced in Chapter 1 covered factors at both school and individual levels. Therefore, the collected data from the two sample groups contain information that include two distinct levels – student level (individual level) and school level (organisational level). School level factors include school curriculum and classroom climate (including teachers), and individual level factors include gender, self-esteem, motivation, parents' aspirations as perceived by the students, and attitudes towards computers.

In this study, it was considered important to gain some insights from physics teachers into their views, beliefs, and practices of teaching physics in the classroom since teachers have been studied in numerous research studies, and it has been found that they contribute to students' attitudes towards physics. Equally important were the perceptions and beliefs of physics students that might have contributed to shaping their attitudes towards physics, and ultimately, their decision to study physics (their uptake of physics). Therefore, in addition to the use of scales to measure students' attitudes towards physics, open-ended questions were included in the SUPSQ for the students, and teacher interviews were conducted to gain understanding of teachers' views, beliefs and teaching practices in physics.

13.3 Summary of findings

This section presents the description of the key findings of the interrelationships between the various factors examined in this study. The results of the analyses showing the complexity of the interrelationships of these factors on how they affect students' attitudes are also presented. In addition, evidence that emerged from the analyses of the gathered data and teacher interviews is also reported. The results for the South Australian sample and the Filipino sample are discussed separately since the scales exhibited measurement variance between the two groups of samples. With the presence of measurement variance, combining the two groups of sample could lead to errors caused by inaccurate observations, overgeneralisation and illogical reasoning (Babbie, 2010; Raudenbush & Bryk, 2002; Jöreskog & Sörbom, 2001).

The present study examined a number of factors and their interaction that affect students' attitudes towards physics that could influence their uptake of physics. Two methods were employed to address the general research questions advanced in Chapter 1: single-level path analysis and multilevel analysis. The methods employed were related to the conceptual framework advanced in Chapter 2 (Figure 2.2, p. 57) where two different levels of factors were considered for examination – school level factors and individual level factors. The conceptual framework shows the hypothesized relationships, based on various literatures reviewed, between the variables examined in this study.

Overall, for the South Australian sample, students' attitudes towards physics are influenced by school-level and student-level factors.

At the school level, the students' school level/school curriculum (high school or university) shows a positive influence which suggests that upper high school students hold more positive attitudes towards physics compared to first year university physics students. This is consistent with the results of the study on attitudes towards physics carried out by Reid and Skryabina (2002). They found that students who are doing higher level physics have significantly weakened attitudes towards physics compared to those who are doing lower level physics subjects. They added that this was perhaps because the lower level physics subjects in their study was application-based, compared to the principle-based higher level physics subjects, which was claimed by the students to be more enjoyable, interesting and important. These results are also consistent with the report of similar studies by Hipkins and Bolstad (2005). This pattern of changing attitudes towards physics implies a trend that physics students are generally positive about physics when they are younger. In other words, beginning physics students' positive attitudes towards physics could potentially be explained by their curiosity of how things work (Reid and Skryabina, 2002). Moreover, Alagumalai (2010) highlighted the prestige attached to learning physics in secondary schools, and this would have added to the novelty of learning physics in their 'specialisation' years. However, as they age and gain more experiences in trying to learn the subject, these positive attitudes and interest start to decrease. This is supported by a number of related literature reports, reviewed by Osborne (2003), that provide evidence that students' attitudes towards science (particularly physics) are eroded by their experience of the subject as they advance to the next level. According to Osborne, students failed to perceive the relevance of physical science in their everyday lives as they are constantly learning more equations as they go along. In other words, more advanced physical sciences are still highly theoretical, or content-based rather than application-based. But in this study, the age difference between upper high school and university students is so little that this may not likely to be a reason for the difference between the attitudes towards physics of high school and university students.

Also at the school level, the investigation aspect of students' ideal classroom climate, through the performance goal aspect of motivation to learn physics, negatively influences attitudes albeit very little. This suggests that students' preference for more investigation activities is closely related to their motivation to perform well in a physics class. However, the result also indicates that these factors do not necessarily create positive attitudes towards physics. Although the cross-level interaction effect between these two variables has been demonstrated in Chapter 12 as having a very small effect on attitudes. This is consistent with the results of Angell et al's (2004) study on students' views of physics in Norway. They have concluded that students wish that they had more investigative work in the classroom to motivate them to learn more about physics. This is despite the fact that the students they surveyed perceived physics to be a very demanding (high difficulty level) subject.

At the individual level, three aspects of the factor 'motivation to learn physics' appear to influence attitudes towards physics. These are science learning value, self-efficacy and performance goal. This is consistent with the results of a number of studies (e.g., Thomson & DeBortoli, 2008; Murphy & Whitelegg, 2006; Tuan et al., 2005; Reid & Skryabina, 2002; DeBacker & Nelson, 2000; Fischer & Horstendahl, 1997; Lee &

Brophy, 1996) relating to students' motivation to learn science (which includes physics). However, in the present study, the motivational aspects found to influence attitudes are all negative which suggest that motivation to learn physics may not necessarily contribute to positive attitudes towards physics. For example, students may be motivated to study physics not because they have positive attitudes towards physics, but they perceive physics as an important part of the career (other than physics) they choose to pursue. A number of the South Australian respondents indicated this when they were asked about their perceptions of physics. The following are examples of these responses:

> Student 7: *Very available due to the amount of engineering courses and demand for engineers.*
>
> Student 8: *Physics is an important feature of engineering. Therefore, many jobs are available that require physics.*
>
> Student 41: *Lots of engineering jobs available for people specialising in physics.*
>
> Student 54: *Physics is a prerequisite for many engineering university courses. There are many engineering jobs awaiting.*
>
> Student 91: *Important to achieve a very successful and high-paid occupation such as engineering and aviation.*
>
> Student 106: *There is a great amount of jobs that require physics including engineering, surveying, electricians, drafts people. Usually the more interesting and thought provoking jobs.*

A similarity with the South Australian sample was observed when the Filipino data was subjected to the multilevel analyses. A number of school-level and individual-level factors appear to have direct influence on students' attitudes towards physics.

At the school level, the present study found that, with the Filipino sample, students who were doing physics in the high school level had more positive attitudes towards physics compared to their university counterpart. In addition, school type as a school-level factor contributes to attitudes towards physics. Within the Filipino sample, school type pertains to whether the school or university is government-owned or privately-owned. In this study, it was found that physics students who attend private schools/universities are likely to have more positive attitudes towards physics than those who are enrolled in government-owned educational institutions. It can be argued that private educational institutions in the Philippines are better equipped in terms of their facilities for science experiments, physics experiments in particular. They might also have the better teachers since they have more strict guidelines in hiring teachers/instructors. Often, private schools have more reference materials than government schools, not only in physics but other learning areas as well (Marinas, n.d.). These provide physics students more options to explore and learn new concepts which therefore give them better appreciation of and more positive attitudes towards the subject. This has already been reported in a number of studies (see e.g., Reid & Skryabina, 2002, and the review of related literature by Osborne, 2003).

The lack of materials that can be utilised in a physics laboratory has always been the grievance of teachers from the government schools and universities in the Philippines (Marinas, n.d.), even the one that is considered to be the country's top educational institution. This has been one of the themes extracted from the responses of government school teachers in the teacher questionnaire and the interviews about their perceptions of the physics curriculum (see Appendix F and H). A few examples include:

> Physics Teacher 1: *Actually, I have been telling the school that my plan or my dream is to have a complete set of materials. So far, we lack budget. I cannot put blame on the school because we lack budget, but how I wish in a few years time, as I told our Director, we will have a complete and sufficient materials for teaching.*

> Physics Teacher 2: …*if we have enough tools, instruments, devices, visual aids, seminars, lectures and others, I can say that physics curriculum in our school will be more enjoyable for our students to think, do and learn about the world around them.*

Physics Teacher 17: *Though I lack materials, I always make it a point to have some improvised materials. But I think it is more enjoyable if my materials are enough since I can't improvize all the materials needed in our experiment.*

Also at the school-level, the actual classroom climate, as perceived by the students focussing on its investigation aspect, contributes to students' attitudes towards physics. However, as indicated in Chapter 12, Figure 12.4, this factor did not exhibit direct effects on attitudes. Instead it affects (albeit very small and negative) attitudes towards physics through its interaction with the motivation factor.

It is worth noting the negative effect (Figure 12.4 in Chapter 12, p. 388) of the investigation aspect of the actual physics classroom on attitudes. The negative effect suggests that students' positive attitudes towards physics diminish as a result of doing investigative activities in the classroom. Although the finding supports many of the related research results discussed above, the positive effect the classroom investigation brings to attitudes, as reported in many studies, is contradicted by the negative result exhibited in the analysis results (see Table 12.6, p.387, or Figure 12.4, p. 388 in Chapter 12). This suggests that investigative activities in physics do not necessarily lead to positive attitudes. This could be explained by the very limited materials (and sometimes none) that teachers and students use in their physics laboratory. The author of this study had the privilege to have a look at the laboratory manuals and materials in the physics laboratories he visited in the country. Generally, the laboratory manuals used by the students have been prescribed by the country's department of education. Often, the activities in these manuals are of cookbook-type, one-size-fits-all, and only work with the materials it came with. In addition, the activities also seem to be 'detached' from physics applied to the real world as they are still those planes, tracks, pulleys, boxes, circuit boards and ticker tapes that were common in the physics classroom in the 1960s and 1970s. In other words, these are outdated materials that are often found by students to be boring. This could mean that little or no resources in the physics classroom will affect views about practice and thus, attitudes. More modern equipment such as computers with simulation and modeling software are barely found in these classrooms even in those that are privately-owned and government-owned 'elite' schools (Rodrigo, 2003).

Unfortunately, the problem might have also been compounded by teachers, especially those who do not have proper physics training, teaching the subject traditionally. As a result of teaching physics as if it was from a cookbook, teachers might have led students to confusion rather than facilitating understanding (Johnston & Ahtee, 2006; Spall et al., 2003). This is reflected in one of the themes extracted from the questionnaire and interview responses; that teachers who use traditional methods would prefer more professional development and training programs in teaching physics. Some examples of their responses to the question of how they deliver their physics classes include:

> Physics Teacher 1: *Uhm, as of now, to be honest, I also deliver my classes traditionally [lecture method] because there are some topics wherein we lack materials so what I did is just to draw then explain the concept behind that drawing then…uhm, I just…I just explain it on how to do it on how to experiment it because we don't have actually materials to use.*

> Physics Teacher 2: ...*Because in teaching Physics I'm also learning so many things about the natural world inspite of some problems met like lack of instructional materials, seminars, forums and others.*

> Physics Teacher 4: *I think…I have to undergo some training first before I can do that particular way of teaching a particular topic where I tend to become a traditional teacher.*

At the individual level, this study found that the affective and cognitive domains of attitudes towards computers have significant effects on their attitudes towards physics. This further supports students' preference for more innovative ways of learning physics than the traditional 'textbook, prescribed didactic' method (Alagumalai & Keeves, 1998; Toh & Alagumalai, 1997)

One positive effect of the affective domain of attitudes towards computers on attitudes towards physics can be observed from the analysis results (see Figure 12.4 in Chapter 12, p. 388): students who are positive towards the use of computers tend to be more positive towards physics.

Also at the student level, it was found in this study that the learning environment stimulation and science learning value aspects of the 'motivation to learn physics' factor negatively contribute to attitudes towards physics. Similar to the results from the South Australian sample, this suggests that motivation to study physics does not necessarily lead to positive attitudes towards physics.

The above discussion of results needs careful consideration, however. They may only be applicable to the schools where students were sampled to participate in this study. Furthermore, there is really no physics uptake in Philippine secondary schools since physics is a compulsory subject. Physics uptake can only be measured at university level. Furthermore, the results of the analyses using the Filipino sample may be spurious; the compulsory nature of physics in Philippine secondary schools makes it difficult to determine how attitudes are shaped by the factors examined in this study. Therefore, further studies with much bigger sample size are needed to be carried out in universities to obtain results that are more reliable.

Overall, the relationship between attitudes, as gauged through the various validated and standardised scales and actual behaviour as compared to reported motivation needs scrutiny.

13.4. Implications of the study

Since the study involved two countries, a comparison is expected. However, the instrument used in this study showed measurement variance when used in two different sample groups. Therefore, direct comparison was not possible. Notwithstanding this, the study is expected to contribute to the identification of factors that could influence attitudes towards a subject in South Australia and the Philippines. Unfortunately, the factors that were identified in this study to which positively influence attitudes (i.e. school level and school type) do not suggest any consistent and effective change that can be made since they are unchangeable. However, the other factors (motivation and attitudes towards computers) identified as influencing attitudes, although negative, warrant some attention because of their implication on a school's (or an institution's) physics curricula. The physics curricula for both South Australia and the Philippines may be examined for their relevance to catering for students' learning and appreciation for the subject. The information from the results of this study may also be used to effectively identify what teachers needs are in terms of professional development programs to improve their physics teaching approaches and to be able to motivate students to further study the subject. This is particularly true for the physics teachers in the Philippines where professional development programs for teachers are limited.

Theoretical implications

The declining trend of physics uptake in last three or so decades has been the centre of attention for many science education researchers. Because of the perceived importance of physics in many aspects of our society, the decrease in the participation of students in physics has aroused the interest of educational researchers attempting to find answers to the basic question of 'Why is this happening?' Many of these researchers have examined numerous factors that may contribute to the negative attitudes of students that lead to their non-participation in this seemingly challenging subject. The factors include school environment, the physics curriculum, teachers, parents, students' motivation and prior achievement, self-concept, among others. Additional factors have been examined especially in those countries where physics is not compulsory in the secondary schooling. Many researchers have found relationships among these factors that appear to affect students' attitudes towards physics. However, these findings can hardly be considered a generalisation that can be applied to any school setting in any location. One reason for this is that most research on this problem was only carried out where the education systems are mostly from Western background. There is very little similar research carried out in the Eastern systems. Therefore, the underlying assumptions about how these factors play their role in shaping students' attitudes towards physics may not be applicable. This brings to the conclusion that the knowledge about the possible reasons for the decline in physics uptake is still fragmented. This was why the present study was conceptualised. By reviewing existing literature on the different factors examined and found by researchers to have significant influence on students' attitudes towards physics, an initial conceptual framework was established. This framework was presented in Chapter 2 (Figure 2.2, p. 57), and included school- and individual-level factors that are found by numerous studies to affect attitudes towards physics. The results of the analyses of the data sets confirm some of the hypothesized relationships in the conceptual framework. Consequently, the contributions of this study are threefold. Firstly, this study examined a number of factors that have been believed to contribute to attitudes towards physics using samples coming from two different countries with different physics curricula, not to mention different systems of education. In South Australia, upper school physics is an elective subject while in the Philippines it is a compulsory subject to be taken in order to graduate. Differences could be observed about how a subject made compulsory might affect students' attitudes towards that subject. It has been shown in the results that curriculum appears to have a significant effect on attitudes. However, it is difficult to extract a meaningful conclusion from this because the details of each curriculum have not been examined, and that might give a better perspective as to how it affects attitudes. Although this was not possible in the present study, other school-level factors have been examined.

This brings to the second contribution of the study. This study provides empirically-based analytical procedures that can be used to test and extend existing frameworks and models of how different factors affect attitudes. As a consequence of the different analysis techniques employed, path diagrams (both single-level and multilevel) that represent models of how attitudes are affected by different factors have emerged (see Chapter 11 for the single-level path model, and Chapter 12 for the hierarchical model). Although there are differences between South Australia and the Philippines in terms of the education system, school environment, and student characteristics, it was found that, generally, factors that affect students' attitudes towards physics are similar except for attitudes towards computers which are only significant for the Filipino sample. However, there are differences in the more specific aspects of the factors that appear to influence attitudes to both sample groups. For instance, the factor 'motivation to learn physics' may be the same for both sample groups but they differ in the more specific aspects (except for science learning value) of motivation that significantly influence attitudes. This finding provides a better understanding of what motivates each sample group to study physics. In addition, it may also imply that culture has an influence on these differences.

Thirdly, most similar studies used samples that chose not to study physics. This study did the exact opposite. All the student respondents were studying physics or were enrolled in physics courses at the time of data collection. Some useful perspectives may be drawn from the findings of this study. Instead of knowing why students did not choose to study physics, this study tried to find out why students choose to study physics. Generally, the results support previous findings. However, interesting results have also been found, particularly with the Filipino sample. It has been found that, although a very small effect, learning environment stimulation tends to negatively affect attitudes. In addition, the affective domain of attitudes towards computers has negative effects on attitudes. These results have been discussed above and should be subject to further research.

This study might be the first one to be carried out that included the factor of 'attitudes towards computers' as possibly contributing to students' attitudes towards physics. The results of the HLM analyses suggest that two aspects of this factor have significant influence on attitudes towards physics. This should also be subject to further research.

Methodological implications

The research questions advanced in this study addressed how a number of factors affect students' attitudes towards physics, thus influencing their uptake of the subject (see Chapter 1). These include school-level factors and individual-level factors. Review of related literature facilitated the design of the research (see Chapter 3) employing both quantitative and qualitative methods for obtaining data. The quantitative method employed a questionnaire designed to measure the factors considered for examination. The qualitative method employed both questionnaires with open-ended questions, and interviews. Data were collected from schools and universities. However, the data collected were from a group of samples purposively chosen. Therefore, the findings can only fit the samples in the study. The samples reflect the hierarchical nature of the data collected which was taken into account in the analysis. In addition, contemporary procedures have also been employed in handling missing data and in transforming scores into measures.

Missing responses are inevitable in any research employing a questionnaire survey method to collect data. These missing responses affect the analysis of the data as well as the interpretability of the results. Standard statistical techniques focused on removing data with missing values have been widely available. These include techniques such as listwise deletion, pairwise deletion and imputation methods. As with any other methods, these all have their own strengths and weaknesses. Their strengths are mainly simplicity and univariate statistics comparability. Their weaknesses include potential loss of information, introduction of bias, and varying sample size base for each variable in the data that can lead to faulty estimates of the parameters of the model. As with the imputation methods, this could lead to inflated observed correlations biasing them away from zero and also the non-response bias being ignored (Patrician, 2002; Schafer, 1997). In this study, a contemporary technique has been employed to handle missing data. This technique is called multiple imputations (MI) and was developed by Rubin (1987). The MI methods allow for valid estimates of the variance to be calculated using procedures employed when a data set is complete. In this study, LISREL was used to carry out MI.

Raw scores have been transformed to measures to achieve uniformity for more valid interpretation of the results. A technique that has been employed in transforming scores to measures was the weighted likelihood estimation (WLE). This technique was developed by Warm (1989). This technique has the advantage of a minimised estimation bias compared to similar transformation techniques. The WLE technique has been employed as part of the data analyses in recent large-scale studies such as the Programme for International Student Assessment (PISA). Transformed scores using the WLE method were further transformed to *W* scale (developed by Woodcock and Dahl in 1971). The main advantages of the *W* scale are the elimination of the negative values and the decimal values that add to convenience in the interpretation of analysis results. In this study, the ConQuest computer program was used to carry out the WLE method. Microsoft Excel was used in transforming WLE-derived values to *W* scale.

As indicated above, the data collected for this study is hierarchical in nature. Both sets of data collected from the South Australian and Philippine sample consist of information relating school-level variables such as school type, curriculum and classroom climate. The sets of data also include student- or individual-level related factors such as motivation, parents' aspirations for their children and support for their learning, attitudes (towards physics and computers), self-esteem, and gender. Nevertheless, it is always interesting to examine these models by combining different hierarchies of a data set into a single level even when problems arise as a result of this combination. Problems of analysing multilevel data using single-level techniques usually have something to do with the effect of introducing bias and over- or under-estimation of the magnitude of the effects. These have been discussed in more detail in Chapter

10. Ways of carrying out single-level analysis using multilevel data include aggregation of data from individual level to organisational level, and disaggregation of organisational level data to the individual level. In this study, single-level analyses have been carried out using the LISREL computer program. The resulting models form the basis for further analyses using the multilevel techniques.

Acknowledging the problems associated with single-level techniques, further analyses were carried out employing a multilevel technique. The multilevel modeling technique employed in this study is the Hierarchical Linear Modeling (HLM). This either eliminates or minimises known issues inherent within single-level modeling techniques. Furthermore, it also provides for the estimation of the cross-level interaction effects that may be present between the school-level factors and the student-level factors.

The number of students who showed strong positive attitudes towards physics through their responses to the open-ended questions was not reflected in the magnitude of the quantitative data. This implies that other factors not included in this study might have stronger influence on attitudes. Therefore, a re-examination of the implication of triangulation in mixed methods design is also implied in this study.

Curriculum and physics teacher professional development implications

Based on the results obtained from the analyses of the two data sets, both quantitative and qualitative, a number of factors have been suggested to have influence on students' attitudes towards physics affecting their decision to study the subject. These factors include curriculum, motivation, and attitudes towards computers (for the Filipino sample). This study provides implications for curriculum and professional development for physics teachers, albeit limitations of the study should also be considered.

This study supports the findings of research studies that have suggested an examination of the physics curricula of the schools where the studies were carried out. Physics curricula should be made relevant in such as way that students are able to apply physics concepts in their everyday life to get full appreciation of the subject. Even if a good portion of students (both from South Australia and the Philippines) indicated in their open-ended question answers that they are aware of the importance and benefits of physics, it still seems like they lack interest in further studying the subject. Are we doing enough to make the subject more interesting and more 'relevant' to what the students' need? This remains to be answered. Furthermore, the results from the analysis of the Filipino data raise the question of whether physics in senior secondary schooling should be kept compulsory or should it be made an elective subject. There is really no physics uptake in secondary schools in the Philippines because physics is a compulsory subject. However, there are hints from the analysis that, generally, students have negative attitudes towards physics and that they are studying it for the sake of completing the requirements to obtain a secondary school certificate. Thus, a review of the physics curriculum, and whether it should be a compulsory subject, is recommended.

The South Australian physics curriculum has already a considerable amount of application-based physics activities built into the curriculum. Although this is the case, South Australian physics students have indicated, as the analysis results suggest, they would prefer to have fewer investigation activities in the physics classroom, which clearly suggests a review of the curriculum. The Philippines' physics curriculum on the other hand is a little short in providing students with investigative physics activities due to lack of materials. This was highlighted in the Filipino teacher interviews. Students have to learn physics concepts somehow through imagination and memorisation of mathematical formulas. This was also highlighted in the themes that emerged from the Filipino teacher interview transcriptions; that they need training programs that would make them better equipped to meet the learning demands of their students. This study further validates the importance of investigative activities, not only in the physics classroom but also in other science classrooms. Therefore, physics curriculum for both South Australia and the Philippines should be examined in terms of their investigation activities making sure that students would be provided with a good understanding of physics concepts. In addition, as a prelude to these investigation activities, the role of classroom demonstrations should not be discounted. As Dawson (2009) pointed out, demonstrations can be useful when a teacher wants to, among others; focus students' thinking and desire a spectacular effect (on students). As a consequence, this will have an impact on how teachers will deliver the contents of their physics curriculum. Therefore, professional development and training for physics teachers should strongly be considered and carefully planned.

Overall, what transpires from the discussion above simply poses the question, "How do we motivate our students to study physics and lead them to have positive attitudes towards the subject?" Unfortunately, the results of this study hardly have an answer. Thus, further research is required to somehow come up with an answer to the question.

13.5. Limitations of the study and implications for further Research

All research carried out has limitations. Needless to say, this study has sevaral limitations. In either the single-level path or multilevel models, the causal paths must be seen as hypotheses. Therefore, all models including their causal links must be tested for adequacy even if the results support other existing research findings.

This study does not suggest that the factors examined are the only ones that affect students' attitudes towards physics. As implied in the analysis results, there are arguably other variables that play significant roles in forming these attitudes. The problem is so much more complex than what we could imagine.

Generalisation based on the findings of this study is only limited to the sample and does not extend beyond it. The sample can hardly be considered as representative of the population for this study. This was due to the challenges encountered in the collection of data. Also, as a result of these challenges, random sampling was not totally achieved. This study ended up choosing its samples purposively which also had an impact on the analysis of data.

Furthermore, a longitudinal study would ideally have been chosen as obtaining responses over some longer duration could result in stronger findings. However, the researcher only managed to carry out a cross-sectional study due to time and resource limitations.

Collection of the data also posed some challenges. Difficulties were encountered in getting schools to participate in the study, especially in South Australia. In addition, only one out of three South Australian universities (with less than 50 first year physics students) agreed to participate in the study. It was not so difficult to get schools and universities to participate in the Philippines. However, challenges include getting around a very crowded city, which eventually posed time constraints on administering the questionnaire due to the researcher's limited time in the Philippines. Another factor that added to problems collecting data was the rainy weather that caused some flooding in the study's target area.

Because of the problems cited above, suggestions are therefore advanced that, should similar research be conducted;

- A larger sample size coming from a variety of schools/universities representative of the target population is needed. This means that proper random sampling methods should strongly be considered and adhered to, taking into account the hierarchical nature of the data.

- The scales used in this study have shown some strength in measuring and identifying the factors that influence students' attitudes towards physics affecting its uptake. However, the development of a new instrument is also suggested in order to obtain more meaningful results. This study examined a fairly large number of factors; however, a new questionnaire should be carefully designed and validated, and be made compact (i.e. fewer number of items).

- Long survey questionnaires introduce respondent fatigue that results in drawing some 'unusual' responses from samples. The SUPSQ instrument used in this study is long (183 items) and this certainly drew some unusual or non-response from students who filled it out. Administration of the survey questionnaire should also be made consistent (i.e. handing out and collection, and time given for completing the questionnaire) as much as possible throughout the duration of the data collection. This will reduce additional facets or biases that need to be considered in the analysis of data.

- Longitudinal study is strongly suggested considering its advantages discussed above and in Chapter 3.

- Interview questions also need to be revised should further research in the same area be undertaken. The questions need to be carefully designed to elicit more information that could be meaningfully interpreted, complementing the findings from the quantitative analyses.

Data analysis also posed some challenges to the completion of this study. The data collected are multilevel in nature which needs appropriate analysis methods in order to obtain meaningful results. However, even when there is a plethora of analysis techniques available, they are not widely known and neither are they very well established. Nevertheless, these challenges were fairly managed and much better knowledge about different analysis techniques was obtained. The author of this study believes that the practical implications of this study, and some new theoretical understanding of how different factors affect students' attitudes towards physics, makes it a useful contribution to knowledge about the importance of these factors and how they interact and influence students' attitudes.

By improving all the weaker aspects of the present research, more meaningful results can be obtained from future research undertakings in the same area of physics education. Essential keys to good research are proper planning and execution.

13.6. Concluding remarks

On identifying the contributing factors to students' attitudes towards physics, the intention was to provide a set of suggestions which, if taken on board, would enable physics educators to increase the positive attitudes of their students. However, this aim was hardly met. Instead the major strength of this study is in its methodological approaches to the main question.

The use of structural equation modeling and multilevel analysis techniques provided 'strength' in the validity of the analysis results because the issues (such as loss of information, erroneous estimations, etc.) in using 'ordinary' statistical techniques were addressed.

In terms of the contribution to physics education, little can be said about guidelines to improve attitudes to the study of physics.

Those factors identified as affecting attitudes were the type of institution in which students were studying: those in schools were more positive towards physics than those in first year university. And this applied both South Australia where physics is an option in upper secondary school and in the Philippines where it is compulsory.

Other factors include classroom climate which affects students' motivation to learn physics (in both South Australian and Filipino samples), and attitudes towards computers which affect students' attitudes towards physics (in the Filipino sample).

While one might speculate that differences in curricula, or in teaching approaches, at the two levels might lead to this difference in attitudes, no such finding explicitly arose from the statistical analysis, and they were merely implied.

In fact, the most interesting finding was that there was no factor, or combination of factors, which were looked at which had a strong positive or negative impact on attitudes.

Why might this be so? In fact the study was one of groups, and group averages, and this potentially masks the responses of individual students. Let us say that a teacher, in an attempt to improve attitudes, decides to introduce more practical investigation into the curriculum. For some students, committed perhaps to a deep approach to learning, this initiative might be well received. For others, committed toward achievement on an examination, it might be seen as a waste of learning time. Their attitude might be "give us the objectives and the information, and let us learn". And, in the end, for the group as a whole, the overall effect of the change might be neutral – though for individuals this wouldn't be the case.

As the results presented above show, identifying the factors that may affect students' attitudes towards physics is very complex. This is so even when some of the results confirm what was advanced in this study's conceptual framework. While, a priori, a teacher, or physics educator, might suspect a particular change will improve attitudes to the subject, a detailed investigation into the actual changes might be disappointing.

Possibly a solution to this sort of dilemma might be to offer different routes to the same outcomes, so that students can follow their own preferred approaches – but this really presents a challenge to teachers.

In all of this, one point to remember is that all the students in this study were in situations where examinations were not too far ahead. And that might colour very much how they see the subject, its presentation, and its place in the world yet, as was noted in the literature review, there is evidence that strong attitudes to physical phenomena can be formed much earlier, even in middle primary school. So possibly at that time, when there is no examination pressure, the effect of particular interventions in curriculum and teaching approaches could be greater – however, at this time, such a thought is pure speculation.

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