Gender Differences in Learning Mathematics in Hong Kong: PISA 2003 Study

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Mak, Hok Kiu Edward

Abstract

Many western studies have investigated gender differences in learning Mathematics; however, inconclusive results were obtained. In Hong Kong, research on gender differences is scarce but most scholars have reported that boys are better at learning Mathematics when compared with girls. The present study aims to explore gender differences in learning Mathematics using data from PISA 2003 by adopting self-regulated learning theory. Significant differences in effects of gender on Mathematics achievements were found in the domain of space and shape, change and relationships, and quantity by regression. All the results were in favour of boys significantly except in the domain of uncertainty.

To further investigate the gender effect on Mathematics achievements, three sets of concepts generated from self-regulated learning theory were input into the causal models as mediating variables. The first set of variables was the personal variables, including intrinsic motivation, instrumental motivation, self-efficacy, self-concept, and anxiety. They were added to the causal models to explore the gender effect. The results showed that all the values of direct effects of gender were positive and were statistically significant except in the domain of quantity. All the values of indirect effects of gender were negative and were statistically significant. Three behavioral variables, including control strategies, elaboration, and memorization were added to the causal models. The results showed that all the values of direct effects of gender on the achievements were

negative and are statistically significant except in the domain of uncertainty and all the values of indirect effects of gender on the achievements were positive but none of the them was statistically significant. Two environmental variables, namely competitive learning preference and cooperative learning preference; were added to the causal models for exploring the gender effects. The results showed that the values of direct effects of gender were negative in all other three domains except in the domain of uncertainty and the results were statistically significant in the domain of space and shape and the domain of quantity. All the values of indirect effects of gender were negative but only in the domain of space and shape, the result was statistically significant.

Lastly, all the variables were incorporated in one causal model to verify the relative effects among the three sets of variables in the self-regulated learning theory. The results showed that there were no consistent results in direct effect of gender on the four domains. The value of direct effect of gender was negative and was statistically significant in the domain of quantity, which means that the direct effect of gender was significantly in favor of males in the domain of quantity. But, the direct effect of gender was positive and was statistically significant in the domain of uncertainty, it showed that it was significantly in favor of females in the domain of uncertainty; while no significant direct effect of gender in the remaining two domains. However, consistent results were obtained in indirect effect across the four domains. The values of indirect effects of gender on the achievements were all negative and were statistically significant in all four Mathematics domains. Therefore, there is no evidence that Mathematics achievements have been influenced directly by gender but differences existed in the learning styles, preferences and processes. In fact, all these factors are changeable. Effort can be put to make the change and also improve students' learning. Through this study, unidirectional relationships among the personal factors, behavioral factors and environmental factors in theory of self-regulated learning were supported by empirical evidence.

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Introduction

1.1 Introduction – Statement of the problem

Do boys perform better than girls in Mathematics or vice versa? Or do they perform equally well?

According to Chiang Yik-Man, a professor of Mathematics at a local university, HKUST, 'Male students are good at logical thinking; female students are good at organizing and expression' after analyzing the results of the World Class Tests (Mathematics and Problem Solving) which assesses the competencies of gifted students (8-14 years old) of senior primary and lower secondary in Mathematics and problem solving (News from Apple Daily on 25/3/2009). HKUST also issued a press release concluding that 'HKUST have found that boys aged eight to 11 performed better in logical deduction while girls in the same age group excelled in organising and expression' and the test 'also found that in the high performance groups there are more boys than girls, especially in the 8-to-11 age group'." (News cited from SCMP on 28/3/2009)

Although a professor of Mathematics from a renowned university made the above assertions, since it was based on simply doing a comparison of two sets of data, is such conclusion strong enough to inform the public that "males outperform females in Mathematics"? Is that better male performance a common perception among the public? After the assertion had been made, many people from the academic sector strongly opposed it and raised questions such as:

Does such conclusion reflect the reality? Does gender difference in outcome exist? If it does or does not, what are the reasons behind it? All these issues are worthy of be exploration and discussion in greater depth.

When examining the history of the education development, the topic of gender difference appears to be one which very few people have touched on in the context of Hong Kong (Ed: you must say where – local means nothing without locale) . In the preceding several decades in China and Hong Kong, not all children were able to enjoy schooling. Chinese women had been heavily oppressed by feudal traditions and this raised the problem of gender inequality in schooling (Tang, Zheng, and Wu, 1996).

To solve the problem, the Hong Kong Government implemented compulsory education in 1976 for students up to grade six, and in 1978 for students up to grade nine. This policy was not focused on the equal learning opportunity between gender; rather the aim of compulsory education was to settle the tens of thousands of youngsters as immigrants from China by reorganizing the education system (Section 2.2, Overall Review of the Hong Kong Education System).

Such a brief overview of the education development in Hong Kong, produces only a loose link between policy and gender. The only research that related the gender issue to policy was the Formal Investigation Report on the Secondary School Places Allocation (SSPA) System conducted by the Equal

Opportunities Commission in 1999 and the critique by Tsang (2000). Even so, the focus of these two research studies was on the argument of gender equality in learning opportunity, rather than the gender difference in learning outcomes. Since the implementation of the new SSPA policy, no new policy concerning gender equality in learning opportunity has been introduced and it is hard to find any evidence from the curriculum guide for Mathematics education to show that the Curriculum Development Council has given consideration to the issue when designing the curriculum in these years.

Borrowing the experiences from western countries, there seems to be a linguistic turn in the issue of gender differences. Several decades ago, the studies in gender differences mainly focused on learning outcomes of both sexes in general; a review of pre-1960 psychological literatures by Garai and Scheinfeld (1968), concluded that "no significant sex differences were found in computational tasks, but in arithmetical reasoning and mathematical ability males have consistently been observed to perform better than females as a group" (cited from Fennema, 1974). As time has passed, no further studies have made a definite conclusion on gender differences in learning Mathematics. In recent decades, the discourse of gender difference has turned from investigation into learning outcomes of both sexes in general to under-achieving boys (Giddens, 2006) and more relevant research studies can also be found. Hayes & Lingard (2003) conducted a research study on rearticulating gender agendas in schooling; Francis & Skelton (2005) conducted another research study on discussing the discursive positioning of underachieving boys and Ringrose

(2007) conducted a study on examining the discourse of successful girls. Various education policies have been introduced and implemented in western countries led by and based on the constructed discourses to address the gender differences in learning outcomes, such as 'The National Policy for the Education of Girls in Australian Schools' in Australia (p. 39, Francis, and Skelton, 2005); 'The Teacher Training Agency's (TTA) Corporate Plan for 2003-6' in United Kingdom (p. 43, Francis, and Skelton, 2005); and the policy support for single-sex education (TES, 2004) in USA (p. 42, Francis, and Skelton, 2005). No matter if the discourse is failing boys or the closing of the gender gap; they seem to have vanished in the local context. Therefore, it is worthwhile to investigate the status quo of gender differences in learning and learning outcomes in Hong Kong.

Although there is limited number of serious academic research studies that relate to the gender differences in learning outcomes and education policy in the local context, two large scale international research studies, PISA and TIMSS, which investigate the performance of students in various subjects, mainly Mathematics, Science, Reading, and Problem Solving, could provide valuable information on this issue.

This study has chosen to use the data of PISA instead of TIMSS since the latter one focuses on academic achievement whereas the former one focuses on assessing how well-prepared the students are to meet the challenges of today's society upon the completion of compulsory schooling. The concept of

"Literacy" in PISA not only assesses students' curricular competencies but also concerns the application of knowledge and skills in key subject areas and analyzes, reasoning and communicative effectiveness as students pose, solve and interpret problems in a variety of situations (OECD, 2004, p. 20). Therefore, this study measures student approaches to learning by adopting a model of self-regulated learning which depends on the interaction between what students know and can do on the one hand and their motivation and dispositions on the other (OECD, 2004).

Although the primary aim of the PISA study is to compare and evaluate the effectiveness of the education system by assessing how well 15-year-old students at the end of compulsory education (CUHK 2008a, 2008b; HKU 2008), most public attention is drawn to the cross-nation comparison or the ranking of students' performance cross-nationally.

Therefore, the present study will make use of the data from PISA to deeply investigate gender difference in learning Mathematics in the local context – Hong Kong - with the hope of inspiring education policy makers, to improve the current education system and more importantly, to enhance the learning of every individual learner.

1.2 Research Background

1.2.1 Theoretical Background

As mentioned in the previous section, there is a lack of research, discussions or debates on the gender issue and education policy in the local context. Even the one mentioned before, Formal Investigation Report on Secondary School Places Allocation (SSPA) was conducted by the Equal Opportunities Commission instead of the Education Department.

In order to have a better understanding of the development of the discourse of gender and education, it is worthwhile looking at such developments in western countries. However, solely considering the discourse of gender issue and education could not provide a holistic picture of the development. So, it is necessary to consider the development of discourse of education and the development of discourse of gender and education at the same time. Table 1.1 below shows the summary of the discursive shifts of education and the discourse of gender and education from the 1940s to the mid-1990s. According to Weiner, Arnot, and, David (1997), the discourse of gender and education had been focusing on the discussion of equality in nature of males and females (intelligence) in the 1940s and 1950s and male disadvantages in performance and achievement since the mid-1990s.

Table 1.1: Parallel educational discourses (Weiner, Arnot, David 1997)

Historical period	Prevalent discourses on education	Prevalent discourses on gender and education
1940s, 1950s	Equality of opportunity: IQ testing (focus on access)	Weak (emphasis on equality according to 'intelligence')
1960s, 1970s	Equality of opportunity: progressivism/mixed ability (focus on process)	Weak (emphasis on working-class, male disadvantage)
1970s to early 1980s	Equality of opportunity: gender, race, disability, sexuality etc. (focus on outcome)	Equal opportunities/ anti-sexism (emphasis on female disadvantage)
Late 1980s, early 1990s	Choice, vocationalism and marketization (focus on competition)	Identity politics and feminism (emphasis on femininities and masculinities)
Mid-1990s	School effectiveness and improvement (focus on standards)	Performance and achievement (emphasis on male disadvantage)

From the 1940s to the 1960s, the discussion mainly focused on directing children to different types of schools (grammar, central, secondary modern) according to their measured intelligence, so as to help them to be employed. Therefore, male disadvantage, especially for working class boys was the focus of the discussion. However, from the 1970s to the early 1980s, the focus of the discussion had been switched to equal opportunity for girls. By the late 1980s, due to the impact of feminism on education, together with the concept of equality and justice, the target of the discussion changed to identify social groups and communities; in schooling, the focus was on patterns of differences in examination results for girls and boys as social groups. Since the mid-1990s, the discussion of education has focused on school effectiveness and school improvement by assessing and addressing 'good' and 'bad' schools. The discourse on gender and education was then focusing on underachieving boys because the phenomenon of 'underachieving boys' may be the indicator of a 'bad' school – A suggestion was made that the discourse of underachieving boys is not a reality, instead, boys still perform better than girls but the gender gap is not as large as it was in the past. In conclusion, the discursive shifts are mainly based on the claims of equal opportunity, gender fairness culture, and improvement performance. It is important to investigate these claims but it is more worthy to find out if gender differences exist and what factors contribute to gender similarities or differences.

Apart from the development of discourses, the elements that were embedded in the discourses were another argument, whether the constituents that caused gender differences are natured or nurtured. In this study, it is believed that gender difference (if it exists) is not due to innate properties of males and females. A further explanation will be given in the next section -- Empirical Background of the Present Study. As the concept of gender is a social construct, the present study will borrow the lens of social cognitive perspective to deeply investigate how boys and girls learn Mathematics. A detailed review will be given in the next chapter.

1.2.2 Empirical Background

After reviewing the theoretical background of the gender issue, the empirical background of the gender issue must be studied. In order to have a more comprehensive and overall picture, the results of a large scale research study will be included in the following as a reference of the background of the gender issue.

The results of TIMSS1995 showed small gender differences in average Mathematics achievement at the fourth and eighth grades. However, data from

18 out of 21 participant countries showed that males had significantly greater achievement in Mathematics in the final year (grade twelve) of secondary school (TIMSS 2000). A more detailed summary of the results of TIMSS in various cycles has been summarized in Table 1.2. By looking at the results of Hong Kong students from 1995 to 2007, the trend seemed to be different. In the TIMSS studies, there is no gender difference in general at the fourth grade. In the most recent study – TIMSS 2007 however, girls perform better in Data Display and boys perform better in Number, and both results are statistically significant. At the eighth grade, in general, the trend changes from favouring males in TIMSS 1995 to favouring females in TIMSS 2007, although neither result are statistically significant. However, the statistics show that girls perform significantly better in algebra in TIMSS 2007. As TIMSS is a large scale cross-nation study, the results have offered help in framing the discourse of gender differences in achievement. From the results, one may interpret that there is no gender gap between male and female students before junior secondary level but that male students perform better than female students at senior secondary level and Hong Kong seems also to fit this interpretation. However, focusing on the trend of the results of Hong Kong students, there may be another interpretation: that boys may be underachieving. In the results of TIMSS 1995 for Hong Kong students, there was no gender difference in the fourth grade and although males performed better in the eighth grade, it was not statistically significant. In the 1999 TIMSS and 2003 TIMSS, there was no gender difference in grade four and grade eight for Hong Kong students. However, in TIMSS 2007, at the fourth grade, boys performed better in number

and girls performed better in data display when looking at various mathematical domains and both results were statistically significant. Although boys performed better in general, it was not statistically significant. At grade eight, girls performed better in general although it was not-statistically significant, but they performed better than their male counterparts in algebra and it was statistically significant. Therefore, girls seem to perform better than boys. However, caution must be taken because no matter which way one interpreted, the results gender was the only factor taken into consideration which affected the academic achievement in Mathematics. Is it valid to say this? Could there be any other factors that act as mediators affecting Mathematical performance? If gender is a factor, to what extend does it affect Mathematics achievement? Could there be other factors that act as mediators affecting the Mathematical performance and if gender is a factor, to what extend does it affect Mathematical achievement?

Table 1.2: Summary of gender differences in Mathematics of TIMSS studies.

Year	No of participating countries	Grade	Overall Results	HK results
1995[1]	22	4	No differences.	Gender difference not statistically significant.
	34	8	No differences.	Favor males but not statistically significant.
	18	12	Males perform better.	N.A.
1999[2]	38	8	Favoring boys.	Gender difference not statistically significant.
2003[3]	29	4	No differences in general, in Knowing domain and in Reasoning domain, but favoring boys in Applying domain.	Gender difference not statistically significant in Knowing cognitive domain, Applying cognitive domain, Reason cognitive domain.
	52	8	Girls perform better in Knowing domain and Reasoning domain, boys perform better in Applying domain.	Gender difference not statistically significant in Knowing cognitive domain, Applying cognitive domain, Reason cognitive domain.
2007[4]	67	4	No differences in average achievement.	In general, boys perform better but not statistically significant. Boys perform better in number and is statistically significant; girls perform better in data display and is statistically significant; no difference in geometric shapes and measures.
		8	Girls perform better.	Favor girls but not statistically significant in general. Girls perform better in algebra and is statistically significant; no differences in number, geometry, and data and chance.

1. Source: Mullis, I. V. S., Martin, M. O., Fierros, E. G., Goldberg, A. L., and Stemler, S. E. (2000). Gender Differences in Achievement: IEA's Third International Mathematics and Science Study (TIMSS). Chestnut Hill, MA: Boston College.
2. Source: Mullis, I. V. S., Martin, M. O., Gonzalez, E. J., Gregory, K. D., Garden, R. A., O'Connor, Kathleen M., Chrostowski, S. J., and Smith, T. A. (2000). TIMSS 1999 International Mathematics Report: Findings from IEA's Repeat of the Third International Mathematics and Science Study at the Eighth Grade. Chestnut Hill, MA: Boston College.
3. Source: Mullis, I. V. S., Martin, M. O., and, Foy, P. (2005). IEA's TIMSS 2003 International Report on Achievement in the Mathematics Cognitive Domains: Findings from a Developmental Project. Chestnut Hill, MA: Boston College.
4. Source: Mullis, I. V. S., Martin, M. O., and, Foy, P. (2008). TIMSS 2007 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades. Chestnut Hill, MA: Boston College.

Table 1.3: Summary of gender differences in Mathematics Literacy of PISA 2003.

Country	Space and shape	Change and relationships	Quantity	Uncertainty	Overall
Liechtenstein	Male, *	Male, *	Male, *	Male, *	Male, *
Korea	Male, *	Male, *	Male, *	Male, *	Male, *
Macao-China	Male, *	Male, *	Male, *	Male, *	Male, *
Greece	Male, *	Male, *	Male, *	Male, *	Male, *
Slovak Republic	Male, *	Male, *	Male, *	Male, *	Male, *
Italy	Male, *	Male, *	Male, *	Male, *	Male, *
Luxembourg	Male, *	Male, *	Male, *	Male, *	Male, *
Switzerland	Male, *	Male, *	Male, n.s.	Male, *	Male, *
Denmark	Male, *	Male, *	Male, *	Male, *	Male, *
Brazil	Male, n.s.	Male, *	Male, *	Male, *	Male, *
Turkey	Male, *	Male, n.s.	Male, *	Male, *	Male, *
Czech Republic	Male, *	Male, *	Male, n.s.	Male, *	Male, *
Ireland	Male, *	Male, *	Male, *	Male, *	Male, *
New Zealand	Male, *	Male, *	Male, *	Male, *	Male, *
Portugal	Male, *	Male, *	Male, *	Male, *	Male, *
Tunisia	Male, *	Male, *	Male, *	Male, *	Male, *
Uruguay	Male, *	Male, n.s.	Male, *	Male, *	Male, *
Canada	Male, *	Male, *	Male, *	Male, *	Male, *
Mexico	Male, *	Male, n.s.	Male, *	Male, n.s.	Male, *
Russian Fed.	Male, *	Male, n.s.	Male, n.s.	Male, *	Male, *
Germany	Male, *	Male, *	Male, n.s.	Male, *	Male, *
Spain	Male, *	Male, *	Male, n.s.	Male, *	Male, *
France	Male, *	Male, n.s.	Male, n.s.	Male, *	Male, *
Japan	Male, n.s.	Male, n.s.	Male, n.s.	Male, *	Male, n.s.
Hungary	Male, *	Male, *	Male, n.s.	Male, *	Male, *
Austria	Male, *	Male, n.s.	Male, n.s.	Male, n.s.	Male, n.s.
Belgium	Male, *	Male, n.s.	Male, n.s.	Male, n.s.	Male, n.s.
Finland	Male, n.s.	Male, *	Male, n.s.	Male, *	Male, *
Sweden	Male, *	Male, n.s.	Male, n.s.	Male, *	Male, *
United States	Male, *	Male, n.s.	Male, n.s.	Male, *	Male, *
Norway	Male, n.s.	Male, n.s.	Male, n.s.	Male, n.s.	Male, n.s.
Poland	Male, *	Male, *	Male, n.s.	Male, *	Male, n.s.
Australia	Male, *	Male, n.s.	Male, n.s.	Male, n.s.	Male, n.s.
Netherlands	Male, n.s.	Male, n.s.	Female, n.s.	Male, *	Male, n.s.
Hong Kong-China	Male, n.s.	Male, n.s.	Female, n.s.	Male, *	Male, n.s
Indonesia	Male, *	Male, n.s.	Male, n.s.	Male, n.s.	Male, n.s.
Latvia	Male, *	Female, *	Male, n.s.	Female, *	Male, n.s.
Serbia	Male, n.s.	Male, n.s.	Female, n.s.	Male, n.s.	Male, n.s.
Thailand	Male, n.s.	Female, n.s.	Female, n.s.	Female, n.s.	Female, n.s.
Iceland	Female, *	Female, *	Female, *	Female, *	Female, *

Source: OECD (2004). Learning for tomorrow's world: First results from PISA 2003. Paris: Author.
"Male": results favoring males; "Female": results favoring females; "*": statistical significant; "n.s.": not statistical significant

Another large cross-national study, PISA, shows inconsistent results. However, PISA, unlike TIMSS, focuses on young people's ability to use their knowledge and skills to meet real-life challenges (OECD, 2004) and would like to shed light on lifelong learning of students, therefore, the concept of Literacy has been introduced and it will be discussed in the next chapter. In the PISA 2003 study, 27 out of all 41 participating countries indicated male students performed better in learning Mathematics. Only one country, Iceland, showed that female students performed better than males; and in the remaining participating countries, no statistically significant gender differences were found. Since no consistent pattern for the gender differences in learning Mathematics can be found, the claim of inborn nature being the cause of gender differences is not sufficient to explain such phenomenon; rather, a further investigation should be conducted locally to find out the reasons that lead to the inconsistent pattern. Hong Kong students performed best among all the participating countries in PISA 2003 and no gender difference was found in the Mathematics literacy for Hong Kong students after their compulsory schooling (OECD 2004). A more detailed investigation, called 'Learning for Tomorrow's World' (OECD 2004), was conducted based on the PISA 2003 survey by OECD. The report divided Mathematics Literacy into four areas, namely Space and Shape domain, Change and Relationships domain, Quantity domain, and Uncertainty domain. In the Space and Shape domain, 31 out of the 41 participating countries showed boys performed better than girls and again, Iceland was the one country showing that girls performed better than boys. The remaining nine countries, including Hong Kong, showed no statistically significant gender difference in this Mathematics area, although the results favoured boys. In the Change and Relationships domain, 21 out of the 41 participating countries showed boys performed better than girls and the remaining twenty countries showed no statistically significant gender difference in this Mathematics area, including

Hong Kong but excepting Iceland. Iceland is the only country in which it was found that girls performed significantly better than boys in this Mathematics area. Although there was no statistically significant result found in Hong Kong in this area, the result favoured boys. In the area of Quantity domain, 17 out of the 41 participating countries showed boys performed better than girls and the remaining twenty three countries including Hong Kong but excepting Iceland, showed no gender difference. Again, although there was no statistically significant result found in Hong Kong, the result favoured girls in this area. Iceland is the only country in which it was found that girls performed significantly better than boys in this Mathematics area. In the Uncertainty domain, 29 participating countries returned statistics showing boys performed significantly better than girls, including Hong Kong. Two countries, Iceland and Latvia, showed that girls performed better than boys. The remaining participating countries showed there was no gender difference in this area. Again, even if Mathematics Literacy is further divided into four areas, there is still not a consistent pattern of gender difference. Moreover, the results seemed to be different from that of the results of TIMSS. Therefore it is hard to conclude that gender is the innate factor that affects Mathematics learning. Rather, gender is a factor that inconsistently affects the learning of Mathematics. So, it is worth further investigating what role it plays in Mathematics learning. However, the same caution should be taken when interpreting the TIMSS study. Is gender the sole factor that contributes to the result? Are there any mediating factors that contribute to the results? How do these reasons contribute to the results? Apart from Mathematics performance, there are other learning outcomes that may influence lifelong learning of the students, such as Mathematics self-concept, self-efficacy, anxiety, etc. Are there any gender differences in all these learning outcomes? Is the learning style the same for male and female students? These questions need answering because the answers to these questions not only provide valuable information on the similarities or differences in how male and female students learn Mathematics, and hence frame the discourse on gender difference, but also enhancing students' learning in the future.

1.3 Research Questions

In Hong Kong, compulsory education is implemented from primary one to secondary three. After that, students may choose to further their study to secondary four or full-time courses run by the Vocational Training Council for secondary three leavers. The point before this critical streaming is a suitable moment to assess how well the students learn after finishing compulsory education. This completely matches the primary goal of the Programme for International Student Assessment (PISA) which is to assess how well 15-year-old youths approaching the end of compulsory education have acquired the knowledge and skills essential for surviving in a challenging society. In particular, PISA addresses issues including: (1) to what extent young adults are prepared to meet the challenges of the future; (2) whether they are able to analyze, give reasons, and communicate their ideas effectively; and (3) the capacity to continue learning throughout their lives (cited from Ho, 2005a, 2005b; OECD, 2004). All these are important qualities for the development of further study on career of individuals. Since the PISA survey is a large scale study with serious research method, the results have good generalizability and are unbiased. Therefore, the PISA 2003 survey will be used in the present study.

This study addresses the following research questions:

1. Are there any differences in effects of gender on Mathematics achievements in the domains of space and shape, change and relationships, quantity and uncertainty in Hong Kong? Multiple regression analysis will be used to explore the effect of gender on the achievements using LISREL.
2. Are gender effects on Mathematics achievement mediated by personal variables in self-regulated learning theory? These variables include intrinsic motivation, instrumental motivation, self-concept, self-efficacy, and anxiety. More specifically, what are the mediating effects of personal variables on the effect of gender on Mathematics achievements? In order to answer this question, two sub-questions should be asked, (a) are there any gender differences in these personal variables? (b) If the answer is positive, then would these differences affect Mathematics achievements, and how?
3. Are gender effects on Mathematics achievement mediated by behavioural variables in self-regulated learning theory? These variables include control strategies, elaboration, and memorization. In other words, what are the mediating effects of behavioural variables on the effect of gender on Mathematics achievements? In order to answer this question, two sub-questions should be asked, (a) are there any gender differences in these behavioural variables? (b) If the answer is positive, then would these differences affect Mathematics achievements and how?

4. Are gender effects on Mathematics achievement mediated by environmental variables in self-regulated learning theory? These variables include competitive learning and cooperative learning. That means, what are the mediating effects of environmental variables on the effect of gender on Mathematics achievements? In order to answer this question, two sub-questions should be asked, (a) are there any gender differences in these environmental variables? (b) If the answer is positive, then would these differences affect Mathematics achievements and how?
5. Are the effects of gender on Mathematics achievements mediated altogether by the three sets of variables in the self-regulated learning theory, namely personal variables, behavioural variables, and environmental variables?

1.4 Significance of the Research

The present study provides empirical evidence on how male and female students learn Mathematics in Hong Kong. Therefore, local stakeholders, such as students, parents, teachers, education researchers, and policy makers may make use of the results to improve Mathematics learning for Hong Kong students. For example, strategies of "blaming students", (Biggs, 1991; Ginsberg, 1992; Kember & Gow, 1991; Leung 2001) was said to be a common strategy used in schools in East Asian counties, including Hong Kong. If teachers know that anxiety has a negative effect on students' learning, especially for girls, teachers may try to lower anxiety levels and encourage students more so as to raise their confidence and self-efficacy

Apart from the affective impact, the present study also provides empirical evidence on how learning strategies affect student's learning. It is said that East Asian learners are rote learners. In the present study, other learning strategies are being considered. The results may help different stakeholders to understand how Hong Kong students learn Mathematics effectively. At teachers' level, they may be used to access those effective learning strategies which enhance students' learning; at school administrators' level, they might give advice on better class allocation; at policy makers' level, they might lead to a review of the difference of effectiveness of building either single-sex schools or co-ed schools so as to benefit students' learning and at teacher training institutions' level, they might use the results as an illustration to let student-teachers know the gender differences between boys and girls in learning processes so as to equip them for their future teaching. All these practical issues can inspire different stakeholders with the ultimate aim to benefit students the most in Mathematics learning.

Many researchers have examined different factors that might affect students' learning in Mathematics from different perspectives, including students' mother tongue (e.g., Fuson & Kwon, 1991; Geary, Bow-Thomas, Liu, & Siegler, 1996), societal expectation (e.g., Jiang & Eggleton, 1995; Stevenson et al., 1990), parental involvement (e.g., Stevenson & Stigler, 1992), social beliefs and cultural values (e.g., Stevenson, Chen, & Lee, 1993; Wong, 1998), learning behavior such as the amount of time spent on Mathematics (e.g., Stevenson, Stigler, & Lee, 1986), curriculum and textbooks (e.g., Cai, Lo, & Watanabe, 2002; Zhu, 2003; Wong, Han, & Lee, 2005; Fan, Chen, Zhu, Qiu, & Hu, 2005), self-regulated learning (e.g. Abdul Ali Khan ,2001; Matambo, 2001; Schunk, 1998; Prudie, & Hattie, 1996; Kurman, 2001; Ho, 2004, 2007), self-related cognitions (Whang, 1994; Chen, & Stevenson, 1995; Marsh, & Hau, 2004; Ho, 2007), etc. However, most of the researches were western researches and only considered a small number of factors related to Mathematics achievement and the samples were also not comprehensive; this greatly affected the generalizability of the results. The present research based on the data of PISA 2003, which comprehensively covered all different types of schools and randomly selected all the samples, to investigate the learning characteristics of Hong Kong students who performed excellently in Mathematics literacy in PISA 2003 and also to confirm the models of how learning characteristics influence Mathematics performance. It is hoped that this study can not only provide valuable empirical evidence for confirming and filling the knowledge gap of the actual learning characteristics of Hong Kong students, who are typically said to be rote-learners, and the gender differences among them, but also contribute to and supplement the research gap between western and eastern perspectives which is theoretically significant.

The present study offers a non-biological explanation of gender differences in Mathematics learning. This has very important implications for show that if there are gender differences, the differences are not due to biological differences between males and females, and hence leading from that, the gender differences in learning Mathematics could be manipulated, and the gender gap could be reduced through societal factors. Such a non-sexist attribution might contribute to equal level performance for boys and girls. In Singapore, Mathematics is not regarded as male-dominant discipline and females are encouraged to have confidence in learning Mathematics and their Mathematics ability is better. In Shanghai, girls also outperformed boys (Liu, 2009, P.5). This ideological significance gives a substantial reason for providing equal and balanced learning environments for both males and females.

Reducing or closing of the gender gap (Liu, 2009), means what? And what about 'boys are underachieving'? Is the meaning of 'boys are underachieving' that they performed worse than girls? Or does it mean that the gender gap between boys and girls has become narrower, so boys are 'relatively' underachieving? Some scholars have questioned such discourse as providing a reason for directing attention and resources at under-achieving boys (Giddens, 2006). This attention to boys is another form of inequality in education. In response to one of the objectives of the present study, the reopening of the discourse of gender difference in achievement, and hence providing an opportunity to reframing the discourse of gender differences and the rhetoric used in the discourse. This is the discursive significance of the present study. It is extremely important that discourse, or more precisely the dominating discourse, represents and explains the way the public think of the reality which is embedded in the practice which ignores their existence. If, for example, the underachievement of boys is the dominating discourse, this may direct the attention of the public and resources to help to raise the performance of boys, and hence the creation of inequality if such a discourse is not the truth.

Therefore, if we do not investigate the discourse of "boys are underachieving" or we just accept the dominate discourse of "the gender gap is closing", the truth will never be known. Only by clarifying the relationship between Mathematics and gender are we able to achieve gender equality in Mathematics learning. In order to help frame or reconstruct the discourse, and also to enhance learning by understanding the similarities and differences of the learning style of boys and girls, the present study aims at providing empirical evidence on whether boys outperform girls, or vice versa or both boys and girls would perform equally well. Moreover, the results also reveal the differences in how boys and girls learn Mathematics.

Comprehensive explanations of students' learning characteristics are essential to explore the gender and Mathematics issue because these factors could bring practical improvement to the situation and change attitudes among teachers, parents, and students. This study hopes to contribute a better understanding of how Hong Kong students learn Mathematics and the gender differences of the learning outcomes in order to shed light on improving students' Mathematics learning and future studies.

1.5 Organization of the Thesis

This thesis consists of six chapters. The remaining chapters of this study will examine the gender differences in learning Mathematics for Hong Kong students based on the theory of self-regulated learning. In Chapter two, literatures concerning the relationships among gender, factors of self-regulated learning and Mathematics performance will be reviewed. Methodology of the present research including conceptual framework, conceptualization of the constructs, the data collection in PISA 2003, treatment of missing values, and the methods used in the present thesis will be presented in Chapter three. Confirmatory factor analysis of the constructs will be examined in Chapter four. Results and findings will be presented in chapter five. Conclusions, limitations and Implications of this thesis, will be presented in chapter six.

1.6 Summary

The beginning of the chapter is an introduction. It explains the focuses and the background of the study. It also addresses the statement of the problem and the significance of the research. The organization of the thesis marks an end of the chapter. Related literature and theories will be presented in the next chapter.

Chapter 2

Literature Review

2.1 Introduction

Is the gender gap between boys and girls in Mathematics performance narrower? If this is the truth, how narrow is the gap? Or do the gender differences in Mathematics performance still exist? If gender differences still exist, what is their status quo in Mathematics performance? In this chapter, gender differences in Mathematics performance will be first of all reviewed to see whether the argument of gender differences in Mathematics has been settled or not. However, regardless of the answer, there is a need to investigate what the reality is and this is one of the purposes of the present study.

In recent years, educators and researchers have been interested in students' ability to regulate their own learning. The focuses of learning theories and research studies have considered students as active information seekers and processors, and students can participate actively and employ a large degree of control in the attainment of their own learning goals (Bandura, 1986; Weinstein & Mayer, 1986), rather than the traditional perspective on education, which considered students' learning ability and environment factors as fixed and unchangeable entities. Another purpose of the present study is to investigate how gender plays a role in learning Mathematics by means of self-regulated learning from a social cognitive perspective.

2.2 Gender differences in Mathematics

2.2.1 Gender differences vary across grades

Gender difference in Mathematics achievement has been a hot and controversial topic for a long time. Since the early 1960s, research on gender differences in academic Mathematics performance, especially in grades nine to twelve, have been well documented (e.g., Fennema, 1974; Flanagan et al., 1964; Halpern, 2002; Kupermintz, Ennis, Hamilton, Talbert, & Snow, 1995; Schildkamp-Kuendiger, 1982). In a study by Garai and Scheinfeld (1968), after reviewing pre-1960 psychological literature, the authors concluded that there were no significant sex differences in computational tasks but males performed better than females in arithmetical reasoning and mathematical ability (cited from Fennema, 1974). According to Fennema's (1974) meta-analysis, thirty-six studies were reviewed. Only four of the studies were conducted on kids at pre-school level. The studies focused on investigating the differences in mathematical knowledge of three-, four-, or five-year-old boys and girls. Three out of four studies showed no significant differences and only one study showed that girls performed better than boys. The results have been summarized by Fennema (1974) in Table 2.1. Further in Brush's (1978) study, a total of 86 students was selected of which 45 were males and 41 were females. The results of the study showed that there was no gender difference in the concept of addition and subtraction. More recently, in Aunola et al's (2004) study which selected 103 boys and 91 girls of age 5- to 6-year-old in a Finnish school, one of the aims is to examine the difference in the level of their Mathematics performance. The result of the study showed that there was no gender difference.

In Penner and Paret's (2008) study, data from the Early Childhood Longitudinal Study was used to explore the gender differences in Mathematics achievement in early grades. The results indicated that boys performed slightly better than girls at kindergarten level but the results were not statistically significant. From Table 2.1, all the studies were from western countries; hardly any studies were found which focused on preschool level in local context.

Table 2.1: Gender differences in Mathematics achievement at preschool level

Author	Region	Age of subject	Method	Dependent variable(s)	Results
[1]Estes & Comb (1966)	USA	3 and 4 years	Not provided.	Perception of quantity (numerousness)	No significant difference between boys and girls found
[1]Brace & Nelson (1965)	USA	Preschool	Not provided.	Concept of number (rational counting, equivalent and non-equivalent sets, conservation of numerousness, cardinal and ordinal properties, place value)	No significant differences between boys and girls found.
[1]Heard (1970)	USA	Entering kindergarten	Not provided.	Mathematical concepts and abilities possessed by kindergarten entrants (SMSG Fall Inventory Test)	No significant difference between boys and girls found
[1]Rea & Reys (1970)	USA	Entering kindergarten	Not provided.	Mathematical ideas (money number, vocabulary, geometry, pattern identification, measurement), recall, and total scores	Girls scored significantly higher on number, geometry, recall, and total scores.
Brush (1978)	New York	Preschool	Chi-square test	Knowledge of addition and subtraction	No gender differences
Aunola et al (2004)	Finland	Preschool	latent growth curve modeling	Diagnostic Test for Basic Mathematical Concepts	No gender differences
Penner and Paret (2008)	USA	Preschool	Regression	Early Childhood Longitudinal Study	Boys performed better but not statistically significant

"1": Source from Fennema, E. (1974). Mathematics learning and the sexes: A review. Journal for Research in Mathematics Education, 5, pp.127.

At early elementary and at school level, according to Fennema's (1974) study, there were no consistent significant gender differences in learning Mathematics. According to her report, one study (Hervey, 1966) indicated that boys performed better than girls. One study (Lesser, Fifer, & Clark, 1965) showed that boys performed better than girls in space and scale. Two studies (Lowery & Allen, 1970; Wozencraft, 1963) showed that girls performed better than boys. Another five studies showed there were no significant differences. The results have been summarized by Fennema (1974) in Table 2.2. In a more recent study by Callahan and Clements (1984), 4722 first-grade children were selected, of which 2289 children were girls and 2433 children were boys, to examine the gender difference in number skills. The results of the study showed that there was no gender difference. From the above literature, there is no general conclusion as to whether there is any gender difference in early elementary level. In addition, all of the above captioned literature is western research studies, rarely is there a local research study focusing on the gender difference at early elementary level.

Table 2.2: Gender differences in Mathematics achievement at early elementary level

Author	Region	Grade	Method	Dependent variable(s)	Results
[1]Van Engen & Steffe (1966)	USA	1	Not provided.	Concept of addition	No significant difference found.
[1]Lowery & Allen (1970)	USA	1	Not provided.	Ability to categorize items differing on one, two, or three attribute	Girls performed significantly better than boys in middle and upper SES classes.
[2]Engle & Lerch (1971)	USA	1	Effect size	Open and closed sentences	Favor girls slightly.
[1]Almy (1970)	USA	Longitudinal study: K, 1, and 2	Not provided.	Conservation of number and weight, class inclusion, seriation, ordination, reordering and transitivity	"On an overall basis, the performance of the boys and girls is strikingly similar."
Hervey (1966)	USA	2	Not provided.	Ability to solve verbal problems before instruction in the specific mathematical operation that would enhance the solution	Boys solved significantly more problems than did girls before instruction.
Grouws (1971)	USA	3	MANOVA	Ability to solve 4 types of open sentences involving addition	No significant difference found.
Stern & Keislar (1967)	Los Angeles	3	ANOVA	Ability to acquire a problem solving strategy (concept identification)	No significant difference found
Lesser, Fifer, & Clark (1965)	New York	1	ANOVA	Numerical scale, space scale	No significant differences in numerical scale. Significant difference in favor of boys on space scale.
[2]Wozencraft (1963)	USA	3	Effect size	Standardized achievement test	In arithmetic reasoning, girls were significantly better in total group. Girls were significantly better in middle IQ range. No significant differences in arithmetic computation.
Callahan and Clements (1984)	Not provide	1	T test	Counting	No gender differences

"1": Source from Fennema, E. (1974). Mathematics learning and the sexes: A review. Journal for Research in Mathematics Education, 5, pp.128.
"2": Source from Hyde, J. S., Fennema, E., and Lamon, S. J. (1990). Gender differences in Mathematics performance: A meta-analysis. Psychological Bulletin, Vol. 107, No. 2, 139-155.

At upper elementary and early high school levels, the picture of gender differences in learning Mathematics has became more confusing. As cited from Fennema (1974), boys and girls excelled in different domains when the differences were significant, for example, boys excelled in arithmetic reasoning whereas girls excelled in Mathematics computation. According to Fennema's (1974) study, four studies (Cleveland & Bosworth, 1967; Parsley et al., 1963; McGuire, 1961; and Gainer, 1962) reported no significant differences; one study

(Zahn, 1966) reported boys performed better than girls on total score but two studies (Singhal and Crago, 1971; Wozencraft, 1963) were vice versa ; two studies (Jarvis, 1964; and Parsley et al., 1964) reported boys performed better than girls on reasoning but girls performed better than boys in computation. The results were summarized in Table 2.3.

Table 2.3: Gender differences in Mathematics achievement at upper elementary and early high school level

Author	Region	Grade	Method	Dependent variable(s)	Results
(1) Cleveland & Bosworth (1967)	USA	6	Not provided.	Standardized achievement test	No significant differences found. "Virtually no differences between the sexes in any aspect of arithmetic achievement."
Parsley et al. (1963)	California	2-8	Critical ratio	California arithmetic test	No significant differences found
McGuire (1961)	USA	Junior High	ANOVA	Standardized achievement test	No significant differences found
(1) Gainer (1962)	USA	6-12 years	Not provided.	Standardized achievement test	No significant differences found
(1) Zahn (1966)	USA	8	Not provided.	Arithmetic achievement and reasoning (standardized test)	On 5 out of 32 subtests boys performed significantly better than girls; on 0 out of 32 sub-tests girls performed significantly better than boys.
Singhal and Crago (1971)	New York	5-16 years K-11 grades	T-test	Wide range achievement test (Level 1)	Before instruction girls had higher grade-equivalent scores in arithmetic as a total group and at most grade levels. After six weeks (approx.) of instruction boys made gains significantly higher than girls in grades 3, 4, and 9. The differences in the total gains for boys and girls were non-significant
(2) Wozencraft (1963)	USA	6	Effect size	Standardized achievement test	Standardized achievement test found in arithmetic reasoning. Girls performed significantly better on arithmetic computation. On arithmetic average girls in middle IQ range per-formed significantly better.
(1) Jarvis (1964)	USA	6	Not provided.	Standardized achievement test	Boys tended to excel in reasoning at all IQ levels. Girls per-formed better in fundamentals in 3/4 IQ levels
Parsley et al. (1964)	California	4-8	T test	California arithmetic test	Boys with IQ of 125+ outperformed girls with similar IQs on arithmetic reasoning. Girls with IQs of 75-124 outperformed boys with similar IQs on arithmetic fundamentals. The overall differences appear to be non-significant.
Senk & Usiskin (1983)	USA	9-12	T test	Cognitive Development and Achievement in Secondary School Geometry (CDASSG) project	No significant differences found.
Stockard & Wood's (1984)	USA	7-12	ANOVA	California Test of Mental Maturity	Females performed better.

Table 2.3: (Continued)

Author	Region	Grade	Method	Dependent variable(s)	Results
Hanna & Sonnenschein (1985)	Not provided	8	T test	Algebra grades	Females performed better.
Martin and Hoover (1987)	USA	3-8	T test	Iowa Tests of Basic Skills	Females showed higher levels of achievement on Mathematics computation and male showed superior achievement on visual materials, such as maps, graphs, and tables, Mathematics concepts, and Mathematics problem solving.
Caporrimo (1990)	Not provided	8	T test	Standardized Mathematics achievement	No gender differences.
Cahan and Ganor (1995)	Israeli	4-6	T test	Intelligence tests	Gender differences favoring male students for Mathematics ability.
Seegers & Boekaerts (1996)	Netherlands	8	ANOVA	National assessment study	Boys outperformed girls on Mathematics tasks.

"1": Source: Fennema, E. (1974). Mathematics learning and the sexes: A review. Journal for Research in Mathematics Education, 5, pp.130-131.
"2": Source from Hyde, J. S., Fennema, E., and Lamon, S. J. (1990). Gender differences in Mathematics performance: A meta-analysis. Psychological Bulletin, Vol. 107, No. 2, 139-155.

Research studies on gender differences in Mathematics achievement have been continuing, and the findings at the elementary and secondary levels vary widely. A study conducted by Cahan & Ganor, (1995) on gender differences among 11,000 Israeli children in grades 4-6 with respect to verbal, spatial and mathematical ability as measured by 12 intelligence tests showed that there were gender differences favouring male students in Mathematics ability. In Martin & Hoover's (1987) longitudinal study, a sample of 4875 females and 4497 males from Grade 3 to Grade 8 were selected from schools participating in the Iowa Basic Skills Testing Program, results revealed that females showed higher levels of achievement on Mathematics computation and males showed superior achievement on visual materials, such as maps, graphs, and tables, Mathematics concepts, and Mathematics problem solving. In Seegers & Boekaerts' (1996) study, 90 boys and 96 girls of grade eight were selected from nine schools in Netherland. The results showed that boys outperformed girls on

Mathematics tasks. However, in Senk & Usiskin's (1983) study, 674 female students and 690 male students were selected at aged 14-17; all of them were included in geometry classes and they studied proof writing in Geometry. The results showed that there were no gender differences. Also, in Caporrimo's (1990) study, 70 female students and 52 male students of eighth-grade were selected to examine the relationship of standardized Mathematics achievement scores, no gender differences were found. Nevertheless, in Stockard & Wood's (1984) study, 287 males and 283 females in the 7th through 12th grades were selected. The finding showed that there were no gender differences apart from 7th year Mathematics grades Female grades were significantly higher than males' for all the years and areas studied. Therefore, at elementary and secondary level, no conclusion could be drawn whether males outperformed females or female outperformed males.

At the college level, some studies have shown a lack of significant relationship between gender and mathematical ability, such as in Hong and Karstensson's (2002), study, 154 males and 144 female students from college level enrolled in statistics courses were selected. The results showed that there were no gender differences in Mathematics ability (i.e. Mathematics achievement in statistics). And in Cooper & Robinson's (1989) study of 381 college students, which 298 male and 83 female freshman undergraduates enrolled in engineering, computer science, physics and Mathematics, were selected. The results of the study showed that no significant gender differences were found regarding Mathematics performance. A recent study conducted by

Karimi and Venkatesan (2009) in India, 144 males and 140 females from 10th grade were selected to examine the gender difference in Mathematics performance. The result of the study showed that no gender differences were found. , By reviewing a tremendous amount of literature, Kimball (1989) reported that females from middle school through university tend to perform significantly higher at all levels of Mathematics courses (for example, Deboer, 1984 ; Rech, 1996) though males are usually found to perform significantly better on standardized tests. Ors, Palomina, and Peyrache (2008) used a dataset which consisted of 5743 students who applied for Master of Science program in Management in a top-ranked French business school, of which 50.48% were males and 49.16% were females, to examine whether the comparative nature of tournament structure could explain the gender difference in performance. The results of the study below showed that males performed better in a competitive setting whereas females performed better than males in non-competitive setting.

Table 2.4: Gender differences in Mathematics achievement at college level

Author	Region	Grade	Method	Dependent variable(s)	Results
Deboer (1984)	USA	High school to college level	Longitudinal study, multiple regression	Mathematics course grades	Females performed better.
Kimball (1989)	Not provided.	High school to college level	Meta-analysis; effect size.	Standardized test and course grades.	Males performed better on standardized test and females better in course grades.
Cooper & Robinson (1989)	USA	College level	T test and multiple regression	Standardized test	No gender difference in math ability, anxiety and performance.
Rech (1996)	USA	College level	MANOVA	Algebra courses grade.	Females had better grades in intermediate algebra course than males. No difference in college algebra.
Hong and Karstensson (2002)	USA	College level	Structural equation modeling	Statistics course exam	No gender difference in math ability.
Ors, Palomina, and Peyrache (2008)	France	College	Longitudinal Study, z score, T test, regression	Course grades, Admission exam	Males performed better in competitive setting; females performed better in non-competitive setting
Karimi and Venkatesan (2009)	India	High school	T test	School math exam	No gender difference.

Some researchers looked at the issue of examination. Further, upon categorizing Mathematics courses by content as more advanced (analytical geometry, calculus, probability and statistics, and elementary functions) and less advanced (algebra, plane geometry, and trigonometry), Kimball (1989) found that women's grade advantage increased in more advanced courses. It showed that women possessed the ability to manage high level cognitive tasks. Conversely, analyses of major testing programs, including the National Adult Literacy Survey (NALS), Standard Test of Academic Skills (TASK), Iowa Tests of Educational Development (ITED), National Assessment of Educational Progress – Report Cards (NAEPr), National Assessment of Educational Progress – Trend Tests (NAEPTr), Preliminary Scholastic Aptitude Test (PSAT-Math), National Education Longitudinal Study (NELS), High School and Beyond (HSB), National Longitudinal Study (NLS), and Armed Services

Vocational Aptitude Battery (ASVAB), indicated that values of standard mean differences were between -0.28 and 0.19 (Willingham, Cole, Lewis, and Leung, 1997). It means that the results of gender difference studies vary. The summary of the results of the study by Willingham et al (1997) was presented in table 2.5 below. Form Willingham et al's study, except the ASVAB for numerical operation, males performed better than their female counterpart in all these national test programs. It seems to match the idea that males perform better in high stake tests whereas females perform better in course tests.

Table 2.5: Summary of gender differences in major test of USA

Tests	Standard mean differences	Standard errors
ASVAB – Numerical Operation	0.19	0.030
NALS – Quantitative Literacy	-0.02	0.042
NELS – Mathematics	-0.07	0.025
TASK - Mathematics	-0.08	0.035
ITED – Ability to Do Quant. Thinking	-0.1	0.053
NAEPr - Mathematics	-0.11	0.034
PSAT – Mathematics	-0.12	0.018
NAEPt – Mathematics	-0.14	0.025
ASVAB – Mathematics Knowledge	-0.14	0.030
HSB – Mathematics	-0.23	0.019
NLS – Mathematics	-0.24	0.023
ASVAB – Arithmetic Reasoning	-0.28	0.030

Source from Willingham, W. W., Cole, N. S., Lewis, C., and Leung, S. W. (1997). Test performance. In Willingham, W. W., Cole, N. S. (Eds.), Gender and fair Assessment. P.58. Mahwah, NJ: Erlbaum

A way to shed light on this gender issue is by using meta-analysis. In the meta-analysis conducted by Hyde, Fennema, and Lamon (1990), they reviewed 100 studies and those studies yielded 254 independent effective sizes and represented the testing of 3178188 students. In the study, the statistic used was d, (effect size). Generally, a d value of 0.20 is considered as a small difference, d = 0.50 is considered as a moderate difference and d = 0.80 is considered as large (Cohen, 1969). The results showed that the averaged over all effect sizes (d) of gender differences in Mathematics was -0.05. This means that females performed better than males in general. Although this value indicated that females outperformed males by only a negligible amount, the results contradicted the general beliefs that males perform better than females and also contradicted many of the results mentioned.

From the above literature, no consistent conclusion could be made. Moreover, most of the western studies as mentioned in previous chapter of the present study, gender issue is a silent topic in local context. It is hard to find any studies in Hong Kong which are related to gender differences except the PISA studies and TIMSS studies.

Not only those studies conducted by educators showed inconsistent results in gender differences. An international students' assessment reported in 2000 also showed inconclusive results across countries. PISA, an international study investigated the performance of 15-year-old students in reading, Mathematics, sciences literacy and problem solving. The results showed that there were statistically significant differences in about half of the participating countries, in all of which males performed better and the remaining half showed no statistically significant gender differences in Mathematics performance (OECD, 2000). In PISA 2003 study, similar results were attained: male students performed better in 27 participating countries, no gender differences were found in the remaining countries except in one country, Iceland where female students performed better than their male counterparts. In Hong Kong, although male students performed better than female students, the result was not statistically significant.

Another international study, TIMSS (2000), showed that gender differences in Mathematics performance among students increased for higher grades. In the fourth grade, only three countries, Japan, Korea, and Netherlands, showed gender differences and all the results of these three countries were favoring males; the remaining countries showed no statistically significant gender differences. In the eighth grade, eight countries, Japan, Spain, Portugal, Iran, Korea, Denmark, Greece, and Israel, showed statistically significant gender difference favoring males; and all the remaining countries showed no statistically significant gender differences. However, in the final year of secondary schooling, that is the twelfth grade, the results showed that there were only three countries, Hungary, United States, and South Africa, which did not show statistically significant gender differences, and the remaining participant countries showed statistically significant gender differences favoring males (Mullis, Martin, Fierros, Goldberg, and Strmler, 2000). It seems that, the phenomenon of gender differences in Mathematics performance will aggravate as the years of schooling increase Hong Kong has joined the TIMSS studies since 1995. The results of gender differences of the overall Mathematics performances have been summarized in table 2.6 below. From the table 2.6, at grade four, there seems to be a tendency for boys to perform better than girls. In TIMSS 1995, there was a trend for higher performance for girls and in TIMSS 2003, there was no gender difference between boys and girls but in TIMSS 2007, the trend for higher performance shifted from girls to boys but the difference was not statistically significant. And at grade eight, except in TIMSS 1995, girls performed better than boys in TIMSS 1999, TIMSS 2003, and TIMSS 2007. It seems that there is a tendency that girls performed better than boys at grade eight but caution must be taken as all the results are statistically insignificant. In addition, factors which affect Mathematics learning should also be examined. Although TIMSS study is a comprehensive international study, it aims at investigating the results or the status quo but not the reasons behind the results. Therefore, there is an urge to examine not only the status quo of the gender difference in students' mathematical learning students after their compulsory education but also the mechanisms underlying their learning processes.

Table 2.6: Summary of gender difference of Hong Kong students in TIMSS studies

	Fourth Grade	Eighth Grade	Twelfth Grade
TIMSS 1995	Female, n.s.	Male, n.s.	N. A.
TIMSS 1999	N. A.	Female, n.s.	N. A.
TIMSS 2003	No difference	Female, n.s.	N. A.
TIMSS 2007	Male, n.s.	Female, n.s.	N. A.

"Male": performance favors males;
"Female": performance favor female;
"n.s.": not statistically significant.

From the above literature, no conclusion could be made for gender differences across grades. Hence, researchers tried to explore this issue by decomposing the general Mathematics achievement into various domains.

2.2.2 Gender differences vary across Mathematics domains

Gender differences also vary depending on skill subsets (Hong, O'Neil, and Feldon (2005). Garner & Engelhard (1999) selected 3952 eleventh graders who took the 1994 Georgia High School Graduation Test for analysis. 53% of them were women and 47% were men. Four Mathematics areas, namely number and computation, data analysis, geometry and measurement, and algebra, were explored for gender differences in performance. All the results showed statistically significant gender differences. Males performed better then females in the areas of number and computation, data analysis, geometry and measurement; and females performed better than male in algebraic items. In Pattison & Grieve's (1984) study, 156 girls and 192 boys in grade ten and 106 girls and 122 boys in grade twelve were selected for the study. The results showed that females in grades 10 and 12 outperformed males in logic and geometrical reasoning, but males scored better on items testing scale and three-dimensional solid geometry. From the above findings, it seems that males are strong in numbers, computation, and geometry.

However, there is conflicting evidence by Snow and Ennis (1996). In their study, females were stronger in computation than males, but males performed better on inferential reasoning tasks. Besides, in Kupermintz, Ennis, Hamilton, Talbert, and Snow's (1995) study, data from the National Educational Longitudinal Study of 1988 (NELS: 88) was used for analysis. The findings showed that males improveo their inferential reasoning skills at a significantly greater rate and to a significantly greater level than females throughout high school. In 2005 NAEP Mathematics assessment, girls performed better in algebra and boys performed better in geometry (Halpern, Aronson, Reimer, Simpkins, Star, and Wentzel, 2007). Therefore, even if there is a further investigation on various areas of Mathematics, no consistent conclusions can be drawn in terms of gender differences.

Moreover, in the meta-analysis of the study by Hyde et al. (1990), the results further stated that the value of d was -0.14 (the negative value indicating superior performance by females) for computation; for understanding of mathematical concepts, d was -0.03; for complex problem solving, d was 0.08 (the positive value indicating better performance by males). An examination of age trends indicated that girls showed a slight superiority in computation in elementary school and middle school. There were no gender differences in problem solving in elementary or middle school; differences favoring men emerged in high school (d = 0.29) and in college (d = 0.32), which meant there were gender differences which favoured males in higher grades in problem solving. Therefore, Hyde et al. (1990) pointed out that attention was required in high school because of the lower performance of females in problem solving.

In a local context, the TIMSS and PISA studies may shed light on this issue. Table 2.7, Table 2.8 and Table 2.9 showed the summary of gender differences of the TIMSS studies on various mathematical domains. Table 2.10 showed the summary of gender differences of PISA 2003 on various Mathematics domains. At the fourth grade of TIMSS 1995, boys performed better in the domains of fractions and proportionality, and geometry whereas girls performed better in data representation, analysis, probability, patterns, relations and functions. However, none of the results were statistically significant. And there were no gender differences in the overall Mathematics performance, in the domain of whole numbers, measurement, estimation and number sense. At the fourth grade of TIMSS 2003 study, girls performed better in knowing cognitive domain and reasoning cognitive domain; boys performed better in applying cognitive domain and none of the results were statistically significant. There was no gender difference in the overall Mathematics performance. At the fourth grade of TIMSS 2007 study, boys performed better in the overall performance and girls performed better in geometric shapes and measures although both results were not statistically significant. However, in the domain of number, boys performed better and in the domain of data display, girls performed better and both results were statistically significant.

At the eighth grade of TIMSS 1995 study, boys performed better than their female counterparts although none of the results were statistically significant. In TIMSS1999 study, boys performed better in all tested domains except the domain of data representation, analysis and probability at which girls performed better although not all the results were statistically significant and there was no gender difference in the domain of measurement. In TIMSS 2003 study, there seemed to be a dramatic change. Girls performed better in all tested domains although none of the results were statistically significant and there was no gender difference in the area of applying cognitive domain. In TIMSS 2007 study, girls continually performed better than their male counterparts in all tested domains although none of the results were statistically significant except algebra, in which girls performed statistically significantly better than boys. It seems that girls perform better than boys in recent years. However, the results of PISA 2003 offered inconsistent results. In PISA 2003 study, females only performed better than males in the area of quantity whilst males performed better than girls in all other domains together with overall performance. Not all the results were statistically significant except in the domain of uncertainty where males statistically significantly performed better than females.

According to the results of the international studies, although a conclusion could be drawn that there were gender differences in performance under various mathematical domains, the results were not consistent across various mathematical domains. Therefore, it is worthwhile considering the gender difference in various mathematical domains separately. In the present study, the Mathematics domains that would be considered are quantity, space and shape, change and relationship, and uncertainty.

Table 2.7: Summary of gender difference of Hong Kong students in TIMSS 1995 and 1999 studies in various domains.

Grade	Domains	TIMSS 1995	TIMSS 1999
	Overall	No diff	N.A.
	Whole numbers	No diff	N.A
	Fractions & proportionality	Male, n.s.	N.A.
4th	Measurement, estimation, & number sense	No diff	N.A.
	Data representation, analysis, & probability	Female, n.s.	N.A.
	Geometry	Male, n.s.	N.A.
	Patterns, relations, & functions	Female, n.s.	N.A.
	Overall	Male, n.s.	Male, n s.
	Fractions & number sense	Male, n.s.	Male, n.s.
	Geometry	Male, n.s.	Male, n.s.
8th	Algebra	Male, n.s.	Male, n.s.
	Data representation, analysis, & probability	Male, n.s.	Female, n.s
	Measurement	Male, n.s.	No diff
	Proportionality	Male, n.s.	N.A

"Male": performance favor males; "Female": performance favor female;
"n.s.": not statistically significant; "No diff": no gender differences

Table 2.8: Summary of gender difference of Hong Kong students in TIMSS 2003 study in various domains

Grade	Domains	TIMSS 2003
	Overall	No diff
	Knowing cognitive domain	Female, n.s.
4th	Applying cognitive domain	Male, n.s.
	Reasoning cognitive domain	Female, n.s.
	Overall	Female, n.s.
8th	Knowing cognitive domain	Female, n.s.
	Applying cognitive domain	No diff
	Reasoning cognitive domain	Female, n.s.

"Male": performance favor males; "Female": performance favor female,
"n.s. ": not statistically significant; "No diff": no gender differences

Table 2.9: Summary of gender difference of Hong Kong students in TIMSS 2007 study in various domains.

Grade	Domains	TIMSS 2007
	Overall	Male, n.s.
	Number	Male, *
4th	Geometric shapes & measures	Female, n.s.
	Data display	Female, *
	Overall	Female, n.s.
	Number	Female, n.s.
8th	Algebra	Female, *
	Geometry	Female, n.s.
	Data and chance	Female, n.s.

"Male": performance favor males; "Female": performance favor female;
"n.s. ": not statistically significant; "*": statistically significant

Table 2.10: Summary of gender difference of Hong Kong students in PISA 2003 study in various domains.

Domains	PISA 2003
Overall	Male, n.s.
Space and Shape	Male, n.s.
Change and relationships	Male, n.s.
Quantity	Female, n.s.
Uncertainty	Male, *

"Male": performance favor males; "Female": performance favor female;
"n.s.": not statistically significant; "*": statistically significant

2.2.3 Gender differences in Mathematics are declining

Although there are still gender differences in Mathematics achievement, it seems to be worthless to continue any further studies on this issue if the gender gap is declining. If this is the truth, further studies should still be continued on this issue so as to monitor the narrowing of the gap. If it is not the truth, further studies should also be conducted to see what the reality of the gender differences in Mathematics achievement is. By reviewing some research studies, it seemed that the Mathematics performance gap between males and females has narrowed over the past decade.

In Cole's (1997) study, which was a four years' study using data of more than 400 tests and other measures from more than 1500 data sets involving millions of students, it reported that males' greater achievement in learning Mathematics has declined since 1960. Besides, Sherman (1978) reviewed the study by Maccoby and Jacklin (1974) on cognitive gender differences and pointed out that the overall magnitude in the differences was small, although it tended to be larger at the high school level. Hyde (1981) conducted a meta-analysis based on the data used by Maccoby and Jacklin (1974). It also found that gender differences seemed to account for no more than 1% to 5% of the variance in the entire distribution of scores, and which led to the conclusion that the magnitude was not very large and it was up to the readers to interpret whether the differences were large and important enough to offer further attention even thoughthere were gender differences.

In the past decade, some studies also showed that the gender differences in Mathematics achievement seemed to be narrower or even to have disappeared. In the meta-analysis of the study by Hyde et al. (1990), 100 studies were analyzed and 3175188 students were involved. The results showed that, in general, females performed slightly better than male's students. Although there were gender differences favoring males in problem solving at high school level (d = 0.29) and in college level (d = 0.32), the differences were only small to moderate. Moreover, according to Hyde et al. (1990), the gender differences were smaller and favored females in samples of the general population, grew larger with increasingly selective samples, and were the largest in highly selected samples and samples of highly precocious persons. The magnitude of gender difference has declined over the years; for studies published in 1973 or earlier, d was 0.31, whereas it was 0.14 for studies published in 1974 or later. In Hall, Davis, Bolen, & Chia's (1999) study, 38 boys and 36 girls from fifth and eighth-grade students were selected for the analysis. The results showed that there were no gender differences in Mathematics performance. So, from the above studies, it seems that the gender differences were declining. However, is this evidence strong enough to conclude that further analysis into gender differences is worthless and should even stop?

Looking at some nationwide studies, rather than studies with small and highly selective samples (Hyde, 1997), may clarify the above question. In The Nation's Report Card: Mathematics 2009 (NCES, 2009), the results showed that the average Mathematics scores for male and female students in 2009 remained unchanged from 2007. Male students continued to score 2 points higher on average than female students in 2009. Indeed, the difference in the average Mathematics scores was 3 points in 2000, 3 points in 2003, 2 points in 2005, 2 points in 2007and 2 points in 2009. Another meta-analysis using data from five large, well-sampled nationwide studies of high school students' performance on standardized tests, including the Project Talent which was conducted in 1960s with 73425 students of 15-years-olds; the NLS-72 which was conducted in 1972s with 16860 students of 12th-graders; the NLSY which was conducted in 1980s with 11914 non-institutionalized students of 15- to 22-year-olds; the HS&B which conducted in 1980s with 25069 12th-grade students; and the NELS:88 which was conducted in 1992s with 24599 8th-grade students. The findings showed that the effect size for gender differences in Mathematics performance ranged from +0.03 to +0.24 which means that all the five studies showed males performed better than females but the differences were small (Hedges, & Nowell, 1995). Therefore, from the above literature, results from every size of sample seem to indicate that the gender gap in Mathematics seems to be smaller and narrower. However, the results also show that even if the gender gap in Mathematics performance is narrower, male students continued to perform better than female students. So, it all depends on how we interpret the results from which perspective, such as the narrowing of the gender gap, the existences of the gender gap, underachievement of males or the continuation of good performance of males.

Except for the curiosity of the gender differences in Mathematics performance, the gender differences in the belief of Mathematics competence seems contradictory to the general belief that males have higher -perceptions of their Mathematics ability than their female counterparts. In a recent study by Jacobs et al. (2002), 761 students were selected across grades 1 through 12 in a longitudinal study, of which 53% were girls and 47% were boys. The results showed that, although males' have higher self-perceptions of Mathematics ability than females in the early grades, those differences decrease with age and have disappeared by the 12th grade. Therefore, the declining of gender differences not only in Mathematics performance, but also in self-perception should be queried.

2.3 Gender and self-regulated learning

2.3.1 Theory of Self-regulated Learning

Before going into the discussion of the relationships between self-regulated learning and gender differences, it is better to clarify the meaning of self-regulated learning, and the characteristics of self-regulated learning. Students are self-regulated to the degree that they are metacognitively, motivationally, and behaviorally active participants in their own learning process (Zimmerman, 1986; Zimmerman, & Schunk, 2001). More precise definitions than these tend to vary on the basis of the researchers' theoretical perspective (Zimmerman, 2001). However, among all the definitions, students are assumed to be aware of the potential usefulness of self-regulation processes in enhancing their academic achievement (Zimmerman, 2001). Another feature of most definitions of self-regulation is a self-oriented feedback loop during learning (Carver & Scheier, 1981; Zimmerman, 1989, 2000a, 2001). The loop refers to a cyclical process in which students monitor the learning strategies they used and give feedback to enhance the effectiveness of the learning. Therefore, self-regulated learning theory is a theory that tries to describe and explain how students learn in terms of the methods they use and their own perceptions. So, self-regulated learning theorists believe that students' learning and motivation cannot be separated as they are interdependent (Abdul Ali Khan, 2001

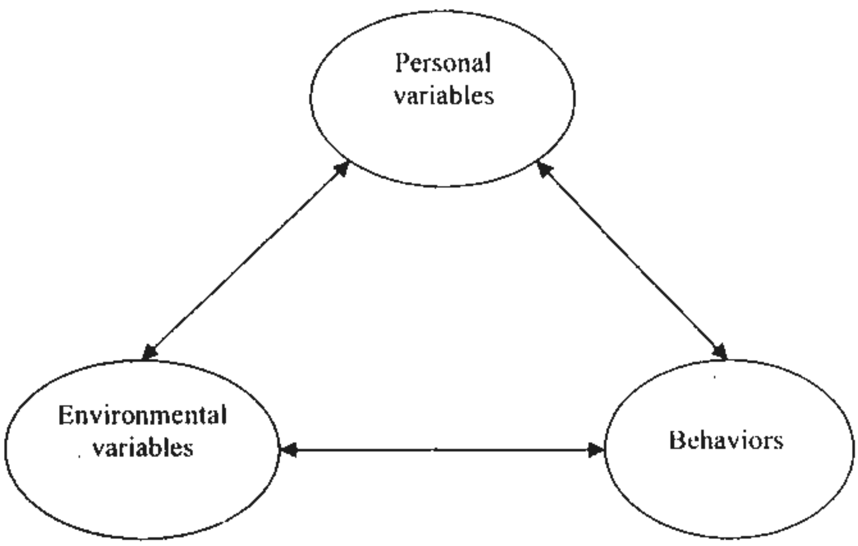
Various theorists have tried to understand, interpret and implement the self-regulated learning in various theoretical perspectives in the past three decades (see Zimmerman 1989b, 2001). According to Schunk (2001), these include operant perspective, phenomenological perspective, social cognitive perspective, volitional perspective, Vygotskian perspective, models of information processing perspective and cognitive constructivist views on self-regulated learning. Although there are several different perspectives of self-regulated learning, they have five common issues that explain how students become self-regulated learners: (1) what motivates students to self-regulate during learning, (2) through what processes do students become self-aware, (3) what are the key processes or responses that self-regulated students use to attain their academic goals, (4) how does the social and physical environment affect students' self-regulated learning, and (5) how does a student learner acquire the capacity to self-regulate during learning (Zimmerman, and Schunk, 2001). These seven perspectives on self-regulated learning have different focuses and approaches but they hold the view that learning is not something that happens to students; it is something that happens by students (Zimmerman 1989b). Therefore, self-regulated students are learners who personally engage in their academic tasks for their own interests and actively participate to acquire necessary knowledge and skills, and also self-monitor their learning progress so as to attain the academic goals.

Although there are a number of different models of self-regulated learning from various perspectives that propose different constructs, different conceptualizations, and hence different mechanisms that link to the academic performance, Pintrich (2000) suggested that there is a need for models of self-regulated learning that included both motivational and cognitive processes. The model assumed self-regulated learning as an active, constructive process in which learners set goals for their learning and select suitable learning strategies to achieve the goals. During the learning process, self-regulated learners would try to monitor, control and regulate their cognition, motivation, and behavior as well as the external environments when possible. With respect to this general framework, one of the objectives of the present study is to investigate how Mathematics achievement is affected by motivations, and cognition with the self-regulatory process. Since this is only a general framework, a more specific model from a social cognitive perspective will be adopted in the present study.

2.3.2 Social Cognitive Perspective in Self-Regulated Learning

Bandura's (1986) social cognitive learning theory considered human functioning as reciprocal interactions between personal, behavioral, and environmental factors (Fig 2.1.). And Zimmerman (1989) proposed a formulation of self-regulated learning based on Bandura's triadic theory of social cognition.

Figure 2.1: Reciprocal interactions in human functioning.

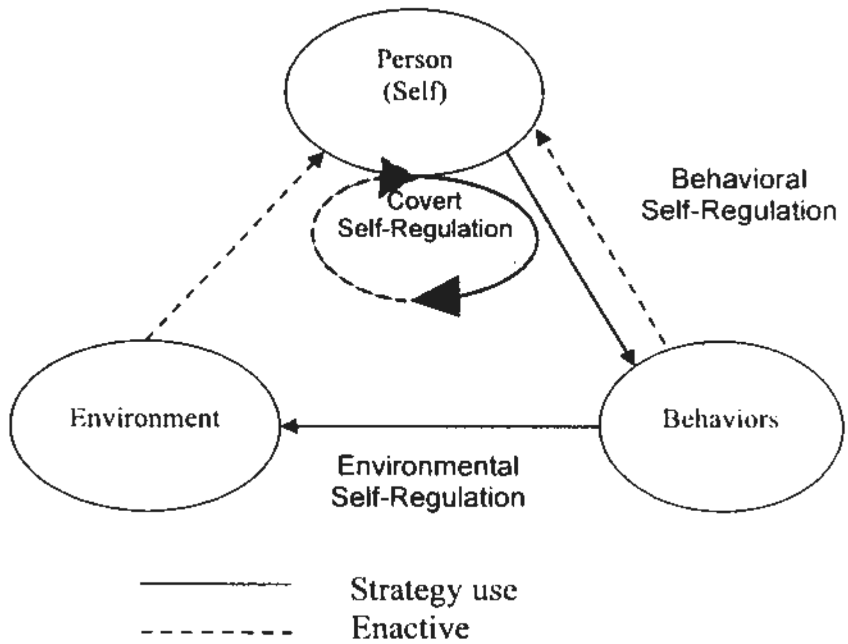


Source: From Social Cognitive theory and self-regulated learning by D. H. Schunk. In B. J. Zimmerman and D. H. Schunk (Eds.) (2001), Self-regulated learning and academic achievement.

According to Schunk (2001), self-regulated learning is constructed as situationally specific in a social cognitive theoretical framework. That means self-regulated learning is highly context dependent, and thus students who are not generally self-regulated or non-self-regulated. In other words, learners are not expected to engage in self-regulation equally in all domains. For instance, a student who is a self-regulated learner in Mathematics may not be a self-regulated learner in language, or, even a student who is a self-regulated learner in algebra may not be a self-regulated learner in geometry.

Zimmerman (1989) pointed out that students were described as self-regulated to the degree that they are metacognitively, motivationally, and behaviorally active participants in their own learning process (Zimmerman, 1986, 1989b). In accordance with Bandura's (1977, 1986) triadic reciprocality theory of social cognition, there are distinctions for self-regulated learning from others in terms of (1) the assumption of reciprocal relationships between the triadic influences of the personal, behavioral, and the environmental dimensions (Zimmerman 1989) (Fig 2.2); (2) the interactions of the three key processes of self-observation, self-judgment, and self-reaction (Schunk, 2001); and (3) the role of self-efficacy perceptions (Zimmerman, 1989; Schunk, 2001).

Figure 2.2: Triadic analysis of self-regulated functioning.



Source: From A social cognitive view of self-regulated academic learning by B. J Zimmerman, Journal of educational psychology, 81(3), p. 330.

Therefore, from the social cognitive perspective, self-regulated learning is determined by personal processes; these processes are assumed to be influenced by environmental and behavioral events in reciprocal fashion (Zimmerman, 1989). For example, a student who gives a response to a problem is assumed to be determined by several factors, the personal perceptions of efficacy, the environment stimuli, such as encouragement from teacher, and previous experience of answering similar questions. This is also a reciprocal formulation which allows that such self-regulative responses as self-recording can influence both the environment (e. g., a document is created, such as exercise book) and various personal processes (e. g., self-efficacy perceptions) in reverse (Zimmerman, 1989).

According to Zimmerman's (1989) social cognitive perspective of self-regulated learning, there are three classes of determinants for increasing the regulatory influence of person (self-) processes: strategies designed to control behavior, the environment, and the covert processes. That means under the triadic functioning, each determinant can be regulated by students. Although each determinant, the personal (covert) part, behavioral part, and the environment, can function separately, when students engage in their learning, they are reciprocally interdependent. For example, a student uses the memorization strategy through self-recording to prepare a test. The strategy used can be seen as a separate behavioral action taken by the student in preparing the test. However, under the triadic functioning, the use of the strategy as a behavioral action can influence the environment, for example, by making the environment more silent or preparing additional study materials. The use of the strategy may be due to the successful or unsuccessful experiences of the results of previous tests and these experiences influence the perceptions of self-efficacy of the student and hence the choice of the strategy used. In return, once the student receives good results on the test, the choice of the strategy could provide information to the perceptions of self-efficacy and also the subsequent choice of memorization strategy. Conversely, if the student received unsatisfactory results in the test, the perception of self-efficacy would be affected and the information not only affects the subsequent choice of memorization strategy but also the subsequent choice of other strategies.

Zimmerman (1990b) further suggested that there were many determinants of self-regulated learning within the three processes in the triadic functioning (see Table 2.4). To influence the person (self) process, students' knowledge, including declarative and self-regulative, the perceptions of learners' self-efficacy beliefs, goals or intentions, metacognitive processes, such as planning (the choice of strategies) and behavioral control (monitoring the effectiveness of the strategies selected), and affective states, such as anxiety, would all these determinants influencing the person's (self) process of self-regulated learning. Declarative knowledge is the information represented in terms of abstract propositions; whereas, self-regulated knowledge is "constructed during the learning process and retains procedural and conditional qualities from them" (Zimmerman, 1990b), that is, according to Zimmerman (1989), this knowledge relates to how to use strategies, when and why the strategies are effective. So, when a student comprehends this knowledge, the student can self-regulate his/her learning. Another determinant, self-efficacy, the key determinant of the personal process, together with self-concept, would be considered in the present study. More detailed information will be discussed in the latter part of chapter two of the present study.

The personal process, which also influences the students' use of self-regulated learning strategies, not only depends on their knowledge of the strategies but also on metacognitive decision-making process and performance outcome. At a general level, it is described as planning which refers to "decisional process for selecting and altering general self-regulatory strategies"

(Zimmerman, 1989, p. 333). At a specific level, it is described as behavior control which refers to "guiding attentiveness, execution, persistence, and monitoring of strategic and nonstrategic responses in specific contexts" (Zimmerman, 1989, p. 333). The metacognitive decision making also depends on the goals set by the learner. Distal attainment can be led by courses of actions which are guided by the proximal goals. In the present study, intrinsic motivation and instrumental motivation will be considered. Lastly, affective states are the fifth determinant of the person's influences. For example, the anxiety level and perceptions of self-efficacy would affect the goals setting. High levels of anxiety and perceptions of low self-efficacy would affect the metacognitive process adversely and would inhibit setting long-term goals (e.g., Bandura and Cervone, 1986; Kuhl, 1982). In return, a successful experience, such as getting good results in a test, would provide information to the learner and further affect the person (self) process. On the other hand, a negative experience, such as getting a bad result in the test, may also provide information to the learner and further influence the affective state, such as anxiety level, when facing another test. This is referred to the covert process in the triadic function of self-regulated learning.

The behavioral influences of which the determinants included self-observations, self-evaluations, self-reactions, and environmental structuring were affected during the process of self-regulation. In contrast with the covert process, this is the overt process as all the determinants could be overtly observed, trained, and regulated. According to Zimmerman (1989), self-observation is defined as students' responses that involve systematically monitoring their own performance. And self-evaluation refers to students rating their performance with a standard, a goal or others. In the present study, a control strategy is used to represent these two concepts. Self-reaction is the reaction of students due to self-observation and self-evaluation. Elaboration strategy and memorization strategy will be considered. Environmental structuring is when students seek to improve the learning environment, for example, arranging a silent study room to reduce distracting stimuli, prepare studying materials (Zimmerman and Martinez-Pons, 1986).

Regarding the learning environment influence, social sources and physical properties of one's performance context (such as task difficulties, various topics or domains in Mathematics, etc) play a major role in self-regulation. Zimmerman (1990) pointed out that through the social learning process, strategies to improve self-observation, self-judgment and self-reactive responses can be acquired and these processes would enable learners to achieve the ultimate degree of internalization. For example, modeling, verbal persuasion, direct assistance, and symbolic supports (such as diagrams, tables, and figures) can enhance students' self-regulation. Schunk and Zimmerman (1996) proposed that observing models (peers and teachers) could affect one's self-efficacy because the learners would imagine that they may be able to raise their self-efficacy and achievements when the models could show them successful experiences. On the other hand, when the learner observed a pessimistic model which persisted for a long time, this lowered their self-efficacy judgment. One of the efficient situations to enhance modeling is cooperative learning. When cooperative leaning occurs, students in the same group may have a chance to model other students' successful learning experiences or strategies.

Finally, the three classes of self-regulatory determinants are reciprocally interdependent. Self-regulated learning is not only determined by personal (self) processes but also by environmental and behavioral processes in overt processes. Self-regulated learning strategies rely on behavioral and environmental processes to control covert personal processes in reciprocal fashion. In the present study, a social cognitive perspective was adopted, so factors related to person processes, such as anxiety, self-concept, motivations, and perceptions of self-efficacy; behavioral processes, including control strategies, elaboration, and memorization; and environmental processes, such as learning preferences, will be considered.

Table 2.11: Determinants of Self-Regulated Learning

Learning environment influences	Person (Self) influences	Behavioral influences
Physical context	Knowledge	Enactment of self-regulatory activities
Task features	Declarative	Self-observations
External outcomes	Self-regulative	Self-evaluations
Material and social resources	Self-efficacy beliefs	Self-reactions
	Goals or intentions	Environmental structuring
	Metacognitive processes	
	Planning	
	Behavioral control	
	Affective process	

Source: from Self-regulating academic learning and achievement: The emergence of a social cognitive perspective, by B. J. Zimmerman (1990b), Educational Psychology Review, Vol. 2, No. 2., pp. 173-201.

2.3.3 Self-regulated learning strategies

Self-regulated learning strategies are actions and processes directed at acquiring information or skills that involve agency, purpose, and instrumentality perceptions by learners (Zimmerman, 1989; pp. 329). Indeed, all learners could use regulatory processes to a certain extent, but there are still some differences between ordinary learners and self-regulated learners, such as (1) the awareness of strategic relations between regulatory processes or responses and learning outcomes and (2) the use of these strategies to achieve their academic goals. Systemic uses of metacognitive, motivational and behavioral strategies are the key features of most definitions of self-regulated learners (Zimmerman, 1990; pp.5). Zimmerman and Martinez-Pons (1988) had proposed some of the self-regulated learning strategies based on the above criteria, including self-evaluation, organization and transformation, goal setting and planning, information seeking, record keeping, self-monitoring, environmental structuring, giving self-consequences, rehearsing and memorizing, seeking social assistance (peers, teachers, or other adults), reviewing (notes, books, or test). These proposed strategies were all aimed at improving students' self-regulation metacognitively, motivationally, and behaviorally in their learning. For example, giving self-consequences, self-evaluation, and self-monitoring are involved in the behavioral functioning in the learning of self-regulated learners. These strategies help the learners to be self-aware, knowledgeable, and decisive in their approach to learning (Zimmerman, 1990). In optimizing the personal functioning, goal setting and planning, organization and transformation, rehearsing and memorizing could enhance personal regulation in learning.

Record keeping, reviewing (notes, books, or test), information seeking, structuring environment, and seeking social assistance (peers, teachers, or other adults) are the strategies that help to improve the learning environment.

Research on self-regulated learning has shown that there is a significant relationship between the use of self-regulated learning and academic achievement. Moreover, further research studies on self-regulated learning revealed that high achievers would make greater use of learning strategies and higher perceptions of self-efficacy. For example, Pintrich (1990) had performed a correlational study to examine the relationships between self-regulated learning and academic performance. In his study, 100 girls and 73 boys of seventh graders were selected. A self-report measure of perceptions of self-efficacy, intrinsic motivation, test anxiety, cognitive strategies (rehearsal strategies, elaboration strategies, and organizational strategies), and metacognitive strategies (planning and monitoring) were administered. The results showed that metacognitive strategies, self-efficacy and text anxiety were the best predictors of performance. Intrinsic motivation had significant influence on the academic performance by means of its strong relations with metacognitive strategies and cognitive strategies.

In Stoynoff's (1996) study, interviews were conducted with 27 freshman undergraduates in a public northwest university. The 27 students, were divided into three groups: high achievers with GPAs of 3.3 or above, low achievers with GPAs of 2.7 or less, and moderate achievers with GPAs in between 2.7 and 3.3.

Eight categories of self-regulated learning strategies were covered in the interview including: (1) organizing and transforming instructional materials to enhance learning; (2) goal-setting and planning; (3) student-initiated attempts to seek additional information; (4) record keeping and monitoring of efforts; (5) student-initiated efforts to enhance the learning environment; (6) student-initiated efforts to rehearse and memorize content; (7) student-initiated efforts to seek the assistance of peers, teachers, or other adults; and (8) student-initiated efforts to review tests, notes, textbooks, or prepare for classes or exams. The results showed that high achievers reported greater use of learning strategies than low achievers although both high achievers and low achievers reported using many of the same self-regulated learning strategies.

In another study, which was conducted by Zimmerman and Martinez-Pons (1986), 40 sophomores (25 boys and 15 girls) from the advanced achievement tract and 40 sophomores (19 boys and 12 girls) from other (lower) tracks were randomly selected and interviewed to investigate the use of self-regulated learning strategies among high achieving students and low achieving students. The results showed that high achieving students displayed significant greater use of self-regulated learning.

Not only the high achieving students showed greater use of self-regulated learning strategies, gifted students also revealed similar results to the high achievers. Zimmerman and Martinez-Pons' (1990) study, of 45 boys and 45 girls of the 5th, 8th and 11th grades from a school for the academically gifted and identical number of students from regular schools showed that gifted students displayed significantly higher verbal self-efficacy, mathematical self-efficacy, and strategy used than regular students. Moreover, 11th grade students surpassed the 8th graders, who in turn surpassed the 5th graders on the three measures of self-regulated learning. Students' perceptions of both verbal and mathematical efficacy were related to their use of self-regulated strategies.

In Hong Kong, by using the data from PISA 2000, Ho (2004) found that self-regulated learning constructs, including control strategies, effort and persistence, self-efficacy, control expectation, competitive learning and cooperative learning, are all positively and statistically significantly associated to students' academic achievement in Mathematics literacy even when student and school background factors are taken into account Another of Ho's (2007) studies using data from PISA 2003, investigated the association between students' self-related cognition and Mathematics performance in Hong Kong. The results revealed that self-efficacy and self-concept were statistically significantly associated with students' Mathematics performance even after controlling student and school background factors. Another local study, which was a longitudinal study (Ning & Downing, 2010), aimed at examining the reciprocal relationship between motivation and self-regulatory by selecting 272 male students and 309 female students from first year business undergraduates at University of Hong Kong. The results of the study showed that students' self-regulation predicted their subsequent motivation and, after controlling for prior academic achievement, students' motivation and self-regulation were still found to be statistically significantly associated with students' performance.

To sum up, the use of self-regulated learning strategies; perceptions of self-efficacy, together with other motivational factors, such as anxiety, are all related to students' learning and academic performance, according to the preceding literature. In the present study, control strategies, elaboration, memorization, cooperative learning strategy, and competitive learning strategy will be addressed.

2.3.3.1 Control strategies

A learner is self-regulated when he/she is aware of strategies used to attain learning goals. In other words, the learner should be metacognitively aware of the learning status and the effectiveness of the strategies used. This refers to the learners monitoring their own learning. According to the study conducted by Spates and Kanfer (1977), self-monitoring alone could not improve learners' academic performance without criterion-setting. Therefore, Winne (1995) pointed out that monitoring has three functions: (1) to recognize whether information has been comprehended; (2) to gauge the extent to which information comprehended has been learned; and (3) to characterize states of comprehension and learning, if goals are not met. The presence, and perhaps the nature of that discrepancy triggers remedial procedures for filling gaps or repairing errors. Self-monitoring not only offers feedback on learning, so as to monitor whether the action taken and the outcome attained is the expected one and can attain the preset goals but also influences how learners relate to the reasons for success and failure and the level of sense of satisfaction (Ellis, & Zimmerman, 2001). Zimmerman and Paulsen (1995) pointed out that self-monitoring is an important component of self-regulated learning. By means of observing the skills, methods, and strategies used to evaluate the effectiveness for learning progress and performance, students can regulate and modify the actions taken, so as to attain their learning goals. Therefore, self-monitoring is a self-improving tool that helps students focus on their own learning. A formal self-monitoring involves systematic observations and judgments that reflect not only the present activities but also historical events (personal and contextual) leading up to and accompanying the activities. Therefore, through self-monitoring, the specific information gathered can be utilized to evaluate personal progress, to discern patterns of causality, to initiate strategies or interventions aimed at modifying or redirecting the action, and to set realistic performance standards (Bandura 1986; Corno 1989).

In the present study, the name "control strategies" is used instead of self-monitoring. In OECD (2003), it stated that "metacognitive strategies, implying conscious regulation of learning, are summed up in the concept of control strategies". So, control strategies are metacognitive strategies that involve planning, monitoring and regulation (Zimmermann and Schunk, 1989; cited from OECD, 2005). Students who use control strategies are able to manage their own learning: they check what they have learned, assess what they still need to learn and adapt information they have learned to new situations (Thomson, Cresswell, & De Bortoli, 2004). According to Ho's (2005) study, the data from the first cycle of PISA was used to analyze the relation between self-regulated learning and academic achievement of Hong Kong secondary school students by means of Hierarchical Linear modeling and the results of the study revealed that control strategies were one of the most important factors associated with students' academic achievements in all three domains, including reading literacy, Mathematics literacy, and scientific literacy, which were considered in the first cycle of PISA study. Thus, in PISA study, control strategies are important measures of the approaches to learning.

2.3.3.2 Elaboration

Zimmerman and Martinez-Pons (1986) pointed out that organizing and transforming are student-initiated overt or covert rearrangements of instructional materials to improve learning. Corno and Mandinach (1983) suggested that organizing and transforming strategies could reorganize information and this also included the selectivity and connection of new and old information. In the present study, these strategies are named as elaboration strategy, which could help making connections to related areas, thinking about alternative solutions (OECD, 2005). Elaboration strategies involve a student integrating new information with their existing knowledge base or prior learning, by exploring how the material relates to things learned in other contexts, or how the information could be applied in other contexts (Thomson, Cresswell, & De Bortoli, 2004).

In Willoughby, Porter, Belsito, and Yearsley's (1999) study, 134 students (69 males and 65 females) were selected from four elementary schools, of which 44 students were from grades 2, 45 students were from grades 4, and 45 students were from grades 6, to test for memory of information by using elaboration strategies. The results of the study showed that effectiveness of the use of elaboration strategies was important for the purposes of enahancing students' achievement and concluded that introducing strategies as early as possible in the educational curriculum is vital if teachers are to encourage children to become self-regulated learners. Swing and Peterson's (1988) study investigated the effects on achievement of elaboration strategies. There were 121 fifth grade students selected from six Mathematics classes, and the results showed that elaboration strategies were related to better performance. Another study conducted by Pintrich and De Groot (1990) showed similar results. In the study, a total of 173 seventh grade students (100 girls and 73 boys), were selected from eight science and seven English classes to examine the relationships between use of self-regulation, such as planning, skimming, and monitoring; and cognitive strategies, including elaboration strategies, rehearsal strategies, and organizational strategies, and academic performance. The results showed that elaboration strategy and self-regulation were positively correlated to students' performance separately. However, when considering cognitive strategy and self-regulation, cognitive strategy had negative correlations with performance. Pintrich and DeGroot stated that the use of cognitive strategies without the concomitant use of self-regulatory strategies was not conductive to academic performance. This was because students must be able to understand not only the "what" of cognitive strategies, but also how and when to use the strategies appropriately. In Ho's (2004) study, data from the first cycle of PISA was adopted to find out the relationships between self-regulated learning and academic achievement of Hong Kong students. The results showed that elaboration strategy was not a commonly used learning strategy by Hong Kong students when compared with the PISA participating countries but it was again an important learning strategy that statistically significantly affected the academic achievements of Hong Kong students in all three domains investigated in PISA study. Therefore, elaboration strategy will be considered with control strategies in the present study in order to have a better understanding of the learning of students.

2.3.3.3 Memorization

Memorization is a kind of learning strategy that has been studied for a long time. In Zimmerman and Martinez-Pons' study (1986), rehearsing and memorizing strategies were included in their model of self-regulated learning strategies and defined as learning strategies initiated by students to memorize material by overt or covert practice. In another study conducted by Zimmerman (1986), rehearsal and memorization strategies were defined as students making efforts to recite and to remember the information. Similar to Zimmerman, OECD (2005) also defined memorization strategy as repeated learning of material. For example, students could repeatedly write down Mathematics formulae before the Mathematics test until they could firmly remember them. Gauvain (2001) pointed out that memorization is an important learning strategy. As students have to deal with a large amount of information in the learning process, memorization could help students to recite, process, and extract the information that is related to the learning context. Thomson, Cresswell, and De Bortoli (2004) also pointed out that memorization strategy includes rote learning facts or rehearsal of examples. If the learner's goal is simply retrieval of information, then this strategy is adequate; however it rarely leads to deep understanding.

In Zimmerman and Martinez-Pons' study (1986), 54 boys and 27girls of 10th grade students were selected to examine the interrelationship between the use of self-regulated learning strategies and achievement. The results showed that high achievers used memorization strategy more frequently than the low achievers. Many westerners have the idea that Asian learners, especially Chinese learners, outperform their western counterparts (Biggs, 1991) because Chinese students are rote learners (Biggs, 1991; Kember and Gow, 1990). Further, in Marton, Dall'Alba, and Tse's (1996) study, they have found that there is a strong relationship between memorization and understanding among Chinese learners. They then identified two explanations of the use of memorization strategy among Chinese learners: (1) the mechanical memorization (that is simply a surface level approach, such as memorizing the facts) and (2) memorization with an intention to develop understanding (that means memorization with understanding). In Ho's (2004) study, by adopting the data of the first cycle of PISA to investigate the relationships between self-regulated learning and academic achievements of Hong Kong students, the results showed that the mean score in the use of memorization strategy by Hong

Kong students was higher than the OECD average. It means that Hong Kong students more frequently use this learning strategy than the PISA participating countries. Moreover, the results of Ho's (2004) study also revealed that memorization strategy was statistically significant to students' Mathematics learning but negatively correlated. This seemed partially to validate the perception that Chinese learners outperformed western learners because Chinese learners were rote learners. Hence, it is worth investigating how memorization affects the academic performance and whether there are gender differences. In the present study, memorization strategy will be considered as one of the learning strategies together with the control and elaboration strategies affecting academic performance.

2.3.4 Gender and self-regulated learning strategies

Many studies have tried to examine the relationships between self-regulated learning and academic performance and results of the studies have shown that self-regulated learning strategies are positively correlated to academic performance (e.g. Kitsanta, 2002; Pintrich and DeGroot, 1990; Staynoff, 1996; Schunk & Swartz, 1993; Zimmerman & Kitsantas, 1999; Zimmerman and Martinez-Pons, 1990). However, studies examining gender differences in self-regulation are relatively few (Hong, O'Neil, and Feldon, 2005). For example, in Zimmerman and Martinez-Pons' (1990) study, as mentioned before, 45 boys and 45 girls of the 5th, 8th and 11th grades were selected to examine whether there were any gender differences in self-regulation in learning as one of the objectives of the study. The results showed that, female students demonstrated greater use of monitoring, environmental structuring, goal setting, and planning but reported lower self-efficacy than their male counterparts. Another study conducted by Ablard and Lipschultz (1998), 105 girls and 117 boys of seventh-grade students, all high achievers, (scored in the top 3% in a grade-level achievement test) were selected to investigate gender differences in self-regulated learning by types of strategies by means of describing their use of self-regulated learning strategies and rating their achievement goals (mastery and performance). The findings showed that girls demonstrated significantly higher levels of self-regulated learning with advanced problem-solving strategies. Girls also showed a significantly stronger mastery orientation, although there was no difference in performance orientation. Moreover, the overall measures of self-regulated learning for girls were higher than those of boys; girls used strategies that optimized the immediate environment and personal regulation. From the above literature, more girls reported the frequent use of strategies in some kinds of learning contexts than boys. Contrary to these findings, Pokay and Blumenfeld's (1990) study selected 283 high school students in geometry classes mostly 10th grade, 130 girls and 153 boys. The results showed that there were no gender differences in the use of learning strategies, but it was reported that there was greater use of specific strategies (e.g., geometry specific strategies) by girls than by boys. Although there was evidence to show that self-regulated learning strategies could enhance students' academic performance, there were only a handful of studies to address the gender differences in the use of strategies and hence the academic performance. Therefore, there is a need to address whether there are any gender differences in self-regulated learning and how the differences influence the academic performance. In the present study, self-regulated learning strategies including control strategies, elaboration strategy, and memorization strategy will be addressed and they will be used as mediator variables to understand the underlying gender effects on Mathematics.

2.3.5 Gender and self-related cognitions

Self-regulation is any effort to alter or sustain one's own pattern of behavior. (Baumeister, Heatherton, & Tice, 1994), in an academic context, self-regulated learning has been characterized by motivational, cognitive, and metacognitive strategies that facilitate academic achievement (Bandura, 1993; McCombs, 1984). However, knowledge of cognitive and metacognitive strategies is usually not enough to promote student achievement; students must also be motivated to use the strategies as well as regulating their cognition and effort (Pintrich and DeGroot, 1990). Motivations that affect learning behaviors are related to the characteristics of the learners and the learning situations, and all these would also affect the choice of learning strategies. The personal characteristics include motivations, interests, self-efficacy, goal orientations, etc; learning situations include the nature of the tasks, the difficulties of the tasks, etc. The interactions of these factors will also affect the goals setting, expectations, and hence the degree of motivation. Leaners have to take actions to achieve the outcomes. Therefore, self-regulated learning researchers have emphasized that motivational components are crucial to the use of self-regulated learning strategies and academic performance of students (Abdul Ali Khan, 2001).

Based on the theory of motivation, there are three kinds of motivational components, they are (1) value component, which denoted students' beliefs and goals of the task; (2) expectancy component, which referred to the beliefs of the learners in their own abilities to achieve the goals; (3) affective component, which means the emotional reactions of the learners to the task, for example, the feeling of anxiety and worry before the examination. Pintrich and his colleagues (Pintrich, 1989; Pintrich, & DeGroot, 1990; Pintrich, & Schrauben, 1992) pointed out that these motivational components are related to self-regulated learning and academic performance.

Rheinberg, Vollmoyer, and Burns (2000) also pointed out that self-regulated learning is central to the motivational components as self-regulated learning is learning that is goal oriented, conscious, and under no tutors' immediate control. In other words, there is no other immediate control and guidance under self-regulated learning. Thus, learning motivation should play a particularly important role for the learners to keep on learning. Learner's personal characteristics, such as interests, self-efficacy, interaction with the learning situation, such as task difficulty, influence of the goals and expectations can further determine the strength and quality of learning motivation and hence through mediating variables (learning activities or strategies) to achieve learning outcomes. Therefore, self-regulated learning can be seen as the combination of skills and will of the learner. Skills are the use of various learning strategies, and will is the motivation to learn, including goals, values and expectations.

Since motivational components are important to self-regulation and academic performance, these components will be considered in the present study and its relationships with gender will be presented below in detail. In the present study, the motivational components are categorized as self-related cognitions, including intrinsic motivation, instrumental motivation, self-efficacy, anxiety, and self-concept.

2.3.5.1 Motivation

Pintrich and DeGroot (1990) stated that knowledge of cognitive and metacognitive strategies is usually not enough to promote student achievement; students must also be motivated to use the strategies as well as regulating their cognition and effort (Paris, Lipson, & Wixson, 1983; Pintrich, 1988, 1989; Pintrich, Cross, Kozma, & McKeachie, 1986). According to goal theorists, they pointed out that individuals' goals have important implications for how they perceived the learning task and what they learnt. Different researchers have various labels for distinguishing intrinsic and extrinsic goal orientation, for example, Dweck and Leggett (1998) labeled the two orientations as learning and performance goals, Ames (1992) labeled them as mastery and performance goals, Nicholls (1984) labeled them as task-involved and ego-involved goals and, and Maehr and Midgley (1991) named the two orientations as task and performance goals. In the present study, the terms intrinsic and instrumental motivation are used. Intrinsic motivation is internally generated (OECD, 2004) and comes from the rewards inherent to a task or the activity itself. Under intrinsic motivation, individuals are willing to seek to improve their level of competence and understanding in learning. In the present study, intrinsic motivation is subject-related interest, which affects continuity and intensity of engagement with learning, or it is closely related to the interest dimension which is enjoyment of Mathematics and intrinsic value of Mathematics (Aiken 1974). For example, a student puts effort in and spends time on learning Mathematics because the student intrinsically enjoys reading about Mathematics and solving Mathematics questions. Moreover, intrinsic motivation is viewed as having positive effects on learning activities, such as time on task, more comprehensive learning strategies, and performance and activity choices in the absence of extrinsic rewards (Lepper, 1988). In contrast, instrumental motivation comes from the outer world of the learner, simply, the desire to obtain something practical or concrete from the study (Hudson, 2000) or from external rewards for good performance such as praise or future prospects (OECD, 2004). For example, students put effort in learning Mathematics because they want to have better career prospects, or hope that Mathematics could help them in further study. Such motivation is a driving force for the learner in order to have rewards in a practical and concrete form from the outer world but not because of the interest of the learner in Mathematics, but the functional or instrumental value of learning Mathematics.

Studies have shown that both intrinsic motivation and instrumental motivation are important predictors for academic performance and the choices of learning strategies. In Ames and Archer's (1988) study, a hundred and seventy-six students with ninety-one boys and eighty-five girls in grade eight to grade eleven were randomly selected. Questionnaire on their perceptions of the classroom goal orientation, use of effective learning strategies, task choices, attitudes, and causal attributions were used to investigate the relationship. The results showed that the perceived mastery of goals was positively correlated to using effective learning strategies, choosing challenging tasks, positive attitude toward the class, and attributing success to effort. In Pintrich and DeGroot's (1990) study, 173 seventh grade students, with 100 girls and 73 boys were selected and relationships between self-efficacy, intrinsic value, test anxiety, self-regulation, the use of learning strategies and performance were administered. The results showed that intrinsic motivation was positively correlated to academic performance and it also strongly related to self-regulation and the use of learning strategies. In another study, Gottfried (1985) reported that academic intrinsic motivation was found to be significantly and positively correlated with children's school achievement, especially in learning Mathematics. In Ho's (2007) study, data of PISA 2003 was used to analyze the effects of self-related cognitions to Mathematics performance of Hong Kong students. The results of the study showed that intrinsic motivation was significantly and positively associated with students' Mathematics performance. Therefore, intrinsic motivation was an important predictor of Mathematics achievement.

In contrast to intrinsic motivation, instrumental motivation is less likely to lead to high achievement. In Schunk's (1996) research, two studies were conducted. In his first study, 44 fourth-grade students were drawn from two classes in one elementary school, including 18 girls and 26 boys, to investigate if the relationships between self-evaluations of capabilities would positively affect motivation, self-efficacy, learning goal orientation, and skills. The results showed the learning goal (i.e. the intrinsic motivation in the presents study) led to higher self-efficacy, skill, motivation, and task orientation than the performance goal (i.e. the instrumental motivation in the present study). In his second study, 20 boys and 20 girls of fourth grade were selected to further investigate the influence on achievement outcomes by learning goals and performance goal. The results showed learning goals led to better achievement outcomes than performance goals. Moreover, in Schunk's (1996) study, there were no gender difference in either learning or performance goals affecting the achievement outcomes. Intrinsic motivation seems to have greater impact on other motivational components, learning strategies and achievement outcomes than on instrumental motivation. In Eccles and Wigfield's (1995) study, 1317 students were selected from grade five to twelve and they reported that utility value of the task, that is the instrumental motivation in the present study, was found to be positively correlated to intrinsic motivation. In Ho's (2007) study, data of PISA 2003 was used to analyze the effects oi self-related cognitions to students' Mathematics performance. The results showed that both intrinsic motivation and instrumental motivation were positively and significantly correlated to students' Mathematics performance in Hong Kong with the value of correlation coefficient of intrinsic motivation higher than the value of correlation coefficient of instrumental motivation. This shows that both intrinsic motivation and instrumental motivation are important factors in student learning. With higher intrinsic motivation and instrumental motivation, students would pay more effort and have higher levels of persistence in difficult tasks and also have better achievement outcomes.

As both types of motivation are important for learning, are they equally important to different genders? In a study conducted by Wolters and Pintrich (1998), 545 seventh and eighth grade students were selected, of which 280 were female, 265 were male. Students had to complete a self-reported questionnaire that assessed students' motivation and cognition, including the instrumental value and interest, self-efficacy, and test anxiety and the two cognitive components of cognitive and self-regulatory strategy use. The performance measured was teacher reported grades. The results showed that there were no statistical significant gender difference in instrumental value and interest. Another research conducted by Meece, Glienke, and Burg (2006) also reported that there were no gender difference between learning or mastery goal and performance goal. Similarly, in Meece and Jones' (1996) study, 213 fifth- and sixth-grade students (108 girls and 105 boys) were selected to examine gender differences in motivation and strategies used. The results showed no gender differences in mastery and performance goals. However, in Anderman and Young's (1994) study, the relationships of motivations and the use of strategies were investigated in sixth- and seventh-grade students. There were 678 students in the samples selected from two middle schools, of which 51% of the students selected were girls and 49% of the students selected were boys; 51% students selected were from the sixth-grade and 49% of the students selected were from the seventh-grade. The results showed that girls were more learning goal-oriented than boys. Middleton and Midgley's (1997) study selected 703 sixth graders (49% males and 51% females) who also reported similar results that girls espoused task goals (i.e. mastery goal) more than the boys did, whereas, boys showed more performance goal-orientated than the girls did. Eccles (1994), however, reported that girls liked Mathematics less than boys did and girls also rated Mathematics as less useful than the boys did. From the above literature, there are three main discourses. The first one is that there are no gender differences between intrinsic motivation and instrumental motivation; another one is girls are more intrinsic motivation- oriented and less instrumental motivation-oriented than the boys. The third one is that girls are less intrinsic motivation-oriented and less instrumental motivation-oriented than the boys. As both motivational components are important to learning, they will all be considered in the present study, and the role gender plays will also be investigated.

2.3.5.2 Anxiety

The impact of anxiety has raised the concern of many researchers for several decades (Endler & Edwards, 1982). The construct of anxiety is broadly defined to be a state of emotion associated with fear and dread (Lewis, 1970). This emotion is unpleasant, is future-oriented, and is out of all proportion to the threat (Hembree, 1990). Its special characteristics are "the feelings of uncertainty and helplessness in the face of danger" (May, 1977, p. 205). In the present study, Mathematics anxiety will be considered.

According to OECE (2005), Mathematics anxiety is categorized as feelings of helplessness and emotional stress when learning Mathematics and handling Mathematics problems. Richardson and Suinn (1972) defined Mathematics anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of Mathematics problems in a wide variety of ordinary life and academic situations. Mathematics anxiety may prevent a student from passing fundamental Mathematics courses or prevent his pursuit of advanced courses in Mathematics or the sciences" (p. 551). Therefore, Mathematics anxiety is usually found to be strongly and negatively related to Mathematics achievement but this relationship is not in a stable relationship depends on many other factors, such as students' social and academic background (Ma, 1999). It could also be shown that Mathematics anxiety has rather indirect effects on achievement, once self-related cognitions such as self-efficacy and self-concept are taken into account (Meece, Wigfield, & Eccles, 1990).

Numerous research studies have been conducted exploring the relationship between anxiety and academic performance. In Ho's (2007) study, by adopting the data of PISA 2003 to investigate the relationship between Mathematics anxiety and students Mathematics performance, the results showed that Mathematics anxiety was negatively and significantly associated with Mathematics performance. In Hackett's (1985) path analysis, 117 undergraduate students were selected (72 females and 45 males), the results showed that there was a significant negative relationship between Mathematics anxiety and

Mathematics achievement. Moreover, female students showed significant negative relationship with Mathematics anxiety. This is not the only results to show that Mathematics anxiety is negatively related to academic achievement and females have higher anxiety levels when compared with males. For example, Bander & Betz (1981) selected 180 undergraduate students from introductory psychology courses, female students reported higher levels of anxiety than the male students did. In a cross-nation study by Ho, Senturk, Lam, Zimmer, Hong, Okamoto, Chiu, Nakazawa, and Wang (2000), 671 sixth-grade students were selected, in which, 92 girls and 119 boys were from China, 106 girls and 108 boys were from Taiwan, and 111 girls and 135 boys were from the United States, to examine the relationships of Mathematics anxiety in affective and cognitive dimension with Mathematics achievement. The results showed that the affective dimension of Mathematics anxiety was consistently, significantly and negatively associated with Mathematics achievement across-nation whereas the cognitive dimension of Mathematics anxiety yielded inconsistent results across the samples. Gender differences in anxiety level were also found in Taiwanese's and the U.S. samples. A meta-analysis conducted by Hembree (1988) using 562 studies to investigate the difference between males and females and the effect of test anxiety on academic performance. The results showed that test anxiety caused poor performance and females showed a higher level of test anxiety than males did. Another meta-analysis conducted by Hembree (1990) 151 studies were used to investigate the effect of Mathematics anxiety. The results showed that Mathematics anxiety is related to poor performance on Mathematics achievement and females displayed higher levels of Mathematics anxiety than males did. Indeed, a number of research studies have shown similar results that Mathematics anxiety is negatively related to academic performance and females report higher level of Mathematics anxiety. But, what could be the reasons for the negative relationship between anxiety and academic performance?

Hunsley (1985) suggested that anxiety was associated with low self-efficacy. Feeling less prepared and anxious, students had more negative thoughts. So, Mathematics anxiety would link to low self-efficacy in learning Mathematics, and those students were doubting their capacity to learn Mathematics, and hence lower the expectation in their academic performance in Mathematics. Wine (1971, 1980) suggested that highly anxious students are more likely to be extremely self-conscious in performance setting, which distracts their attention from focusing on the tasks in hand. Hill (1972) suggested that anxiety is developed as early as preschool years. Students respond to parents' high standards, coupled with parents' critical reactions to the children's performance. Highly anxious students would become more responsive to adults' evaluative reactions and avoid criticisms and failure or strive for success. In Hill's idea, highly anxious students may persist longer than less anxious students when striving for praise. On the other hand, highly anxious students tend to leave the situation of criticism and failure as soon as possible. Culler and Holahan (1980) tried to explain the relationship between anxiety and academic performance by means of study-related behavior, or studying skills. They reported that highly-anxious students displayed poorer study skills than less anxious students.

In Pintrich and DeGroot's (1990) study, they have also found that high anxiety is related to low self-efficacy and less use of self-regulated learning strategies during learning. Since there are gender differences in the reporting level of anxiety and girls are found to be significantly more anxious than boys. Yue (1996) suggested that this may be due to girls' lower perception of their abilities.

All the above literature shows that the motivational component, anxiety, especially for girls, is one of the important components in clarifying and explaining students' academic performance, which affects the motivational beliefs and also the use of effective learning strategies and skills, and then influences the academic performance in turn. As motivational constructs is one of the three components in self-regulated learning, the present study considered Mathematics anxiety as one of the motivational components in affecting Mathematics performance of students.

2.3.5.3 Self-efficacy

The very fundamental basis of social cognitive theory in human agency is to consider individuals who can proactively engage in their own development and take actions. The basis of this idea is that individuals possess self-beliefs that enable them to exercise a measure of control over their thoughts, feeling, and actions that "what people think, believe, and feel affects how they behave" (Bandura, 1986, p.5). Bandura (1986, 1997) contended that, among all the self-beliefs, it is the beliefs that individuals hold about their capabilities that influences the choices they make, the effort they spend, how much persistence they have when facing difficulties, how anxious they are when facing the tasks. He defined the term, self-efficacy, as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p.391). Simply, self-efficacy is an individual's beliefs regarding his or her own ability to succeed at a particular task (Hong, O'Neil, & Feldon, 2005, p. 269). Pajares (1996) further pointed out that self-efficacy and other expectancy beliefs have in common that they are beliefs of one's perceived competence; and the differences are that self-efficacy is defined in terms of individuals' perceived capabilities to attain designated types of performance and achieve specific results (Pajares, 1996, p. 546). Therefore, self-efficacy is sensitive to contextual factors. Bandura (1986, 1989) and Pintrich and Schunk (1995) also pointed out that self-efficacy judgments are both more task- and situation-specific compared with other expectancy beliefs.

According to Bandura (1986), self-efficacy plays an important role in learning and the feeling of confidence about a specific problem is crucial to an individual's capacity to solve that problem. In Mathematics learning, many research studies have confirmed that Mathematics self-efficacy is positively associated with students' academic performance and directly affects the performance. For example, In Schunk's (1981) study, 33 boys and 23 girls, with mean age from 9 years 10 months, of low arithmetic achievement were selected to examine the effect of self-efficacy, persistence and achievement. The results showed that perceived efficacy was an accurate predictor of arithmetic performance. In Schunk's (1984) another study, it further examined the role of self-efficacy and persistence in achievement and the results of the study showed that self-efficacy affected achievement directly and indirectly through persistence. Similarly, in Zimmerman, Bandura, and Martinez-Pons's (2002) study, 50 boys and 52 girls from grade nine to grade ten were selected to examine the causal role of students' self-efficacy beliefs and academic goals in self-motivated academic attainment by means of path analysis. The results of the study showed that self-efficacy not only influenced achievement directly but also affected students' achievement goals and hence further impacted on achievement. In a meta-analysis of the relationships between self-efficacy beliefs and academic performance, Multon, Brown, and Lent (1991) used 38 studies from 1981 to 1988 for analysis and concluded that self-efficacy was positively and statistically significant related to academic performance.

From the results of the above literature, self-efficacy is not only positively, statistically significant and directly related to academic performance, but it also acts as a mediator to influence achievement indirectly. Bandura (1993) pointed out that perceived self-efficacy exerted its influence through four processes, including cognitive, motivational, affective, and selection processes. In cognitive processes, a student with stronger perceived self-efficacy would set higher goal challenges and persist longer when facing difficulties. For example, in Collins's (1982) study, students at three level of mathematical ability – low, medium, and high, were selected to examine the effect of mathematical self-efficacy. The study found that students with higher perceived self-efficacy not only performed better but also discarded faulty strategies more quickly and reworked more problems they failed at each of the ability levels. In motivational process, self-efficacy influences causal attributions and causal attributions affect motivation, performance and affective reactions. A student who regards himself as highly efficacious would attribute his failure to insufficient effort; and those who regard themselves as inefficacious attribute their failure to low ability. According to Bandura (1993), self-efficacy beliefs contribute to motivation by means of determining the goal setting, spending of effort, level of persistence in face of difficulties, and resilience to failures. For example, Schunk's (1984) study showed that students' development of cognitive skills were directly attained by self-efficacy and indirectly by sustaining persistent effort in face of difficulties. In affective processes, Bandura (1993) pointed out that "people's beliefs in their capabilities affect how much stress and depression they experience in threatening or difficult situations, as well as their level of motivation" (pp.132). In Meece, Wigfield, and Eccles's (1990) study, 131 girls and 119 boys from grade seven to grade nine were selected to examine the relationships between past performance, ability perceptions, performance expectancies, anxiety, and performance. The results showed students' perceived self-efficacy mediate the effect of anxiety on performance. Bandura (1993) further pointed out that only if students' sense of efficacy has been weakening by failures do they become anxious and hence perform less well. Otherwise; their performance, may not be affected. Therefore, students" beliefs in their capabilities have a direct effect in predicting their subsequent academic attainments; than bearing little or no relationship to their academic performances. Another main result of Meece, Wigfield, and Eccles's (1990) study showed that there was no gender difference in Mathematics anxiety to predict achievement for boys and girls. Instead, the difference in achievement is due to the gender difference in achievement-related perceptions. The results of the study give an important implication that one of the possible ways to reduce the level of anxiety is to help develop the sense of self-efficacy. In the selection process, it is believed that beliefs of personal efficacy influence the choice of activities and environments. People with low self-efficacy would avoid taking challenging activities. On the other hand, people who judge themselves as capable would take challenging activities and persist longer when facing difficulties. In Zimmerman, Bandura, and Martinez-Pon's (1992) study, 50 boys and 52 girls of ninth- and tenth-grade students were selected to examine the relationships of students' self-efficacy beliefs, academic goals, and achievement. The results showed that perceived efficacy promoted academic achievement both directly and by raising personal goals. In Ho's (2004) study, the data of PISA 2000 was used to investigate the relationships between self-efficacy and Mathematics performance of Hong Kong students. The results showed that self-efficacy was positively and significantly correlated to Mathematics performance. In another Ho's (2007) study, data of PISA 2003 was used to investigate the effect of self-efficacy to Mathematics performance of Hong Kong students by means of Hierarchical Linear Modeling. In the study, after controlling school level factors, such as percentage of girls, percentage of immigrants, percentage of single parent families, schools' mean SES, and schools' mean intake, self-efficacy was still a strong predictor, positively and significantly, of Mathematics performance. As Pajares (2005) stated that self-efficacy is a not only a stronger predictor of a related outcome, but also as a common mechanism that influences anxiety, self-concept, perceived value, and other motivation constructs. Therefore, Mathematics self-efficacy will be considered together with anxiety, Mathematics self-concept, intrinsic motivation and instrumental motivation in the present study.

Since self-efficacy is so important in predicting students' achievements, is there any gender difference in self-efficacy, more precisely, Mathematics self-efficacy? In Pajares and Miller's (1994) study, 229 females and 121 males undergraduates were selected to examine the predictive and meditational role of self-efficacy in Mathematics and gender differences by using path analysis. As shown from the above literature, the results were consistent as Mathematics self-efficacy was a strong predictor of Mathematics performance and it also acted as a mediator of self-concept. Two important results of the study were that Mathematics self-efficacy also mediated the gender effect on Mathematics performance and males showed higher Mathematics self-efficacy than females. In the present study, gender difference will also be considered.

2.3.5.4 Self-concept

Apart from self-efficacy, another belief that students hold about their own academic abilities is self-concept. Pajares and Miller (1994) pointed out that the conceptual difference between self-concept and self-efficacy was not clear. Different researchers used different terms to define these two concepts. For example, Reyes (1984) synonymously used the terms math confidence and math self-concept; Felson (1984) used the term academic self-concept to refer to self-perceptions of ability; other researchers used the term self-concept of ability and operationalized it as the rating of individuals about their ability in the academic areas (e.g. Bachman & O'Malley, 1986; Feather, 1988). According to Pajares and Miller (1994), this was basically generalized academic self-efficacy. Pajares and Miller (1994, p194) further pointed out that "self-efficacy was a context-specific assessment of competence to perform a specific task, a judgment of one's capabilities to execute specific behaviors in specific situations" whereas, self-concept was not a measurement at that level of specificity and it included "the beliefs of self-worth associated with one's perceived competence". Therefore, self-efficacy is beliefs regarding confidence and hence is part of an individual's self-concept. However, Bandura (1986) argued that these two constructs of beliefs were representing two different phenomena and hence they must not be mistaken for each other. Based on Shavelon, Hubner, and Stanton's (1976) introduction of the differentiation of self-concept in different domains, academic self-concepts were differentiated into various disciplines, such as Mathematics self-concept, English self-concept, science self-concept, etc. And the idea of self-concept became subject-specific. Compared with self-efficacy, beliefs of self-concept are more globalized and less context dependent (Pajares and Miller, 1994, p194).

Although there are imprecise definitions of on self-concept and self-efficacy, few studies tried to clarify them. In Marsh, Walker, and Debus's (1991) study, they tried to compare the effect of Mathematics achievement on self-concept and self-efficacy. The results showed that there was a stronger effect on self-concept than self-efficacy. In Relich's (1983) study, it tried to investigate the relationships between math self-concept, Mathematics achievement, performance on a division task, and self-efficacy for the division task. The results showed that the correlations between Mathematics achievement with self-efficacy and self-concept were equally strong but the correlation between the performance on the division task and self-efficacy for the division task was stronger than with self-concept. This result supported the task-specific nature of self-efficacy. In Pajares and Miller's (1994) study, 350 undergraduates, of which 229 were women and 121 were men, were selected to investigate the effect of self-efficacy and self-concept in Mathematics. The results showed that the effect of self-concept was still positively and statistically significant to Mathematics achievement although self-efficacy was more predictive than self-concept. However, it does not mean that it is not worth considering them separately. In Pajares and Miller's (1994) study, the result also showed that males had a statistically significant higher self-concept than their female counterparts. Also, in Guay, Boivin, and Marsh's (2003) study, 385 students (202 girls, and 183 boys) were selected of which 125 students were from grade 2, 147 students were from grade 3 and 113 students were from grade 4, to investigate the causal ordering between academic self-concept and academic achievement. The results of the study showed that self-concept had a positive significant effect on academic achievement. In a Longitudinal study by Marsh, and Yeung (1998), by using data from NELS88 (National Education Longitudinal Study of 1988) which contained 24599 students from grade 8 in 1988, with follow up data collection in 1990 and 1992, to investigate the gender differences in the model of development in Mathematics self-concept and Mathematics achievement. The results of the study showed that Mathematics self-concept had positive and significant effects on Mathematics achievement, although girls had better Mathematics achievement than boys, they had lower math self-concept. The results were consistent with similar studies conducted over past 20 years (Marsh and Yeung 1998). To summarise, self-efficacy is content-specific whereas self-concept is a belief of self-worth. As shown from the above research studies, self-concept has significant effects on Mathematics achievement; it is not comprehensive enough if only self-efficacy is considered. Therefore, both self-efficacy and self-concept should be included.

2.3.6 Learning preferences

2.3.6.1 Cooperative learning

Learning behavior is also influenced by the students' preference for learning situations. Owens and Barnes (1982, p.183) proposed that "a student's preference for a mode of learning — cooperative, competitive, or individualized — is a basic part of the "mental set" by which a learner perceives dimensions of classroom atmosphere or climate. Cooperative learning and competitive learning are the learning preferences to be considered in PISA 2003 (OECD, 2005) and the present study. Further, according to Johnson and Engelhard (1992, p.385), student learning preferences refer to student choice of the type of classroom structure within which they prefer to work to accomplish academic goals – whether in cooperation with their peers, in competition with their peers, or having no involvement with their peers. PISA 2003 (2004) has defined cooperative learning as a kind of learning atmosphere or environment, in which students prefer to work in groups and think they benefit from group working. In Slavin's (1980) meta-analysis, 28 studies were analyzed to examine the effect of cooperative learning for enhancing students' achievement. The study concluded that cooperative learning had a positive effect on increasing students' achievement. Slavin (1984) has argued that a possible factor responsible for the success of cooperative group instruction is the positive motivational impact of peer support for learning. Cooperative groups may direct students toward improving their knowledge in their pursuit of the team goal of demonstrating achievement. In Slavin's (1996) article, it further explains that cooperative learning enhances achievement in four ways. From motivational perspectives, the personal goal is the same as success of the group. Therefore, in order to achieve the personal goal, group members have to help their groupmates and to encourage them their groupmates to exert maximum effort. From a social cohesion perspective, students help others because they care about one another and want others to succeed. That means the effects of cooperative learning on achievement are strongly mediated by the cohesiveness of the group (Slvain, 1996, p.46). From a cognitive perspective, students' achievement would be increased when there are interactions among students because such interactions would enhance mental processing of information, such as elaboration. When a student is trying to answer a question from another student, information has to be retained in memory and related to information already in memory, then the student has to engage in some sort of cognitive restructuring of the materials (Slvain, 1996, p.50). From a developmental perspective, interaction among children around appropriate tasks increases their mastery of critical concepts. That means students may enhance their achievement through modeling. Zimmerman (1986) also pointed out that learning through peers had better effects than the learning through discovery approach.

Some studies also support the positive effect of cooperative learning in enhancing Mathematics achievement. Nichols and Miller (1994) examined the effects of cooperative group learning on students' motivation and achievement in Algebra II. In their study, sixty-two students were randomly assigned to either a cooperative learning or traditional lecture group. Students took pretests and post-tests which assessed efficacy, intrinsic valuing, and goal orientation. Algebra achievement was assessed at the same time using a teacher-made exam. Students in the cooperative classroom exhibited significantly greater gains than the control group in algebra achievement, efficacy, intrinsic valuing of algebra, and learning goal orientation. In another study conducted by Nichols (1996), 80 students with 68 tenth grade students, 10 eleventh grade students, and 2 twelfth grade students were selected from a suburban high school and were randomly assigned to either a control group receiving traditional instruction or treatment group receiving cooperative learning instruction. Students took pretests, posttests, and post-posttest assessment of efficacy, intrinsic valuing, and goal orientation. Geometry achievement used scores from the IOWA Test of Basic Skills and teacher-made exams. The results of the study showed that when compared to students receiving traditional instruction, students in a cooperative learning condition (a) displayed higher levels of geometry achievement, (b) reported being more learning goal oriented, (c) had greater positive self-efficacy beliefs regarding their abilities in geometry, (d) displayed greater intrinsic valuing of geometry. In Ho's (2004) study, which used data of PISA 2000 to investigate the effect of cooperative learning on Mathematics performance of Hong Kong students, the results of the study showed that cooperative learning was positively associated with Mathematics performance for Hong Kong students although they were not statistically significant. However, very few studies have examined the gender effect in cooperative learning. In Liu's (2009) analysis, the study explored the gender difference of cooperative learning by using PISA 2003 data and regression, and the results showed that more female students from Hong Kong and United States preferred cooperative learning than the male students did. However, cooperative learning showed a negative effect on achievement for both female and male students from Hong Kong and United States, although not statistically significant. This violates most of the results of the previous literature. Therefore, it is necessary to clarify the results in the present study.

2.3.6.2 Competitive learning

Another learning preference of students to be considered in the present study is a competitive learning strategy. According to OECD (2004), competitive learning is defined as striving to be better than others (Owens and Barnes, 1992). According to Deutsch (1949), a competitive social situation is one in which the goal attainment of the separate participants are so linked that there is a negative correlation among their goal attainments. An individual can attain his or her goal if and only if the other participants cannot attain their goals. Thus a person seeks an outcome that is personally beneficial but is detrimental to the others with whom he or she is competitively linked. In a Meta-analysis conducted by Qin, Johnson, and Johnson (1995), 46 studies, published between 1929 and 1993, were used to examine the impacts of cooperative and competitive learning on achievement. The research has categorized the type of problem solving of the 46 studies into 4 categories because one of the objectives of the research is to clarify whether cooperation promotes higher- or lower-quality problem solving than competition does. The four categories include linguistic (solved through written and oral language), nonlinguistic (solved through symbols, math, motor activities, actions), well-defined (having clearly defined operations and solutions), and ill-defined (lacking clear definitions, operations and solutions). The result of the research showed that cooperative learning outperformed competitive learning in all four types of problem solving measures and the results held for all ages and that cooperative learning has a greater effect on nonlinguistic problems than linguistic problems. In Ho's (2004) study, by adopting data from PISA 2000 to analyze the effect of competitive learning on Mathematics performance of Hong Kong students, the results of the study showed that competitive learning was positively and statistically significantly associated with Mathematics performance.

For the gender difference among competitive learning, Owens and Barnes's (1982) study selected 141 girls and 138 boys from grade seven and grade eleven to examine the relationships between learning preferences and English and Mathematics learning. The results showed that more girls than boys preferred competitive learning in English and more boys than girls preferred competitive learning in Mathematics. In another study conducted by Johnson and Engelhard Jr. (1992), 77 boys and 59 girls from sixth- and seven-grade were selected to examine the relationships around gender, academic achievement and student preferences for cooperative, competitive, and individualistic learning. The results showed that girls reported higher preference for cooperative learning than boys' and there were no significant gender differences for competitive learning and individualistic learning. The results of the study also showed that academic achievement did not correlate significantly to any of the preferences. However, academic achievement increased as girls' preferences for competition increased and boys' preferences for competition decreased.

Although many studies reported that cooperative learning could enhance academic achievement and some research studies even showed that cooperative learning had greater effects on academic achievement (see Johnson et al, 1981), it does not mean competitive learning methods are hazardous to learning. In Ho and Hau's (2008) study, it examined the effect of cooperative and competitive learning strategies in a Chinese context. In their study, 1950 seventh-grade Chinese students were selected, of which 47.3% of the subjects were boys and 52.7% of the participants were girls. The results of the study showed that competitive and cooperative learning correlated positively and significantly. That means these two learning preferences were not contradictory to each other in a Chinese context. Hong Kong students would compete and cooperate with others at the same time while learning. However, very few studies have investigated the gender differences in cooperative learning and competitive learning preferences, especially in various Mathematics domains. Therefore, the effects of gender on academic performance under cooperative learning and competitive learning will be investigated in the present study,.

2.4 Summary

Boys outperforming girls in learning Mathematics seems to be a common belief. However, some have argued that the gap is narrower although the gender gap in learning Mathematics still exists. So, there is no need to put extra effort to make changes. No matter what the belief is, it is essential to find out if there are any possible ways of enhancing students' learning for both males and females. At the beginning of the chapter, gender differences in learning Mathematics across grades and across various Mathematics domains, including quantity, space, shape, change and relationship and uncertainty are reviewed. Literature reviews on investigation of the narrowing gender gap followed.

Many studies have examined how students' achievements are affected by various learning strategies, various affective factors, and learning preferences. The effects of gender on those captioned factors on students' achievements have been well researched. However, there are few studies which tried to examine the effects of all these different factors on students' achievement and the gender effects together. Local studies are even fewer. Therefore, the present study will be based on the framework of self-regulated learning and try to examine the effects of learning strategies, affective factors and learning preferences on students' Mathematics achievements and the gender effects. In section two of this chapter, theories of self-regulated learning and self-regulated learning in social cognitive perspectives have been reviewed. The effects of self-regulated learning strategies, including control strategies, elaboration, and memorization; self-related cognitions, including motivation (intrinsic motivation, instrumental motivation), anxiety, and self-efficacy; and learning preferences, including cooperative learning and competitive learning on achievements and their gender effects will be reviewed in section three separately.

Chapter3

The Study

3.1 Introduction

PISA is an international assessment launched by the Organization for Economic Cooperation and Development (OECD) in response to provide cross-nationally comparable evidence on students' performance in Mathematics, Science, Reading and Problem Solving (OECD, 2004). The first PISA assessment was conducted in 2000 focusing on reading literacy and has been administered every three years. The data used in the present study comes from the PISA 2003 assessment which was the second cycle assessment and has been focusing on Mathematics literacy, consisting of both Mathematics assessment and student survey. The Mathematics assessment includes four domains: space and shape, change and relationships, quantity, and uncertainty. The student survey is a student questionnaire that seeks for information on student approaches to learn through self-regulated learning (OECD, 1999, 2004). The instruments in the student questionnaire were constructed and developed by OECD.

3.2 Conceptual Framework

PISA is an international study to asses how well 15-year-old youths approaching the end of compulsory education have acquired the knowledge and skills essential for participation in our challenging society (Ho, 2005a, 2005b; OECD, 2005). In PISA study, the concept of literacy is used because PISA concerns the capacity of students to apply the knowledge and skills and to analyze, reason and communicate effectively as they pose, solve and interpret problems in a variety of situations (OECD, 2004, p.24). PISA 2003 was the study that focused on the Mathematics performance of the students by means of Mathematics literacy. According to OECD (2008), Mathematical literacy is an individual's capacity to identify and understand the role that Mathematics plays in the world, to make well-founded judgments and to use and engage in Mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen. And, according to the Education Bureau of Hong Kong (2008), knowledge of Mathematics is a necessity for every individual if they are to contribute towards the prosperity and the knowledge and skills that will help them live a full life in the society of the 21st century. Moreover, Mathematics pervades all aspects of life. It is not possible to live in the modern world without making some use of Mathematics. Many of the developments and decisions made in industry and commerce, the provision of social and community services as well as government policy and planning etc., rely to some extent on the use of Mathematics. So, in general, Mathematics is essential in the school curriculum of Hong Kong, as it is: (a) powerful means of communication; (b) tool for studying other disciplines; (c) an intellectual endeavor and a mode of thinking; and (d) discipline, through which students can develop their ability to appreciate the beauty of nature, think logically and make sound judgments. Therefore, the data from PISA 2003 will be used in the present research for analysis. However, not the whole data set will be used in the present study, only the student questionnaire of PISA 2003 and part of the questions that are related to the interest of the present study are used.

The present study aims at confirming gender differences on the influences of students' learning characteristics such as motivational factors that affecting learning, self-related beliefs, anxiety to learn, learning strategies using by students, and the learning preferences for learning situations, on Mathematics. Gender differences in learning Mathematics will be measured by means of the differences of effect of gender on Mathematics achievements of the four domains by adopting the theory of self-regulated learning. The present study will use the data gathered from PISA 2003 student questionnaire, which seeks information of students' approaches to learn through self-regulated learning. The conceptual framework of the present study will base on the concept of self-regulated learning theory in social cognitive perspective. According to Bandura (1986), from social cognitive perspective, human functioning is considered as reciprocal interactions among personal variables, behaviors, and environmental variables (Schunk, 2001, Fig 2.1). Zimmerman (1986, 1989) applied the social cognitive perspective to students' self-regulated learning process, and stated that personal processes were influenced by environmental and behavioral events in reciprocal fashion (Zimmerman, 1989, p.

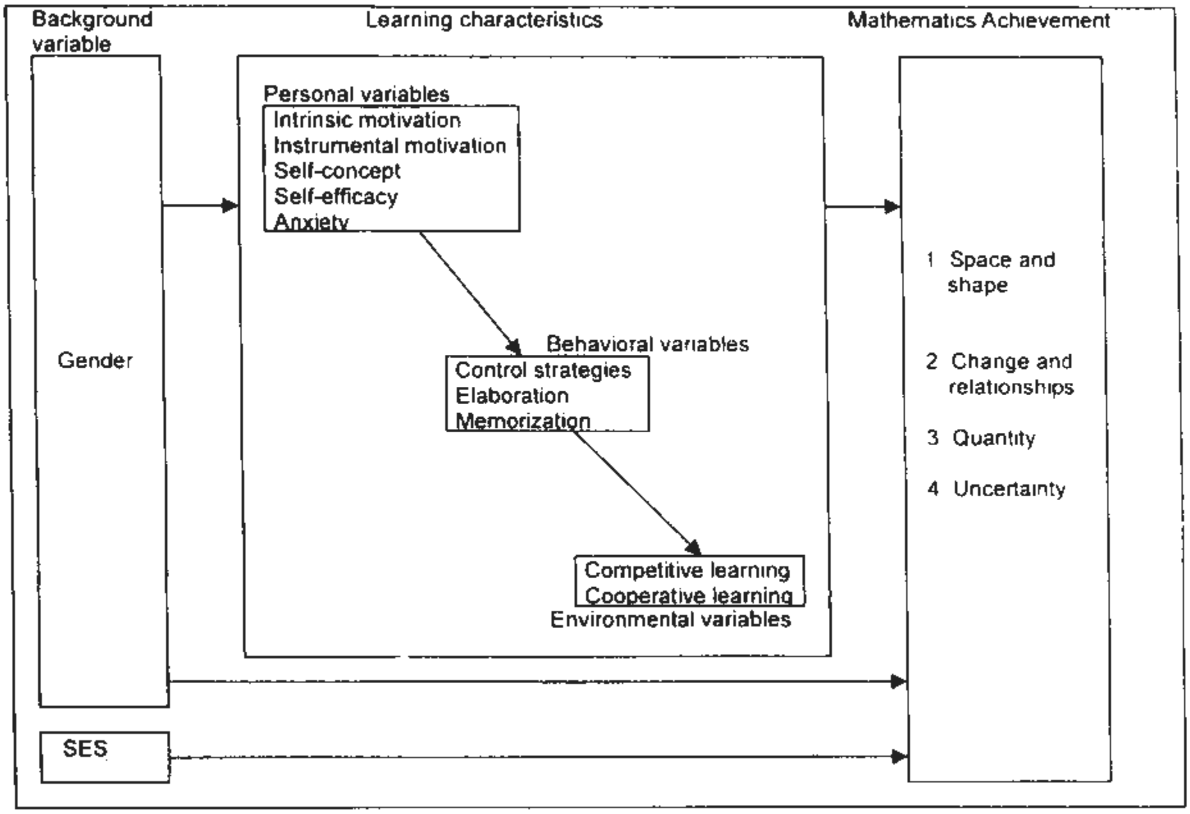
330). The reciprocal interaction means personal factors can affect the how a person behaves and then change the environment. The behavior of a person can also affect personal factors in enactive feedback and the environment. The environment would also affect personal factors in enactive feedback again (Fig 2.2). In order to examine the enactive feedback part of Zimmerman's model, a longitudinal study should be used (Ning & Downing, 2010). So, due to the design of the present study, the enactive feedback part of Zimmerman's model will not be examined.

Zimmerman (1986, 1989) defined students as self-regulated to the degree that they are metacognitively, motivationally, and behaviorally active participants in their own learning. Applying Zimmerman's definition on the selected learning characteristics of students from PISA 2003 student's questionnaire, a conceptual framework is constructed as shown in Fig. 3.1.

Based on the concept of self-regulated learning, the conceptual framework is shown in Fig. 3.1. Personal variables include intrinsic motivation, instrumental motivation, self-efficacy, self-concept, and anxiety; behavioral variables include control strategies, elaboration, and memorization; environmental variables include the preference for competitive learning situation and the preference for cooperative learning situation. Besides the examination of the effect of gender on the three sets of variables and on the Mathematics achievements of the four domains, the effects of the personal variables on behavioral variables and the effect of behavioral variables on environmental variables will also be conducted.

SES is the background variable that would be considered in the present study.

Fig. 3.1: Conceptual framework of the present study.



3.3 Operational Hypotheses

In order to give better understanding of the operation of the conceptual framework and how it addresses the research questions, operational hypotheses of the present study have been stated below together with the recall of the research questions.

1. Are there any differences in effects of gender on Mathematics achievements in the domains of space and shape, change and relationships, quantity and

uncertainty in Hong Kong? The hypotheses for the first research question presented below are to examine the effect of gender on Mathematics achievement in the four Mathematics domains.

$H_0^{G\text{-}ss}$: $\gamma_{G\text{-}ss} = 0$, i.e. there is no effect of gender on Mathematics achievement in the domain of space and shape.

$H_0^{G\text{-}cr}$: $\gamma_{G\text{-}cr} = 0$, i.e. there is no effect of gender on Mathematics achievement in the domain of change and relationships.

$H_0^{G\text{-}qu}$: $\gamma_{G\text{-}qu} = 0$, i.e. there is no effect of gender on Mathematics achievement in the domain of quantity.

$H_0^{G\text{-}un}$: $\gamma_{G\text{-}un} = 0$, i.e. there is no effect of gender on Mathematics achievement in the domain of uncertainty.

("ss": space and shape; "cr": change and relationships; "qu": quantity; "un": uncertainty, "μ" sample mean)

("G": gender; "γ" : effect of an exogenous (independent) latent variable on an endogenous (dependent) latent variable)

2. Are gender effects on Mathematics achievement mediated by personal variables, including intrinsic motivation, instrumental motivation, self-concept, self-efficacy, and anxiety? More specifically, what are the mediating effects of personal variables on the effect of gender on Mathematics achievements? In order to answer this question, two sub-questions should be asked, (a) are there any gender differences in these personal variables? (b) If the answer is positive, then would these differences affect Mathematics achievements?

   To address the first part of the sub-questions, the following five hypotheses need to be examined.

H_0^{intrin} : $\mu_{male}^{intrin} = \mu_{female}^{intrin}$, i.e. there is no gender difference in intrinsic motivation.

H_0^{instru} : $\mu_{male}^{instru} = \mu_{female}^{instru}$, i.e. there is no gender difference in instrumental motivation.

$H_0^{self\text{-}eff}$: $\mu_{male}^{self\text{-}eff} = \mu_{female}^{self\text{-}eff}$, i.e. there is no gender difference in self-efficacy.

$H_0^{self\text{-}con}$: $\mu_{male}^{self\text{-}con} = \mu_{female}^{self\text{-}con}$, i.e. there is no gender difference in self-concept.

H_0^{anx} : $\mu_{male}^{anx} = \mu_{female}^{anx}$, i.e. there is no gender difference in anxiety.

("intrin": intrinsic motivation; "instru": instrumental motivation; "self-eff": self-efficacy; "self-con": self-concept; "anx": anxiety)

In order to address the second part of the sub-questions, the following twelve hypotheses need to be examined for each Mathematics domain. Among the twelve hypotheses, they can be divided as three sets of hypotheses. The first set is to examine the gender effect on personal variables. The second set is to examine the effect of gender and effect of SES on Mathematics achievements. The third set of hypotheses is to examine the effect of personal variables on Mathematics achievements.

The first set of hypotheses is as follows.

$H_{0,\,Ach}^{G\text{-}intrin}$: $\gamma_{G-intrin} = 0$, i.e. there is no effect of gender on intrinsic motivation.

$H_{0,Ach}^{G\text{-}instru}$: $\gamma_{G-instru} = 0$, i.e. there is no effect of gender on instrumental motivation.

$H_{0,\,Ach}^{G\text{-}self\text{-}eff}$: $\gamma_{G-self\text{-}eff} = 0$, i.e. there is no effect of gender on self-efficacy.

$H_{0,\,Ach}^{G\text{-}self\text{-}con}$: $\gamma_{G-self\text{-}con} = 0$, i.e. there is no effect of gender on self-concept.

$H_{0,Ach}^{G-anx}$: $\gamma_{G-anx} = 0$, i.e. there is no effect of gender on anxiety.

The second set of hypotheses is as follows.

$H_{0,Ach}^{SES-Ach}$: $\gamma_{SES-Ach} = 0$, i.e. there is no effect of SES on Mathematics achievements.

$H_{0,Ach}^{G-Ach}$: $\gamma_{G-Ach} = 0$, i.e. there is no effect of gender on Mathematics achievements.

The third set of hypotheses which examine whether there is any effect of personal variables on Mathematics achievements is present below.

$H_{0,Ach}^{intrin-Ach}$: $\beta_{intrin-Ach} = 0$, i.e. there is no effect of intrinsic motivation on the performance in one of the domain of Mathematics achievements.

$H_{0,Ach}^{instru-Ach}$: $\beta_{instru-Ach} = 0$, i.e. there is no effect of instrumental motivation on Mathematics achievements.

$H_{0,Ach}^{self-eff-Ach}$: $\beta_{self-eff-Ach} = 0$, i.e. there is no effect of self-efficacy on Mathematics achievements.

$H_{0,Ach}^{self-con-Ach}$: $\beta_{self-con-Ach} = 0$, i.e. there is no effect of self-concept on Mathematics achievements.

$H_{0,Ach}^{anx-Ach}$: $\beta_{anx-Ach} = 0$, i.e. there is no effect of intrinsic motivation on Mathematics achievements.

("G": gender; "Ach": one of the four domains of Mathematics achievement; " γ " : effect of an exogenous (independent) latent variable on an endogenous (dependent) latent variable and " β ":

effect of an endogenous latent variable on another endogenous latent variable)

3. Would gender effect on Mathematics achievement mediated by behavioral variables, i.e. learning strategies, including control strategies, elaboration, and memorization? In other words, what are the mediating effects of behavioral variables on the effect of gender on Mathematics achievements? In order to answer this question, two sub-questions should be asked, (a) are there any gender differences in these behavioral variables? (b) If the answer is positive, then would these differences affect Mathematics achievements? To address the first part of the sub-questions, the following three hypotheses need to be examined.

H_0^{cont}: $\mu_{male}^{cont} = \mu_{female}^{cont}$, i.e. there is no gender difference in the use of control strategies.

H_0^{elab}: $\mu_{male}^{elab} = \mu_{female}^{elab}$, i.e. there is no gender difference in the use of elaboration strategies.

H_0^{memo}: $\mu_{male}^{memo} = \mu_{female}^{memo}$, i.e. there is no gender difference in the use of memorization strategies.

In order to address the second part of the sub-questions, eight hypotheses need to be examined in each Mathematics domain. Among the eight hypotheses, they can be divided as three sets of hypotheses. The first set is to examine the gender effect on behavioral variables. The second set is to examine the effect of gender and effect of SES on Mathematics achievements. The third set of hypotheses is to examine the effect of behavioral variables on Mathematics achievements.

The first set of hypotheses is as follows.

$H_{0,\ Ach}^{G\text{-}cont}$: $\gamma_{G-cont} = 0$, i.e. there is no effect of gender on the use of control strategies.

$H_{0,Ach}^{G\text{-}elab}$: $\gamma_{G-elab} = 0$, i.e. there is no effect of gender on the use of elaboration strategies.

$H_{0,\ Ach}^{G\text{-}memo}$: $\gamma_{G-memo} = 0$, i.e. there is no effect of gender on the use of memorization strategies.

The second set of hypotheses is to examine whether there i any effect of gender and effect of SES on Mathematics achievement.

$H_{0,\ Ach}^{SES\text{-}Ach}$: $\gamma_{SES\ \ Ach} = 0$, i.e. there is no effect of SES on Mathematics achievements.

$H_{0,\ Ach}^{G\text{-}Ach}$: $\gamma_{G\ \cdot\ Ach} = 0$, i.e. there is no effect of gender on t Mathematics achievements.

The third set of hypotheses is to examine whether there is any effect of behavioral variables on Mathematics achievement.

$H_{0,\ Ach}^{cont\text{-}Ach}$: $\beta_{cont\ -\ Ach} = 0$, i.e. there is no effect of the use control strategies on Mathematics achievements.

$H_{0,\ Ach}^{elab\text{-}Ach}$: $\beta_{elab-Ach} = 0$, i.e. there is no effect of the use of elaboration strategies on Mathematics achievements.

$H_{0,\ Ach}^{memo\text{-}Ach}$: $\beta_{memo-Ach} = 0$, i.e. there is no effect of the use of memorization strategies on Mathematics achievements.

4. Are gender effects on Mathematics achievement mediated by environmental variables, including competitive learning, and cooperative learning? That means, what are the mediating effects of environmental variables on the effect of gender on Mathematics achievements? In order to answer this question, two sub-questions should be asked, (a) are there any gender differences in these environmental variables? (b) If the answer is positive, then would these differences affect Mathematics achievements? To address the first part of the sub-questions, the following two hypotheses need to be examined.

H_0^{comp}: $\mu_{male}^{comp} = \mu_{female}^{comp}$, i.e. t here is no gender difference in competitive learning situation.

H_0^{coop}: $\mu_{male}^{coop} = \mu_{female}^{coop}$, i.e. t here is no gender difference in cooperative learning situation.

In order to address the second part of the sub-questions, six hypotheses need to be examined for each domain of the Mathematics achievements. The six hypotheses can be divided into three sets of hypotheses as to answer the second and the third research question.

The first set of hypotheses is to examine whether there is any gender effect on the two environmental variables.

$H_{0,Ach}^{G\text{-}comp}$: $\gamma_{G-comp} = 0$, i.e. there is no effect of gender on the preference of competitive learning situation.

$H_{0,Ach}^{G\text{-}coop}$: $\gamma_{G-coop} = 0$, i.e. there is no effect of gender v the preference of cooperative learning situation.

The second set of hypotheses is to examine whether there is any effect of SES and the effect of gender on Mathematics achievements.

$H_{0,Ach}^{SES\text{-}Ach}$: $\gamma_{SES-Ach} = 0$, i.e. there is no effect of SES on Mathematics achievements.

$H_{0,Ach}^{G\text{-}Ach}$: $\gamma_{G-Ach} = 0$, i.e. there is no effect of gender on Mathematics achievements.

The third set of hypotheses is to examine whether there is any effect of environmental variables on Mathematics achievement for each domain.

$H_{0,Ach}^{comp\text{-}Ach}$: $\beta_{comp-Ach} = 0$, i.e. there is no effect of the preference of competitive learning situation on Mathematics achievements.

$H_{0,Ach}^{coop\text{-}Ach}$: $\beta_{coop-Ach} = 0$, i.e. there is no effect of the preference of cooperative learning situation on Mathematics achievements.

5. Are the effects of gender on Mathematics achievements mediated by personal variables, behavioral variables, and environmental variables? In order to address this research question, the following forty-two hypotheses need to be examined for each domain in the Mathematics achievements. The

forth-two hypotheses can be divided into nine sets of hypotheses for better understanding.

The first set is to examine whether there is any effect of gender on personal variables.

$H_{0,\ Ach}^{G\text{-}intrm}$: $\gamma_{G-intrm} = 0$, i.e. there is no effect of gender on intrinsic motivation.

$H_{0,Ach}^{G\text{-}instru}$: $\gamma_{G-instru} = 0$, i.e. there is no effect of gender on instrumental motivation.

$H_{0,Ach}^{G\text{-}self\text{-}eff}$: $\gamma_{G-self-eff} = 0$, i.e. there is no effect of gender on self-efficacy.

$H_{0,Ach}^{G\text{-}self\text{-}con}$: $\gamma_{G-self-con} = 0$, i.e. there is no effect of gender on self-concept.

$H_{0,Ach}^{G\text{-}anx}$: $\gamma_{G-anx} = 0$, i.e. there is no effect of gender on anxiety.

The second set is to examine whether there is any effect of gender on behavioral variables.

$H_{0,\ Ach}^{G\text{-}cont}$: $\gamma_{G-cont} = 0$, i.e. there is no effect of gender on the use of control strategies.

$H_{0,Ach}^{G\text{-}elab}$: $\gamma_{G-elab} = 0$, i.e. there is no effect of gender on the use of elaboration strategies.

$H_{0,Ach}^{G\text{-}memo}$: $\gamma_{G-memo} = 0$, i.e. there is no effect of gender on the use of memorization strategies.

The third set is to examine whether there is any effect of gender on environmental variables.

$H_{0,Ach}^{G\text{-}comp}$: $\gamma_{G-comp} = 0$, i.e. there is no effect of gender on the preference of competitive learning situation.

$H_{0,Ach}^{G\text{-}coop}$: $\gamma_{G-coop} = 0$, i.e. there is no effect of gender on the preference of cooperative learning situation.

The fourth set is to examine whether there is any effect of gender and effect of SES on Mathematics achievements.

$H_{0,Ach}^{SES\text{-}Ach}$: $\gamma_{SES-Ach} = 0$, i.e. there is no effect of SES on Mathematics achievements.

$H_{0,Ach}^{G\text{-}Ach}$: $\gamma_{G-Ach} = 0$, i.e. there is no effect of gender on Mathematics achievements.

The fifth set is to examine whether there is any effect of personal variables on behavioral variables.

$H_{0,Ach}^{intrin\text{-}cont}$: $\beta_{intrin-cont} = 0$, i.e. there is no effect of intrinsic motivation on the use of control strategies.

$H_{0,Ach}^{intrin\text{-}elab}$: $\beta_{intrin-elab} = 0$, i.e. there is no effect of intrinsic motivation on the use of elaboration strategies.

$H_{0,Ach}^{intrin\text{-}memo}$: $\beta_{intrin-memo} = 0$, i.e. there is no effect of intrinsic motivation on the use of memorization strategies.

$H_{0,Ach}^{instru\text{-}cont}$: $\beta_{instru-cont} = 0$, i.e. there is no effect of instrumental motivation on the use of control strategies.

$H_{0,Ach}^{instru\text{-}elab}$: $\beta_{insstru-elab} = 0$, i.e. there is no effect of instrumental motivation on the use of elaboration strategies.

$H_{0,Ach}^{instru\text{-}memo}$: $\beta_{instru-memo} = 0$, i.e. there is no effect of instrumental motivation on the use of memorization strategies.

$H_{0,Ach}^{self\text{-}eff\text{-}cont}$: $\beta_{self\text{-}eff-cont} = 0$, i.e. there is no effect of self-efficacy on the use of control strategies.

$H_{0,Ach}^{self\text{-}eff\text{-}elab}$: $\beta_{self\text{-}eff-elab} = 0$, i.e. there is no effect of self-efficacy on the use of elaboration strategies.

$H_{0,Ach}^{self\text{-}eff\text{-}memo}$: $\beta_{self\text{-}eff-memo} = 0$, i.e. there is no effect of self-efficacy on the use of memorization strategies.

$H_{0,Ach}^{self\text{-}con\text{-}cont}$: $\beta_{self\text{-}con-cont} = 0$, i.e. there is no effect of self-concept on the use of control strategies.

$H_{0,Ach}^{self\text{-}con\text{-}elab}$: $\beta_{self\text{-}con-elab} = 0$, i.e. there is no effect of self-concept on the use of elaboration strategies.

$H_{0,Ach}^{self\text{-}con\text{-}memo}$: $\beta_{self\text{-}con-memo} = 0$, i.e. there is no effect of self-concept on the use of memorization strategies.

$H_{0,Ach}^{anx\text{-}cont}$: $\beta_{anx-cont} = 0$, i.e. there is no effect of anxiety on the use of control strategies.

$H_{0,Ach}^{anx\text{-}elab}$: $\beta_{anx-elab} = 0$, i.e. there is no effect of anxiety on the use of elaboration strategies.

$H_{0,Ach}^{anx\text{-}memo}$: $\beta_{anx-memo} = 0$, i.e. there is no effect of anxiety on the use of memorization strategies.

The sixth set is to examine whether there is any effect of behavioral variables on environmental variables.

$H_{0,Ach}^{cont\text{-}comp}$: $\beta_{cont-comp} = 0$, i.e. there is no effect of the use control strategies on the preference of competitive learning situation.

$H_{0,Ach}^{cont\text{-}coop}$: $\beta_{cont-coop} = 0$, i.e. there is no effect of the use control strategies on the preference of cooperative learning situation.

$H_{0,Ach}^{elab\text{-}comp}$: $\beta_{elab-comp} = 0$, i.e. there is no effect of the use elaboration strategies on the preference of competitive learning situation.

$H_{0,Ach}^{elab\text{-}coop}$: $\beta_{elab-coop} = 0$, i.e. there is no effect of the use elaboration strategies on the preference of cooperative learning situation.

$H_{0,Ach}^{memo\text{-}comp}$: $\beta_{memo-comp} = 0$, i.e. there is no effect of the use memorization strategies on the preference of competitive learning situation.

$H_{0,Ach}^{memo\text{-}coop}$: $\beta_{memo-coop} = 0$, i.e. there is no effect of the use memorization strategies on the preference of cooperative learning situation.

The seventh set is to examine whether there is any effect of personal variables on Mathematics achievements.

$H_{0,Ach}^{intrin\text{-}Ach}$: $\beta_{intrin-Ach} = 0$, i.e. there is no effect of intrinsic motivation on Mathematics achievements.

$H_{0,Ach}^{instru\text{-}Ach}$: $\beta_{instru-Ach} = 0$, i.e. there is no effect of instrumental motivation on Mathematics achievements.

$H_{0,Ach}^{self\text{-}eff\text{-}Ach}$: $\beta_{self\text{-}eff-Ach} = 0$, i.e. there is no effect of self-efficacy on Mathematics achievements.

$H_{0,Ach}^{self-con-Ach}$: $\beta_{self-con-Ach} = 0$, i.e. there is no effect of self-concept on Mathematics achievements.

$H_{0,Ach}^{anx-Ach}$: $\beta_{anx-Ach} = 0$, i.e. there is no effect of anxiety on Mathematics achievements.

The eighth set is to examine whether there is any effect of behavioral variables on Mathematics achievements.

$H_{0,Ach}^{cont-Ach}$: $\beta_{cont-Ach} = 0$, i.e. there is no effect of the use control strategies on Mathematics achievements.

$H_{0,Ach}^{elab-Ach}$: $\beta_{elab-Ach} = 0$, i.e. there is no effect of the use of elaboration strategies on Mathematics achievements.

$H_{0,Ach}^{memo-Ach}$: $\beta_{memo-Ach} = 0$, i.e. there is no effect of the use of memorization strategies on Mathematics achievements.

The ninth set is to examine whether there is any effect of environmental variables on Mathematics achievements.

$H_{0,Ach}^{comp-Ach}$: $\beta_{comp-Ach} = 0$, i.e. there is no effect of the preference of competitive learning situation on Mathematics achievements.

$H_{0,Ach}^{coop-Ach}$: $\beta_{coop-Ach} = 0$, i.e. there is no effect of the preference of cooperative learning situation on Mathematics achievements.

3.4 Conceptualization of the constructs

The data used in this study came from the Hong Kong portion of PISA 2003 Mathematics assessment and a student questionnaire, which are developed by OECD. In the Mathematics assessment, there are totally 85 Mathematics items to assess four content domains, namely space and shape, change and relationships, quantity, and uncertainty. More detailed concepts of the four content domains are provided in the Table 3.1.

In this study, students learning characteristics that are related to Mathematics achievement are selected from PISA 2003 student questionnaire. These student learning characteristics include motivational factors, self-related beliefs, anxiety, learning strategies, and preferences in learning situations. Motivational factors consist of intrinsic interest / intrinsic motivation and instrumental motivation in learning Mathematics.

Learners with intrinsic motivation, their reward come from Mathematics learning process itself, accompanying by positive feelings on their ability and their beliefs of achieving desired learning goals. Learners with instrumental motivation, their incentives come from external rewards, such as the results of learning, good career or study prospects.

Self-related beliefs include self-efficacy and self-concept in Mathematics. Self-efficacy in Mathematics measures the belief of students' capability to solve specific Mathematics problems while self-concept in Mathematics measures students' general belief of their overall Mathematics competence. Therefore, the main difference between self-efficacy and self-concept is the concept of specificity, where self-efficacy is said to be domain-specific and self-concept is measured at a more general level. Anxiety in Mathematics measures the extent students feel helpless and under emotional stress while dealing with Mathematics. All these three factors are referred as the affective factors in learning Mathematics in the present study.

Learning strategies include two cognitive strategies, memorization and elaboration, and one metacognitive strategy, control strategies. Memorization strategies refer to the representation of knowledge and process of storing particular data without further processing the information. Elaboration strategies refer to the connection of newly acquired knowledge with prior knowledge or integrating the knowledge learned from other contexts. Comparing with memorization strategies, elaboration strategies require students with greater understanding of the knowledge learned than through simple memorization strategies. Control strategies refer to the monitoring of students' learning and regulating their learning so as to achieve their learning goals.

Learning situations are students' preferences of learning environment, which involves competitive learning situation and cooperative learning situation. Students' striving to be better than others is the most salient aspect for competitive learning while students are willing to learn in groups is referred as preferred cooperative learning. More detailed concepts of categorization of students learning characteristics are provided in the Table 3.2. The conceptualization of the constructs of the students learning characteristics will also be discussed later in this chapter.

In the questionnaire, the following options, "strongly agree", "agree", "disagree", and "strongly disagree" or "very confident", "confident", not very confident", and "not at all confident" were offered to students in response to the survey statements.

Table 3.1: Concepts of PISA 2003 math items by content domain

Content domain	Concept
Space and shape	It relates to spatial and geometric phenomena and relationships, often drawing on the curricular discipline of geometry. It requires looking for similarities and differences when analyzing the components of shapes and recognizing shapes in different representations and different dimensions, as well as understanding the properties of objects and their relative positions.
Change and relationships	It involves mathematical manifestations of change as well as functional relationships and dependency among variables. This content area relates most closely to algebra. Mathematical relationships are often expressed as equations or inequalities, but relationships of a more general nature (*e.g.*, equivalence, divisibility and inclusion, to mention but a few) are relevant as well. Relationships are given a variety of different representations, including symbolic, algebraic, graphic, tabular and geometric representations. Since different representations may serve different purposes and have different properties, translation between representations is often of key importance in dealing with situations and tasks
Quantity	It involves numeric phenomena as well as quantitative relationships and patterns. It relates to the understanding of relative size, the recognition of numerical patterns, and the use of numbers to represent quantities and quantifiable attributes of real-world objects (counts and measures). Furthermore, quantity deals with the processing and understanding of numbers that are represented in various ways. An important aspect of dealing with quantity is quantitative reasoning, which involves number sense, representing numbers, understanding the meaning of operations, mental arithmetic and estimating. The most common curricular branch of Mathematics with which quantitative reasoning is associated is arithmetic.
Uncertainty	It involves probabilistic and statistical phenomena and relationships that become increasingly relevant in the information society. These phenomena are the subject of mathematical study in statistics and probability.

Source: OECD (2004). Learning for tomorrow's world: First results form PISA 2003. Paris: 2004. p. 38-39.

Table 3.2: Student learning characteristics in Mathematics

Category of characteristics and rationale	Student characteristics
A. Motivational factors Motivation is often considered the driving force behind learning. One can distinguish motives deriving from external rewards for good performance such as praise or future prospects and internally generated motives such as interest in subject areas (Deci and Ryan, 1985).	***1. Interest in and enjoyment of Mathematics.*** Students were asked about their interest in Mathematics as a subject as well as their enjoyment of learning Mathematics Interest in and enjoyment of a subject is a relatively stable orientation that affects the intensity and continuity of engagement in learning situations, the selection of strategies and the depth of understanding. ***2. Instrumental motivation in Mathematics.*** Students were asked to what extent they are encouraged to learn by external rewards such as good job prospects. Longitudinal studies (*e.g.*, Wigfield *et al.*, 1998) show that such motivation influences both study choices and performance.
B. Self-related beliefs in Mathematics Learners form views about their own competence and learning characteristics. These have considerable impact on the way they set goals, the strategies they use and their achievement (Zimmerman, 1999). Two ways of defining these beliefs are: in terms of how well students think that they can handle even difficult tasks – self-efficacy (Bandura, 1994); and in terms of their belief in their own abilities – self-concept (Marsh, 1993). These two constructs are closely associated with one another, but nonetheless distinct. Self-related beliefs are sometimes referred to in terms of self-confidence, indicating that such beliefs are positive. In both cases, confidence in oneself has important benefits for motivation and for the way in which students approach learning tasks.	***3. Self-efficacy in Mathematics.*** Students were asked to what extent they believe in their own ability to handle learning situations in Mathematics effectively, overcoming difficulties. This affects students' willingness to take on challenging tasks and to make an effort and persist in tackling them. It thus has a key impact on motivation (Bandura, 1994). ***4. Self-concept in Mathematics.*** Students were asked about their belief in their own mathematical competence. Belief in one's own abilities is highly relevant to successful learning (Marsh, 1986), as well as being a goal in its own right.
C. Emotional factors in Mathematics Students' avoidance of Mathematics due to emotional stress is reported to be widespread in many countries. Some research treats this construct as part of general attitudes to Mathematics, though it is generally considered distinct from attitudinal variables.	***5. Anxiety in Mathematics.*** Students were asked to what extent they feel helpless and under emotional stress when dealing with Mathematics. The effects of anxiety in Mathematics are indirect, once self-related cognitions are taken into account (Meece *et al.*, 1990).

Table 3.2 (continued): Student learning characteristics in Mathematics

Category of characteristics and rationale	**Student characteristics**
***D.* Student learning strategies in Mathematics** Learning strategies are the plans students select to achieve their goals: the ability to do so distinguishes competent learners who can regulate their learning (Brown *et al.*, 1983). Cognitive strategies that require information processing skills include, but are not limited to, memorization and elaboration. Metacognitive strategies, entailing conscious regulation of one's own learning, are measured in the concept of control strategies	***6. Memorization.*** Students were asked about their use of learning strategies for Mathematics that involve representations of knowledge and procedures stored in memory with little or no further processing. ***7. Elaboration strategies.*** Students were asked about their use of learning strategies for Mathematics that involve connecting new material to prior learning. By exploring how knowledge learned in other contexts relates to new material students acquire greater understanding than through simple memorization. ***8. Control strategies.*** Students were asked about their use of learning strategies for Mathematics that involve checking what one has learned and working out what one still needs to learn, allowing learners to adapt their learning to the task at hand These strategies are used to ensure that one's learning goals are reached and are at the heart of the approaches to learning measured by PISA.
E. Learning preferences for learning situations Learning behaviour is also influenced by the students' preference for learning situations: here, preferences include competitive learning and cooperative learning.	***9. Competitive learning.*** Students were asked about the preferred learning situations in learning Mathematics that involve their preferences in competing or comparing with others. Therefore, striving to be better than others (Owens and Barnes, 1992) are the most salient aspects. ***10. Cooperative learning.*** Students were asked about the preferred learning situations in learning Mathematics that involve their preferences in working with others as a group.

Source: OECD (2004). Learning for tomorrow's world: First results form PISA 2003 Paris: OECD p 115-116, 313

3.5 Data source

PISA is an international survey, so the results must be comparable across countries. To ensure this objective, a comparable target population, of which the population is defined with respect to a target age, is needed. In PISA, students who are aged between 15 years 3 months and 16 years 2 months at the time of the assessment, regardless of the grade or type of institution in which they are enrolled and of whether they are in full-time or part-time education, are the target population.

Within the target population, a two-stage stratified sampling procedure is conducted to ensure the sample selected can represent the target population. The first stage sampling is the sampling of schools consisting of 15-year-old students. A minimum of 150 schools, which are sampled systemically with probabilities proportional to its size, are then selected. The second stage sampling is the selection of students within each sampled school. 35 students are selected with equal probability from a list of 15-year-old students of the sampled school, of which is prepared for selection once schools are selected. To ensure the data quality, a minimum response rate of 85 per cent is required for the schools initially selected. Besides, PISA 2003 also requires a minimum participation rate of 80 per cent of students within participating schools (OECD, 2004). The students are then assessed on written tasks for two hours including multiple choice format and other formats that require short answer, a phase or more extended response. There are 85 items for mathematical literacy and these items are organized into 7 clusters together with other 6 clusters of other three domain literacy to form 13 two-hour assessment booklets. Each cluster of questions will appear in 4 of the assessment booklets to provide item linkage for scaling of scores across different booklets. Each student only has to answer one the 13 booklets according to a rotated design to ensure the random coverage of the students (HKPISA center, 2005).

In Hong Kong, the main study was conducted from May to July 2003. Schools are stratified according to the types of school governance that is government schools, aided schools, and independent/private schools and the students' academic intake. This stratified sampling method is to ensure the appropriate proportion of each type of schools is in the sample. The summary of the selected and sampled schools are shown in Table 3.3. A total of 4478 students from 145 schools are selected and accepted for the final analysis according to the OECD sampling standard (HKPISA center, 2005).

Table 3.3: Selected and participating schools for each sampling stratum in HKPISA 2003

Explicit strata	Implicit strata	Total no. of schools	No. of schools sampled by OECD	No. of schools accepted by OECD
Government	High ability	17	8	8
	Medium ability	9	3	3
	Low ability	10	4	4
Aided	High ability	127	51	50
	Medium ability	124	41	41
	Low ability	107	34	33
Independent/Private	Local/DSS	29	5	5
	International	20	4	1
Total		443	150	145

Source: HKPISA Centre (2005). The second HKPISA report: PISA 2003. HK: HKPISA Centre. Page 6.

3.6 Participants

PISA seeks to measure how well the students prepared to meet the challenges of the future, therefore, all the participants in PISA 2003 are the students at the age of 15 and also approaching the end of compulsory schooling (OECD 2003, 2005; HKPISA Centre 2005) and the present study, which is based on the Hong Kong data of the PISA 2003 study, the components of the participants are Hong Kong students varying from secondary one to secondary five, that is from grade seven to grade eleven. Totally one hundred and forty-five schools were selected in the study, of which, 2219 male students and 2259 female students, totally 4478 students were participated in the study. Among all the 2219 male students, 110 of them are in secondary one, 227 of them are in secondary two, 579 of them are in secondary three, 1032 of them are in secondary four and 1 of them is in secondary five. Among all the female students, 101 of them are in secondary one, 212 of them are in secondary two, 553 of them are in secondary three, 1390 of them are in secondary four and 3 of them are in secondary five. All the participants were born in 1987 or 1988, which means the students were about at the age of 15. The details are provided in Table 3.4 below.

Table 3.4 : Distribution table of the samples' education level and gender in PISA 2003

	No of Male students	No of female students	Subtotal
Secondary one	110	101	211
Secondary two	227	212	439
Secondary three	579	553	1132
Secondary four	1032	1390	2692
Secondary five	1	3	4
	2219	2259	4478

*all the participants were born in 1987 or 1988.

3.7 Instruments

3.7.1 Mathematics performance

In PISA 2003, students' Mathematics performance is measured through mathematical literacy which focuses on the mathematical assessment in students' capacities to analyze, reason, and communicate ideas effectively by posing, formulating, solving, and interpreting mathematical problem in various domains rather than their performance in formal mathematical curriculum. Therefore, the mathematical content to be assessed is organized in the mathematical overarching ideas, including the ideas of (1) space and shape; (2) change and relationships; (3) quantity; and (4) uncertainty. Space and shape relates to spatial and geometric phenomena and relationships, drawing on the curricular discipline of geometry. Change and relationships involves mathematical manifestations of change as well as functional relational relationships and dependency among variables, which relate most closely to algebra. Quantity involves numeric phenomena as well as quantitative relationships and patterns, which are associated with arithmetic. Uncertainty involves probabilistic and statistical phenomena and relationships that are similar to the subjects of statistics and probability. There are totally 85 items to be assessed. The distribution of the Mathematics items by overarching ideas in mathematical literacy is shown in Table 3.5. The numbers of items in the idea of change and relationships, quantity, space and shape and uncertainty are 22, 23, 20 and 20 respectively. The distribution of the items in the four overarching ideas is almost evenly distributed. That means none of the ideas are over represented.

Table 3.5: Distribution of Mathematics items of overarching ideas for mathematical literacy

	No. of items	Percentage
Change and relationships	22	25.9
Quantity	23	27.1
Space and shape	20	23.5
uncertainty	20	23.5
Total	85	100

3.7.2 Gender

Before talking about the conceptualization of gender, the present study must clarify the difference between "gender" and "sex". According to Lingard and Douglas (1999), the concept of distinguishing gender and sex are dualistic concepts of mind/body and culture/nature. That means gender is social and cultural construction and sex is a passive neutral biological given. As the present study aims at investigating the differences between male and female students in learning Mathematics, and hence improving both genders' learning by narrowing the achievement gap. Once there is a gender gap in the achievement, the choice for gender or sex must lead to fulfilling the aim of the present study. That means regulation or operation for the enhancement is possible. Therefore, the concept of gender will be used in the present study because of its social and cultural constructional concept.

3.7.3 Socio-economic status

Socio-economic status is a very important factor that affects the academic achievement of students. Although there is an absence of universal instrument to measure the socioeconomic status, it is commonly determined by occupational status, education and wealth. In addition, there is no direct measure on parental wealth in PISA; an alternative measure of the household items was used. Therefore, in PISA 2003, the socio-economic status of students was measured by the index of economic, social and cultural status (ESCS). The ESCS index is a composite measure which aims at measuring wider aspects of student's family and home background together with the occupational status. Therefore, it consists of three kinds of variables: (1) the highest occupational status of the father or mother; (2) the highest level of education of the father or mother; and (3) the number of various kinds educational and cultural resources at home, such as the number of books, a desk to study at, a room of their own, a quiet place to study, a computer they can use for school work, educational software, a link to the Internet, their own calculator, classic literature, books of poetry, works of art (e.g., paintings), books to help with their school work, and a dictionary. At last, the student scores on the index are factor scores derived from a Principal Component Analysis which are standardized to have an OECD mean of zero and a standard deviation of one (OECD, 2004, p. 307). In the present study, the ESCS index will be adopted as the background variable that measures the students' socio-economic status.

3.7.4 Motivational factors

Motivational factors are considered as the driving forces behind learning. In PISA 2003, instrumental motivation and intrinsic motivation were considered. Four statements were asked in the questionnaire to gauge students' instrumental motivation to learn Mathematics. They are "Making an effort in Mathematics is worth because it will help me in the work that I want to do later on", "Learning

Mathematics is worthwhile for me because it will improve my career prospects, chance", "Mathematics is an important subject for me because I need it for what I want to study later on", and " I will learn my things in Mathematics that will help me get a job". Four choices of response are provided throughout the questionnaire ranging from strongly agree with the statement to strongly disagree with the statement. Students who strongly agreed with the statements, which indicates that they were with the highest instrumental motivation to learn Mathematics and the code for the response is 4 whereas students who strongly disagree with the statements which indicate that they were with the lowest instrumental motivation to learn Mathematics and the code for the response is 1. Cronbach alpha will be used to measure the internal consistency of the items. The value of the reliability of the items for measuring instrumental motivation is 0.882, which is an acceptable value according to Henson (2001).

Another four statements that measure the intrinsic motivation to learn Mathematics are "I enjoy reading about Mathematics", "I look forward to my Mathematics lessons", "I do Mathematics because I enjoy it", and "I am interested in the things I learn in Mathematics". These four statements are asking about the enjoyment in learning Mathematics. Students strongly agreed with these four questions which showed a high intrinsic motivation to learn Mathematics. The value of the reliability of the items for measuring intrinsic motivation is 0.905, which is an acceptable value according to Henson (2001).

3.7.5 Self-related beliefs

Self-related beliefs include self-efficacy and self-concept in Mathematics. There are eight statements for measuring Mathematics self-efficacy of students. The statements are "Using a train timetable to work out how long it would take to get from one place to another", "Calculating how much cheaper a TV would be after a 30% discount", "Calculating how many square metres of tiles you need to cover a floor", "understanding graphs represented in newspaper", "Solving an equation like 3x + 5 = 17", "Finding the actual distance between two places on a map with 1:10000 scale", "Solving an equation like 2(x + 3) = (x + 3)(x – 3)", and "Calculating the petrol consumption rate of a car". All these eight statements are asking specific Mathematics questions. In fact, the statements are asking students how they feel in solving these specific Mathematics questions so as to measure their Mathematics self-efficacy. Students replied very confident in answering the questions which showed a high level of self-efficacy in Mathematics. The value of the reliability of the items for measuring self-efficacy is 0.869. Since the value is over 0.8, according to Henson (2001), the value of the reliability of the items for measuring self-efficacy is acceptable.

Five statements are used to measure Mathematics self-concept of students. They are "I am not good at Mathematics", "I get good marks in Mathematics", "I learn Mathematics quickly", "I have always believed that Mathematics is one of my best subjects", and "In my Mathematics class, I understand even the most difficult work". Students strongly agree with the statements which indicated that they had a high level of Mathematics self-concept, except the statement, "I am not good at Mathematics". For students who strongly agreed with the statement, it is known that their level of self-concept in Mathematics was the lowest. Unlike Mathematics self-efficacy, Mathematics self-concept is a general feeling of the student in learning Mathematics, rather self-efficacy is a feeling on a specific Mathematics question. The value of the reliability of the items for measuring self-concept is 0.882. According to Henson (2001), the value of the reliability is acceptable.

3.7.6 Mathematics anxiety

Five statements were asked to measure the level of anxiety in Mathematics. The five statements are "I often worry that it will be difficult for me in Mathematics classes", "I get very tense when I have to do Mathematics homework", "I get very nervous doing Mathematics problems", "I feel helpless when doing a Mathematics problem", and "I worry that I will get poor marks in Mathematics". Students who strongly agreed with these statements showed the highest level of Mathematics anxiety. The value of the reliability of the items for measuring Mathematics anxiety is 0.830. According to Henson (2001), the value of the reliability is acceptable.

3.7.7 Learning strategies

In the present study, three learning strategies are considered, including control strategies, elaboration, and memorization. Five statements were used to measure the control strategies that were used by students in learning Mathematics. They are "When I study a Mathematics test, I try to work out what are the most important parts to learn", "when I study Mathematics, I make myself check to see if I remember the work I have already done", "When I study Mathematics, I try to figure out which concepts I still have not understood properly", "When I cannot understand something in Mathematics, I always search for more information to clarify the problem", and "When I study Mathematics, I start by working out exactly what I need to learn". Students who strongly agreed with the statements showed they would use the control strategies to monitor their learning progress, so as to enhance their learning and overcome the difficulties. The value of the reliability of the items for measuring control strategies is 0.793, which is acceptable according to Henson (2001).

Another five statements were used to measure the use of elaboration of students. They are "When I am solving Mathematics problems, I often think of new ways to get the answer", "I think how the Mathematics I have learnt can be used in everyday life", "I try to understand new concepts in Mathematics by relating them to things I already know", "When I am solving a Mathematics problem, I often think about how the solution might be applied to other interesting question", and "When learning Mathematics, I try to relate the work to things I have learnt in other subjects". These statements are used to measure elaboration strategy that is related to how students relate the Mathematics knowledge they have learnt to other situations. Students who strongly agreed with the statements showed a frequent use of the strategy. The value of the reliability of the items for measuring elaboration is 0.797, which is acceptable according to Henson (2001).

Four statements were used to measure the use of memorization strategy to learn Mathematics. They are “I go over some problems in Mathematics so often that I feel as if I could solve them in my sleep”, “When I study for Mathematics, I learn as much as I can off by heart”, "in order to remember the method for solving a Mathematics problem, I go through examples again and again", and “To learn Mathematics, I try to remember every step in a procedure”. Students who strongly agreed with these statements showed a frequent use of the strategy. The value of the reliability of the items for measuring memorization strategy is 0.572. According to Henson (2001), the value of reliability considered as reliable as it was based on the purpose and the uses of the scores. If the purpose was used in applied settings, such as special education placement, or college admission tests, 0.90 would be the minimally tolerable estimation, and 0.95 would be the “desired standard”. For hypothesized measurement of a construct, 0.50 would be sufficed. Another factor that affects the value of reliability is the interrelationship of the items on the construct. If the correlations of the items are highly correlated, the value of reliability is greater. The more the number of items measures the construct, the higher the value of reliability. As the purpose of the present study is not used for applied settings, and there are only four items used for measuring the construct, memorization. Moreover, the values of all the constructs in the present study range from 0.753 – 0.905, which are all considered as acceptable according to Henson (2001). Therefore, the present study would consider the value of reliability of memorization as acceptable.

3.7.8 Learning preferences for learning situations

There are two preferences of learning situations, competitive learning and cooperative learning. Five statements were used to measure students' preference of competitive learning. They are "I would like to be the best in my class in Mathematics", "I try very hard in Mathematics because I want to do better on the exams than the others", "I make a real effort in Mathematics because I want to be one of the best", "In Mathematics I always try to do better than the other students in my class", and "I do my best work in Mathematics when I try to do better than others". Students who strongly agreed with these statements showed a great preference to learn in competitive learning situation. The value of the reliability of the items for measuring competitive learning situation motivation is 0.814, which is acceptable according to Henson (2001).

Another five statements were used to measure students' preference for cooperative learning. They are "In Mathematics I enjoy working with other students in groups", "When we work on a project in Mathematics, I think that it is a good idea to combine the ideas of all the students in a group", "I do my best work in Mathematics when I work with other students", "In Mathematics, I enjoy helping others to work well in a group", and "In Mathematics I learn most when I work with other students in my class". Students who strongly agreed with these statements showed a great preference to learn in cooperative learning situation. The value of the reliability of the items for measuring instrumental motivation is 0.798, which is acceptable according to Henson (2001).

Table 3.6: Statements measuring students learning characteristics

Student characteristics	Statements	Reliability
Intrinsic motivation in Mathematics	1. I enjoy reading about Mathematics. 2. I look forward to my Mathematics lessons. 3. I do Mathematics because I enjoy it. 4. I am interested in the things I learn in Mathematics.	0.905
Instrumental motivation in Mathematics	1. Making an effort in Mathematics is worth it because it will help me in the work that I want to do later on. 2. Learning Mathematics is worthwhile for me because it will improve my career prospects. 3. Mathematics is an important subject for me because I need it for what I want to study later on. 4. I will learn many things in Mathematics that will help me get a job.	0.882
Self-efficacy in Mathematics	1. Using a train timetable to work out how long it would take to get from one place to another. 2. Calculating how much cheaper a TV would be after a 30% discount. 3. Calculating how many square feet of tile you need to cover a floor. 4. Understanding graphs presented in newspapers. 5. Solving an equation like 3x+5= 17. 6. Finding the actual distance between two places on a map with a 1:100 scale. 7. Solving an equation like 2(x+3)=(x + 3)(x - 3). 8. Calculating the gas mileage of a car.	0.869
Self-concept in Mathematics	1. I get good grades in Mathematics. 2. I learn Mathematics quickly. 3. I have always believed that Mathematics is one of my best subjects. 4. In my Mathematics class, I understand even the most difficult work	0.860
Anxiety in Mathematics	1. I often worry that it will be difficult for me in Mathematics classes. 2. I get very tense when I have to do Mathematics homework. 3. I get very nervous doing Mathematics problems. 4. I feel helpless when doing a Mathematics problem. 5. I worry that I will get poor grades in Mathematics.	0.830

Table 3.6a (continued): Statements measuring students learning characteristics

Student characteristics	Statements	Reliability
Memorization	1. I go over some problems in Mathematics so often that I feel as if I could solve them in my sleep. 2. When I study for Mathematics, I learn as much as I can by heart. 3. In order to remember the method for solving a Mathematics problem, I go through examples again and again. 4. To learn Mathematics, I try to remember every step in a procedure.	0.572
Elaboration strategies	1. When I am solving Mathematics problems, I often think of new ways to get the answer. 2. I think about how the Mathematics I have learned can be used in everyday life. 3. I try to understand new concepts in Mathematics by relating them to things I already know. 4. When I am solving a Mathematics problem, I often think about how the solution might be applied to other interesting questions. 5. When learning Mathematics, I try to relate the work to things I have learned in other subjects.	0 797
Control strategies	1. When I study for a Mathematics test, I try to figure out the most important parts to learn. 2. When I study Mathematics, I make myself check to see if I remember the work I have already done. 3. When I study Mathematics, I try to figure out which concepts I still have not understood properly. 4. When I cannot understand something in Mathematics, I always search for more information to clarify the problem. 5. When I study Mathematics, I start by figuring out exactly what I need to learn.	0 753

Table 3.6b (continued): Statements measuring students learning characteristics

Student characteristics	Statements	Reliability
Competitive learning	1. I would like to be the best in my class in Mathematics. 2. I try very hard in Mathematics because I want to do better on the exams than the others. 3. I make a real effort in Mathematics because I want to be one of the best. 4. In Mathematics I always try to do better than the other students in my class. 5. I do my best work in Mathematics when I try to do better than others.	0.814
Cooperative learning	1. In Mathematics I enjoy working with other students in groups. 2. When we work on a project in Mathematics, I think that it is a good idea.to combine the ideas of all the students in a group. 3. I do my best work in Mathematics when I work with other students. 4. In Mathematics, I enjoy helping others to work well in a group. 5. In Mathematics I learn most when I work with other students in my class.	0.798

Source: OECD. PISA 2003 student questionnaire. Paris: OECD

3.8 Analysis

The present study aims at investigating the gender differences of the learning characteristics of Hong Kong students by adopting the data from PISA 2003. Therefore, series of analyzes are conducted in the present study in order to address the research questions. The analyzes include (a) confirming the factor structure of the learning characteristics across gender, (b) comparing gender effects on Mathematics achievements, (c) comparing gender differences in learning characteristics, (d) comparing gender differences of the impact of learning characteristics in student math achievement. Before conducting any analysis, multiple imputation has been used for dealing the problem of missing values. Details have been discussed in appendix B, covariance matrix has also been provided in appendix C, and the values of means and standard errors for both male and female sample in the four Mathematics domains and the overall performance has been provided in appendix D.

3.8.1 Confirming the factor structure of the learning characteristics across gender

The student questionnaire is designed by OECD and students are required to respond to several statements which are used to measure the learning characteristics. Therefore, the constructs of the learning characteristics will be constructed according to the conceptualization of the design of the questionnaire. However, the design of the questionnaire is based on the data from various participating countries. The constructs for learning characteristics in the presents study is based on the Hong Kong data only, therefore, the validation of the constructs should be confirmed.

Confirmatory factor analysis (CFA) is used to examine the validity of the constructs and multigroup confirmatory factor analysis is used for confirming the validity of the constructs across different groups. Several goodness-of-fit indices will be used to indicate the fitness between the postulated prior structure of constructs and the observed data used in this study. The prior structures of the constructs are the motivational constructs (intrinsic and instrumental motivation), constructs of self-related beliefs (self-efficacy and self-concept), emotional factor (mathematical anxiety), learning strategies constructs (control strategies, elaboration, and memorization), and constructs of learning preferences for learning situation (competitive learning and cooperative learning). The goodness-of-fit indices include the Root-Mean Square Error of Approximation (RMSEA), the Root Mean Square Residual (RMR), the Comparative Fit Index (CFI), the Non-normed Fit Index (NNFI), the Goodness of Fit index (GFI). For the RMSEA, values of 0.05 or smaller indicate a close fit, values less than 0.08 indicate an acceptable fit, while values larger than 0.1 indicate unacceptable model fit. CFI and NNFI have values between 0 and 1, and values between 0.90 and 0.95 suggest an acceptable model fit, and values greater than 0.95 indicate a close fit (Muthen & Muthen, 2004). A good model fit is indicated by values of 0.90 or higher for the GFI. If an unacceptable model fit is obtained for the constructs validation between the postulated prior structure of constructs and the observed data, modification will be conducted based on theories and local context. Reliability of the factors and the correlations between factors within a construct indicated by Cronbach's alpha will also be provided. A software program SPSS will be used to estimate the reliability of the statements within the constructs. Another software program LISREL 8.8 (Jöreskog & Sörbom, 1993) will be used for analyzing the models.

Multigroup CFA consists of two stages. The first stage is to run CFA for the whole sample, female sample, and male sample separately to confirm the validity of the constructs for these three samples. Once the factor structures have been confirmed, second stage can be performed to verify whether there are any differences between the male and female samples. Four models will be conducted in stage two. The first one is the baseline model that without any constraints on invariance among the female and male samples. The second model is a model that the values factor loadings of male samples and female samples are set invariant. The third model is a model that the values of factor loadings together with the values of residuals are set invariant. In the fourth model, additional constraints, the variances and covariances of the factors, are set invariant in both male and female samples. In these four models, more and more parameters are set invariant. The fourth model should be conducted only if the third model is not rejected and the third model should be conducted only if the second model is not rejected. So, when the second model is rejected, there is no need to conduct the third model and the fourth model. However, when the second model is accepted, then it is a need to run the third model. And when the third model is rejected, there is no need to run the fourth model. However, when the third model is accepted, there is a need to run the fourth model. The logic of the analysis is to find out the variance and invariance of the factor structures among gender. Again software program LISREL 8.8 (Jöreskog & Sörbom, 1993) will be used for analyzing the models.

3.8.2 Comparing gender effects on Mathematics achievements

Effects of gender on Mathematics achievements in the four domains are explored by means of multiple regression using LISREL program. SES will also be included in the analysis as a control variable.

3.8.3 Comparing gender differences in learning characteristics

Effects of gender on the three sets of variables, including the five personal variables, the three behavioral variables and the two environmental variables will be calculated by using LISREL program. The positive value of the effect indicates the effect favors females and negative value of the effect indicates the effect favors males.

3.8.4 Gender differences of the impact of learning characteristics on student Mathematics achievement

To investigate the gender difference on the impact of learning characteristics on students' Mathematics performance, a background variable, gender, will be added to the models that constructed in the previous section and the analyzing strategy is based on the strategy used by Reiss (2005). That means the variable, gender, will be added to the models of the three categories separately as well as the model including all variables from the three categories. Male will be set as 0 and female will be set as 1. The positive values of path coefficients indicate that the factors favor female students and the negative values of path coefficients indicate the factors favor male students. The statistical significant of the path coefficients will also be examined. Similarly, the goodness-of-fit indices, such as the Root-Mean Square Error of Approximation (RMSEA), the Root Mean Square Residual (RMR), the Comparative Fit Index (CFI), the Non-normed Fit Index (NNFI), and the Goodness of Fit index (GFI), will be used to evaluate the fitness of the models. Modifications will only be made if they are theoretically and contextually defendable. A statistical software program LISREL 8.8 (Jöreskog &

Sörbom, 1993) will be used for conducting the analysis.

3.9 Summary

The third chapter is the explanation of the methodology used by the present study. It briefly explored the structure of the research subjects and explained the methods used in this study. A discussion of the questionnaire content follows. The conceptual framework of this study was shown and conceptualizations of the constructs were also discussed.

Chapter 4

Measurement models: Confirmation Factor Analysis

4.1 Introduction

This chapter is to confirm the suitability and feasibility of the factor structures that are available for both male and female samples and hence, multigroup confirmatory factor analysis would be conducted. Since PISA 2003 is an international survey, it is worthwhile to examine the suitability of the factor structures from the data of Hong Kong students. As the present study aims at exploring the gender differences in learning Mathematics, multigroup confirmatory factory analysis is not only used for confirming the suitability and feasibility of the factor structures for Hong Kong students, but also more specifically for male and female students. In the coming section, the multigroup analysis will be conducted separately on personal variables, behavioral variables, and environmental variables.

4.2 Confirmatory factor analysis

Since PISA 2003 is an international survey, the present study only focuses on the data of Hong Kong students. Therefore, before performing any further analysis, it is worth to perform confirmatory factor analysis to confirm if conceptualizations of the factors are suitable for Hong Kong context. Moreover, the objective of the present study is the gender effect on learning Mathematics, it is also suggested that the models of conceptualization of the factors are also suitable for both male students and female students. Therefore, multigroup confirmatory factor analysis would be performed to confirm the feasibility and suitability of the conceptualization of the factors for both male students and female students in Hong Kong contexts.

The multigroup confirmatory factory analysis will be performed separately on five personal variables, three behavioral variables, and two environmental variables across gender. There are two stages in each of the multigroup confirmatory factor analysis. The first stage, which involves three models testing, is used for confirming the factor structure for further analysis. The model is considered as a good model if the value of RMSEA is smaller than 0.05 and the values of NFI, NNFI, CFI, GFI and AGFI are greater than 0.90.

The first model is a model that uses all data of Hong Kong students for performing the confirmatory factor analysis so as to confirm the suitability and feasibility of the factor structure for further analysis. The second model only uses the data of female students fitting in the first model. The third model only uses the data of male students fitting in the first model. The reason to do so is for confirming the assumed model, that is the first model, is suitable and feasible for both male and female samples and for further analysis. At this stage, no factorial invariance of the factors is assumed.

The second stage is a multigroup invariant analysis which involves four models testing to test the multigroup factorial invariance across gender. The first model is a baseline model that has no constraints on invariance among the female and male samples. The second model is a model that the values factor loadings of male samples and female samples are set invariant. The third model is a model in which the values of factor loadings together with the values of residuals are set invariant. In the fourth model, additional constraints of the variances and covariances of the factors are set invariant in both male and female samples. In these four models, more and more parameters are set invariant, which means the requirements for the factorial invariance are stricter. Once the second model is rejected, it is not necessary to conduct the third and the fourth model for further analysis. And it means that the assumption of invariance of factor loadings is invalid. Similarly, when the assumption of invariant factor loadings is passed, the third model will be conducted. But when the third model is rejected, there is no need to further construct the fourth model for further analysis because it shows that the assumption of invariant of residuals in both samples is invalid. When the third model is accepted, the fourth model will be conducted. The acceptance of the fourth model indicates that the assumed model is suitable and feasible for both male samples and female samples. The results of the multigroup factor analysis on personal variables, behavioral variables, and environmental variables are shown in the following sections.

4.2.1 Multigroup confirmatory factor analysis of personal variables

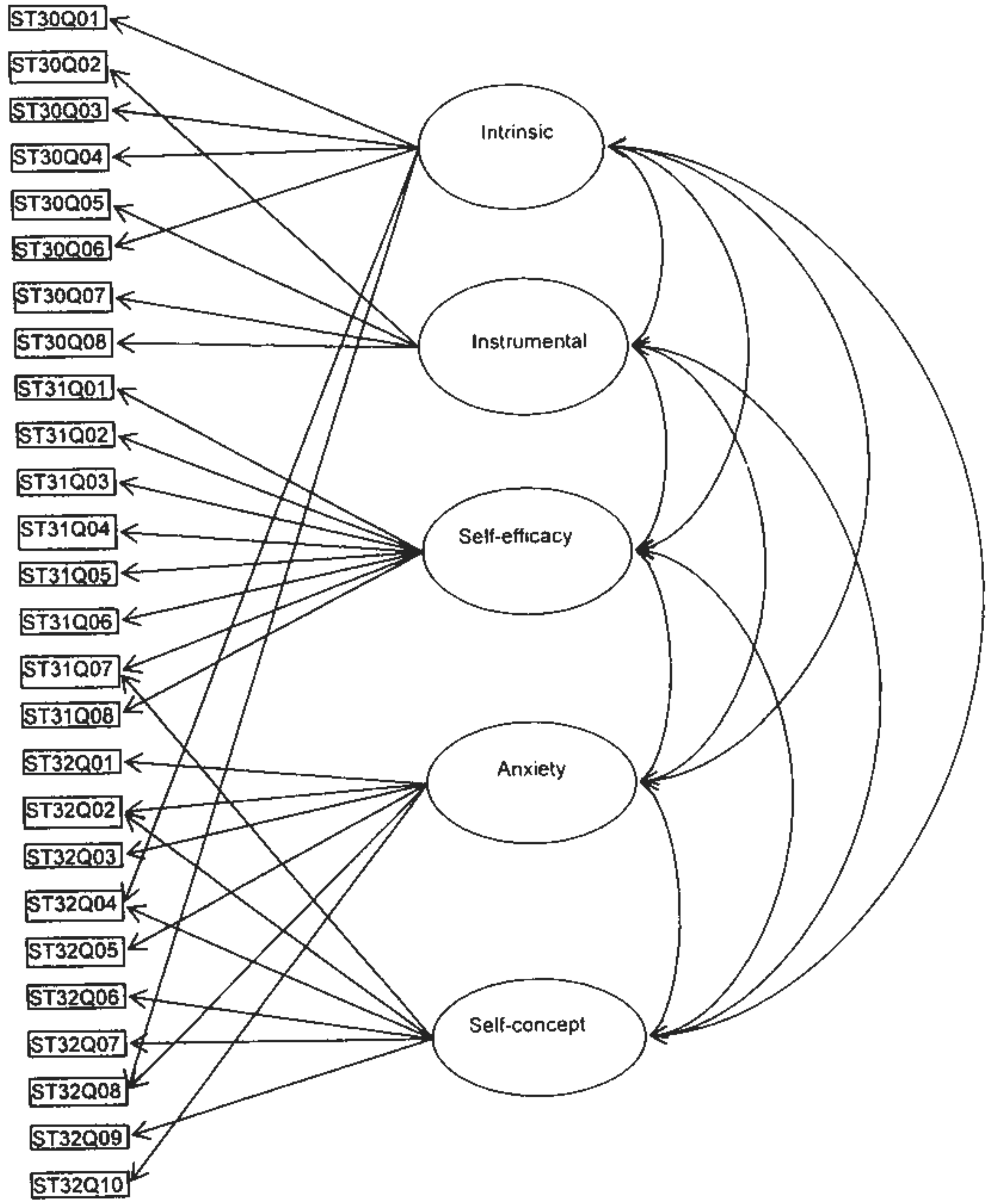
In this section, multigroup confirmatory factor analysis on personal variables is conducted. Figure 4.1 is the assumed model, the first model of stage one of the analysis. Table 4.1 shows the values of goodness of fit indices of the models in both stages of multigroup confirmatory factor analysis. From Table 4.1, the results in stage one of the analyses shows that the assumed model is a good model for the whole sample. The values of RMSEA, confidence interval of 90% of RMSEA, NFI, NNFI, CFI, GFI, and AGFI are 0.039, (0.038, 0.041), 0.99, 0.99, 0.99, 0.96, and 0.95 respectively. All these values show that the assumed model is a good model and hence the factor structure of the assumed model is suitable and feasible for both male and female samples.

In model two of the second stage, the difference in degree of freedom and the value of chi-square between the first and the second model in stage two were 25 and 70.81 respectively although all the values of goodness of fit indices show that the model was a good model after setting the invariance of the factor loadings between the male and female samples. It showed that the setting of invariance of factor loadings in model two led to value change of degree of freedom and chi-square by 25 and 70.81, and this change was statistically significant although all other values of goodness of fit showed that the model was a good model. Therefore, the assumption of the invariance of factor loadings between the male and female samples should be rejected. And there were differences in the factor loadings between male and female samples. The results of this section lead to another question that what the gender differences are in the five personal variables. This will be discussed later in this chapter. As model two is rejected, there is no need to perform the analysis of model three and model four. The results of the analysis of model three and model four are also provided as references in Table 4.1.

Table 4.1: Goodness of fit indices of the multigroup CFA for personal variables

Model	DF (Δ)	Chi-square (Δ)	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI	Decision
Stage one									
Whole sample	280	2070.65	0.039 (0.038, 0.041)	0.99	0.99	0.99	0.96	0.95	--
Female sample	280	1134.52	0.038 (0.036, 0.040)	0.99	0.99	0.99	0.96	0.95	--
Male sample	280	1210.73	0.040 (0.037, 0.042)	0.99	0.99	0.99	0.96	0.95	--
Stage two									
Model one	560	2345.24	0.039 (0.037, 0.040)	0.99	0.99	0.99	0.96	--	--
Model two	585 (25)	2416.05 (70.81)	0.038 (0.037, 0.040)	0.99	0.99	0.99	0.96	--	Rejected
Model three	616 (31)	2622.00 (205.95)	0.039 (0.038, 0.041)	0.99	0.99	0.99	0.96	--	Rejected
Model four	631 (15)	2744.25 (122.25)	0.040 (0.038, 0.041)	0.99	0.99	0.99	0.96	--	Rejected

Figure 4.1: Assumed model in stage one of the multigroup CFA for personal variables



4.2.2 Multigroup confirmatory factor analysis of behavioral variables

In this section, multigroup confirmatory factor analysis on behavioral variables will be conducted. Figure 4.2 is the assumed model that is the first model of the stage one of the analysis. Table 4.2 showed the values of goodness of fit indices of the models in both stages of multigroup confirmatory factor analysis. From Table 4.2, the results in stage one of the analyses showed that the assumed model is a good model for whole sample. The values of RMSEA, confidence interval of 90% of RMSEA, NFI, NNFI, CFI, GFI, and AGFI are 0.045, (0.042, 0.048), 0.98, 0.98, 0.98, 0.98, and 0.97 respectively. All these values showed that the assumed model is a good model and hence the factor structure of the assumed model is suitable and feasible for both male and female samples.

In model two of the second stage, although all the values of goodness of fit indices showed that the model was a good model after setting the invariance of the factor loadings between the male and female samples, the difference in degree of freedom and the value of chi-square between the first and the second model in stage two were 13 and 32.48 respectively. It showed that the setting of invariance of factor loadings in model two led to value change of degree of freedom and chi-square by 13 and 32.48, and this change was statistically significant although all other values of goodness of fit indices showed that the model was a good model. Therefore, the assumption of the invariance of factor loadings between the male and female samples should be rejected. And there are differences in the factor loadings between male and female samples. As model two is rejected, there is no need to perform the analysis of model three and model four. The results of the analysis of model three and model four are also provided as references in Table 4.2.

Figure 4.2: Assumed model in stage one of the multigroup CFA for behavioral variables

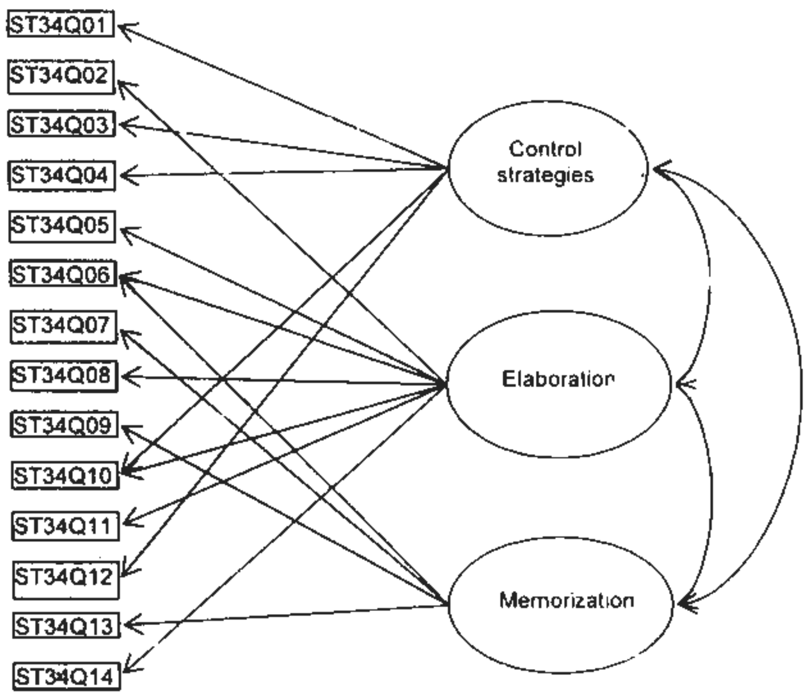


Table 4.2: Goodness of fit indices of the multigroup CFA for behavioral variables

Model	DF (Λ)	Chi-square (△)	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI	Decision
Stage one									
Whole sample	69	653.23	0.045 (0.042, 0.048)	0.98	0.98	0.98	0.98	0.97	--
Female sample	69	379.53	0.046 (0.041, 0.050)	0.97	0.97	0.98	0.98	0.96	--
Male sample	69	395.95	0.047 (0.043, 0.052)	0.98	0.98	0.99	0.97	0.96	--
Stage two									
Model one	138	775.48	0.046 (0.043, 0.050)	0.98	0.98	0.98	0.98	--	--
Model two	151 (13)	807.96 (32.48)	0.046 (0.042, 0.048)	0.98	0.98	0.98	0.97	--	Rejected
Model three	168 (17)	918.03 (110.07)	0.046 (0.043, 0.049)	0.98	0.98	0.98	0.97	--	Rejected
Model four	174 (6)	1008.21 (90.18)	0.047 (0.045, 0.050)	0.97	0.98	0.98	0.97	--	Rejected

4.2.3 Multigroup confirmatory factor analysis of environmental variables

In this section, multigroup confirmatory factor analysis on behavioral variables will be conducted. Figure 4.3 is the assumed model, the first model of the stage one of the analysis. Table 4.3 showed the values of goodness of fit indices of the models in both stages of multigroup confirmatory factor analysis. From Table 4.3, the results in stage one of the analyses showed that the assumed model is a good model for the whole sample. The values of RMSEA, confidence interval of 90% of RMSEA, NFI, NNFI, CFI, GFI, and AGFI are 0.046, (0.041, 0.050), 0.99, 0.99, 0.99, 0.99, and 0.98 respectively. All these values showed that the assumed model is a good model and hence the factor structure of the assumed model for environmental variables is suitable and feasible for both male and female samples.

In model two of the second stage, although all the values of goodness of fit indices showed that the model was a good model after setting the invariance of the factor loadings between the male and female samples, the difference in degree of freedom and the value of chi-square between the first and the second model in stage two were 9 and 23.57 respectively. It showed that the setting of invariance of factor loadings in model two led to the value change of degree of freedom and chi-square by 9 and 23.57, and this change was statistically significant although all other values of goodness of fit indices showed that the model was a good model. Therefore, the assumption of the invariance of factor loadings between the male and female samples should be rejected. And there are differences in the factor loadings between male and female samples. As model two is rejected, there is no need to perform the analysis of model three and model four. The results of the analysis of model three and model four are also provided as references in Table 4.3.

Figure 4.3: Assumed model in stage one of the multigroup CFA for environmental variables

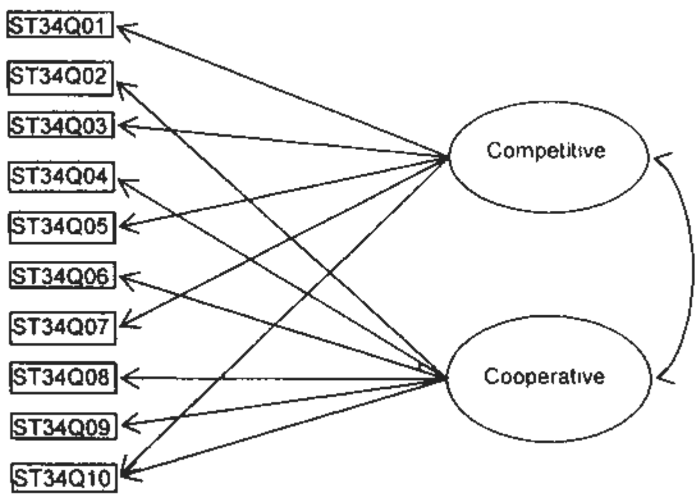


Table 4.3: Goodness of fit indices of the multigroup CFA for environmental variables

Model	DF (△)	Chi-square (△)	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI	Decision
Stage one									
Whole sample	28	291 28	0.046 (0 041, 0.050)	0.99	0 99	0 99	0 99	0 98	--
Female sample	28	169.57	0.047 (0 041, 0.054)	0 99	0 98	0.99	0 99	0 97	--
Male sample	28	153.59	0.045 (0.038, 0 052)	0 99	0 99	0 99	0.99	0 97	--
Stage two									
Model one	56	323.52	0.046 (0.041, 0.051)	0.99	0 99	0 99	0 99	--	--
Model two	65 (9)	347.09 (23.57)	0.044 (0.039, 0.049)	0 99	0.99	0 99	0 98	--	Rejected
Model three	80 (15)	381.72 (34.63)	0.041 (0.037, 0.045)	0 99	0.99	0.99	0 98	--	Rejected
Model four	83 (3)	420.11 (38.39)	0.043 (0.037, 0.045)	0 99	0 99	0 99	0.98	--	Rejected

4.3 Summary

In this chapter, multigroup factor analysis for personal variables, behavioral variables and environmental variables were conducted to confirm the factors used are suitable and feasible for both male and female samples and also the factor structures are appropriate. The results showed that the factor structures are appropriate and also suitable and feasible for both male and female samples. And hence, further analysis can be conducted.

Chapter 5

Structural models: Path Analysis

5.1 Introduction

After the multigroup factor analysis has been conducted to confirm the suitability and feasibility of the factor structures for both male and female students as discussed in the previous chapter, a series of analyses are performed to answer the five research questions in this chapter. First of all, effects of gender on Mathematics achievement of each Mathematics domain are explored to answer the first research question.

Then structural models are constructed to explore the effects of gender on the four Mathematics achievements mediated by personal variables, behavioral variables and environmental variables respectively in order to answer the second, the third and the fourth research question. The fifth research question is then answered by means of considering the effects of gender on Mathematics achievements mediated by all the personal variables, behavioral variables, and environmental variables.

To achieve this, a two-stage analysis is conducted. In the first stage, the effects of gender on Mathematics achievements mediated by all the variables will be considered but the effects of the five personal variables on the three behavioral variables and the effects of the three behavioral variables on the two environmental variables will not be considered. The models in this stage will be named as intermediate models so as to distinguish the full models to be considered in the second stage.

Based on the theory of self-regulated learning under social cognitive perspective (Zimmerman, 1989), the full models to be considered in the second stage are not only the models of the effects of gender on Mathematics achievements mediated by all the three sets of variables but also the effects of the five personal variables on the three behavioral variables and the effects of the three behavioral variables on the two environmental variables. These full models are actually the complete model of the conceptual framework stated in chapter three of the present study. The fifth research question can be answered through the results of the full models of the second stage of the structural models. And by comparing the results of the first stage and the second stage of the structural models, the unidirectional effects in the theory of self-regulated learning can be examined.

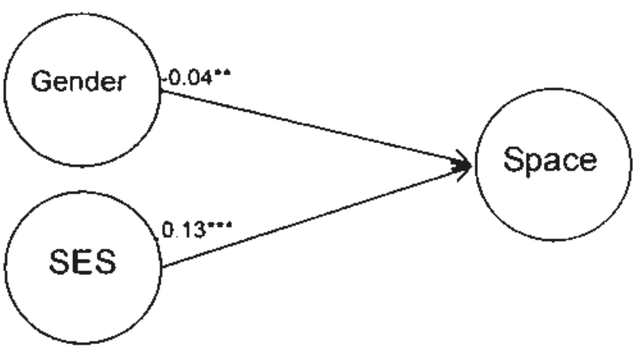
5.2 Gender effects on Mathematics achievements

Gender effects on Mathematics achievements will be explored in this section in each Mathematics domain. The effect of students' SES on Mathematics achievements will also be considered in the analyses. The software, LISREL 8.8, will be used to find out the effects of gender on Mathematics achievement of each Mathematics domain. The codes for males and females have been recoded to 0 and 1 respectively. The positive value of the effect of gender denotes females have the advantage and vice versa. The model is considered to be a good model if the value of RMSEA is smaller than 0.05 and the values of NFI, NNFI, CFI, GFI and AGFI are greater than 0.90.

5.2.1 Gender effect on Mathematics achievement in the domain of space and shape

The model in Figure 5.1 shows the model of the effect of gender and SES on Mathematics achievement in the domain of space and shape. Table 5.1 shows the values of goodness of fit indices of the model. All the values of the goodness of fit indices in Table 5.1 show that it is a good model. In Figure 5.1, it shows that the value of the effect of gender on Mathematics achievement in the domain of space and shape is -0.04 which is statistically significant after controlling the effect of SES on Mathematics achievement in the domain of space and shape. It indicates that males have an advantage of learning Mathematics in the domain of space and shape.

Figure 5.1: Effect of gender and SES on achievement of space and shape



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

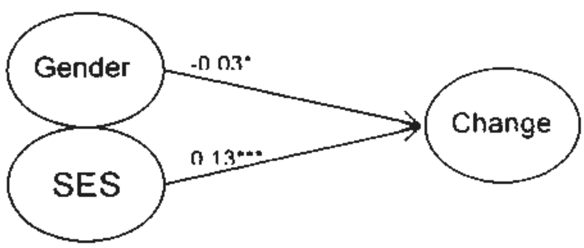
Table 5.1: Goodness fit indices of model of effect of gender on achievement of space and shape

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
1	1.72	0.013 (0.000, 0.044)	0.98	0.97	0.99	1.00	1.00

5.2.2 Gender effect on Mathematics achievement in the domain of change and relationships

Figure 5.2 shows the model of the effect of gender and SES on Mathematics achievement in the domain of change and relationships. The results of the values of goodness of fit indices of the model are presented in Table 5.2. All the values of the goodness of fit indices show that the model is a good model. In Figure 5.2, it shows that the value of the effect of gender on Mathematics achievement in the domain of change and relationships is -0.03 which is statistically significant after controlling the effect of SES on Mathematics achievement in the domain of change and relationships. It indicates that females have a disadvantage of learning Mathematics in the domain of change and relationships.

Figure 5.2: Effect of gender and SES on achievement of change and relationships



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

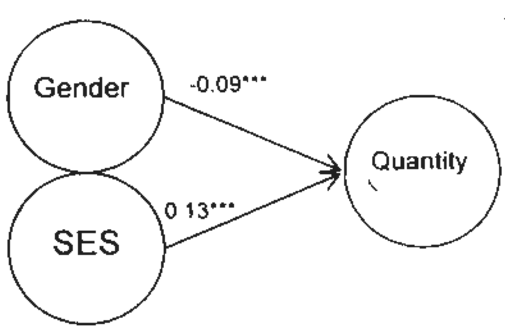
Table 5.2: Goodness fit indices of model of effect of gender on achievement of change and relationships

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
1	1.72	0.013 (0.000, 0.044)	0.98	0.97	0.99	1.00	1.00

5.2.3 Gender effect on Mathematics achievement in the domain of quantity

Figure 5.3 shows the model of effect of gender and SES on Mathematics achievement in the domain of quantity. Table 5.3 shows the values of goodness of fit indices of the model. All the values of goodness of fit indices show that the model is a good model. In Figure 5.3, it shows that the value of the effect of gender is -0.09 and the effect is statistically significant after controlling the effect of SES on the Mathematics achievement in the domain of quantity. Therefore, similar to the results of Mathematics achievement in the domain of space and shape and in the domain of change and relationships, females are at a disadvantage of learning Mathematics in the domain of quantity.

Figure 5.3: Effect of gender and SES on achievement of quantity



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

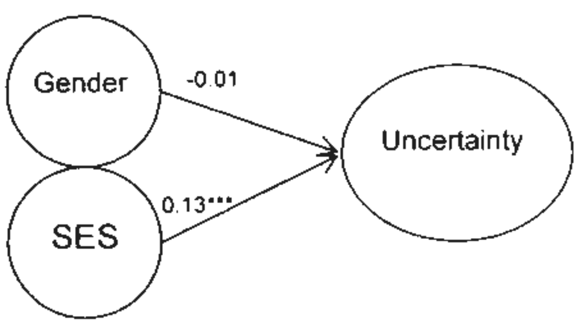
Table 5.3: Goodness of fit indices of model of effect of gender on achievement of quantity

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
1	1.71	0.013 (0.000, 0.044)	0.99	0.98	0.99	1.00	1.00

5.2.4 Gender effect on Mathematics achievement in the domain of uncertainty

Figure 5.4 shows the model of the effect of gender and SES on Mathematics achievement in the domain of uncertainty. Table 5.4 shows the results of the goodness of fit indices of the model. From Table 5.4, all the values of the goodness of fit indices show that the model is a good model. In Figure 5.4, it shows that after controlling the effect of SES on Mathematics achievement in the domain of uncertainty, the values of the effect of gender is -0.01, which is not statistically significant. That means, after controlling the effect of SES on Mathematics achievement in the domain of uncertainty, there is no significant gender effect on Mathematics achievement in the domain of uncertainty. Therefore, there is no significant advantage or disadvantage to males or females in learning Mathematics in the domain of uncertainty.

Figure 5.4: Effect of gender and SES on achievement of uncertainty



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.4: Goodness of fit indices of model of effect of gender on achievement of uncertainty

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
1	1.72	0.013 (0.000, 0.044)	0.98	0.97	0.99	1.00	1.00

5.3 Effects of gender on Mathematics achievement mediated by personal variables

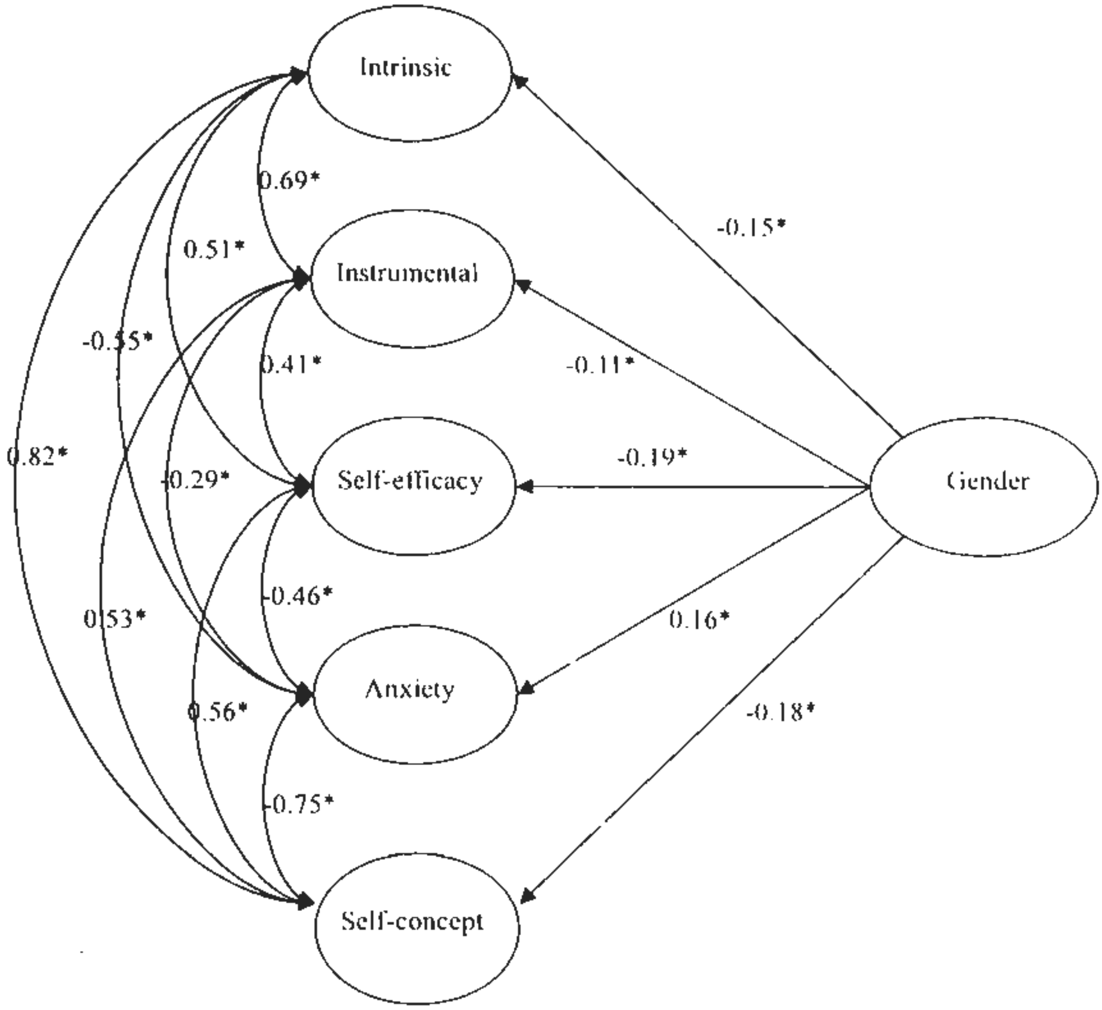
In order to answer the second research question which aims to explore the effect of gender on Mathematics achievements mediated by personal variables, two sub-questions have to be answered. The first one is whether there are any gender differences in personal variables and the second one is how the effects of gender on Mathematics achievement are mediated by personal variables. SES will be considered as control variable in the model for analyzing the effect of gender on Mathematics achievement mediated by personal variables. To answer these two questions, software, LISREL 8.8 will be used to find out the effects of gender directly and indirectly on Mathematics achievement of each Mathematics domains mediated by personal variables. The codes for males and females have been recoded to 0 and 1 respectively. The positive value of the effect of gender denotes females have the advantage and vice versa. The results of the effect of gender on personal variables and on Mathematics achievements mediated by personal variables will be presented in this section. The model is considered to be a good model if the value of RMSEA is smaller than 0.05 and the values of NFI, NNFI, CFI, GFI and AGFI are greater than 0.90.

5.3.1 Gender difference in personal variables

The effects of gender on the five personal variables are examined in the section. The five personal variables are intrinsic motivation, instrumental motivation, self-efficacy, anxiety, and self-concept. Figure 5.5 showed the results of effects of gender on each variable and the results of correlation of each variable also presented. Table 5.5 showed the results of the goodness of fit indices of the model. From Table 5.6, the values of degree of freedom (DF) is 301, the value of Chi-square is 2347.19, the value of RMSEA and its 90% confidence interval are 0.041 and (0.039, 0.042) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.99, 0.99, 0.99, 0.95, and 0.95 respectively. Therefore, the model is considered to be a good model.

In Figure 5.5, the results showed that the values of the effects of gender on intrinsic motivation, instrumental motivation self-efficacy, and self-concept are all negative and statistically significant, meaning that females, have lower intrinsic motivation, lower instrumental motivation, lower sense of self-efficacy, and lower self-concept in Mathematics learning than their male counterparts. The value of the effect of gender on anxiety is positive and is statistically significant. That means, females, are more anxious than males in learning Mathematics. Therefore, the results showed that there are gender differences in all the five personal variables.

Figure 5.5: Results of effects of gender on personal variables



"*": $p < 0.05$

Table 5.5: Goodness fit indices of the model of gender differences in personal variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
301	2347.19	0.041 (0.039, 0.042)	0.99	0.99	0.99	0.96	0.95

5.3.2 Effects of gender on Mathematics achievements mediated by personal variables

In the following four sub-sections, the effects of gender on Mathematics achievement for each Mathematics domains mediated by personal variables will be explored. The model, the values of goodness of fit indices of the model, and the direct and indirect effects of gender will be presented.

5.3.2.1 Effects of gender on space and shape achievement mediated by personal variables

After controlling the effect of SES, the effects of gender on the space and shape achievements mediated by personal variables will be examined in this section. Figure 5.6 show the structural model. The results of the direct and indirect effect of gender on the Mathematics achievement in the domain of space and shape mediated by the five personal variables are shown in Table 5.7. The results of the goodness of fit indices of the model have been provided in Table 5.6. From Table 5.6, the values of degree of freedom (DF) is 349, the value of Chi-square is 2702.80, the value of RMSEA and its 90% confidence interval are 0.040 and (0.039, 0.042) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.99, 0.99, 0.99, 0.96, and 0.95 respectively. All the values of the goodness of fit indices show that the model is a good model.

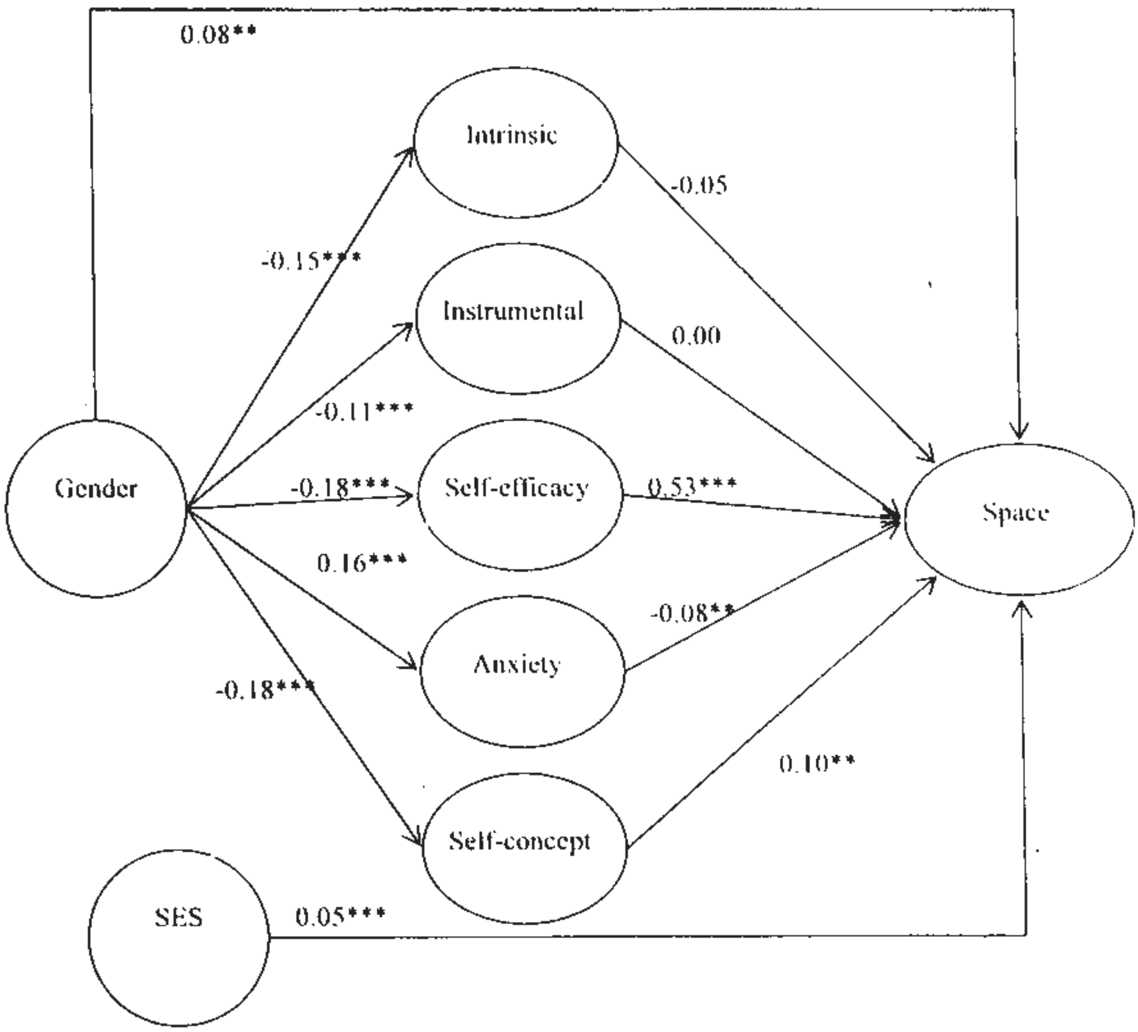
In Figure 5.6, only the path coefficients from self-efficacy, anxiety and self-concept to Mathematics achievement in the domain of space and shape are statistically significant, which indicate that only these three personal variables have significant effects on achievement in the domain of space and shape. The values of the path coefficients from self-efficacy and self-concept to the achievement are 0.53 and 0.10 and both are positive, which show that a higher sense of self-efficacy and self-concept can enhance the learning in Mathematics. The value of the path coefficient from anxiety to the achievement in the domain of space and shape is -0.08 and is negative which indicates the higher the anxiety level, the lower the achievement in the domain of space and shape.

Another set of path coefficient is from gender to the personal variables. In Figure 5.6, it shows that all the values of the effects of gender on the five personal variables are all statistically significant. With the exception of the value of the effect of gender on anxiety, which is 0.16 and is positive, all other four values of effects of gender on intrinsic motivation, instrumental motivation, self-efficacy and self-concept are -0.15, -0.11, -0.18, and -0.18 respectively and all are negative. That means that females have higher anxiety levels in learning Mathematics in the domain of space and shape but lower intrinsic motivation and instrumental motivation in learning Mathematics. Male students also have a high sense of self-efficacy and self-concept in learning Mathematics in the domain of space and shape.

The value of the effect of SES is 0.05, which is positively and statistically significant on achievement in the domain of space and shape. After controlling the effect of SES on achievement and mediated by the five personal variables, the value of the effect of gender on the Mathematics achievement in the domain of space and shape is 0.08, which is positive. That means, after ruling out all the mediating effects of personal variables and the effect of SES on the achievement of the domain of space and shape, females are advantaged in leaning Mathematics in the domain of space and shape. When comparing the results of the Figure 5.1, the effect of gender is decomposed into direct and indirect effect.

Table 5.7 showed the results of direct effect, indirect effect and total effect of gender on the achievement of space and shape mediated by personal variables and all the effects are statistically significant. The value of the total effect is -0.04, which is exactly the same as the results shown in Figure 5.1. However, in Figure 5.6, after controlling the effect of SES and mediated by the personal variables, the total effect of gender has been decomposed into direct effect and indirect effect of gender. The value of direct effect is 0.08. That means that females have an advantage in learning Mathematics in the domain of space and shape. The value of indirect effect is -0.12, which is the sum of the effect of gender on the achievement of space and shape mediated by each personal variable, i.e. -0.15 x -0.05 + -0.11 x 0.00 + -0.18 x 0.53 + 0.16 x -0.08 + -0.18 x 0.10 = -0.1187 = -0.12. That means, being males, they have the advantage of learning Mathematics in the domain of space and shape through the personal variables. Since the value of indirect effect of gender is greater than the value of direct effect of gender, total effect of gender, which is the summing up of the value of direct and indirect effect of gender, is negative. Therefore, although females have an advantage in learning Mathematics in the domain of space and shape, the effect is not only cancelled out but surpassed by the direct effect in the opposite direction. Therefore, the negative value of the total effect of gender is due to the negative value of indirect effect. In other words, the disadvantage females encounter in leaning Mathematics is mainly due to the motivation, lower sense of self-efficacy, lower self-concept but higher anxiety in learning Mathematics in the domain of space and shape.

Figure 5.6: Structural model of effect of gender and SES on achievement of space and shape mediated by personal variables



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.6: Goodness of fit indices of the structural model of effect of gender on the achievement of space and shape mediated by personal variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
349	2702.80	0.040 (0.039, 0.042)	0.99	0.99	0.99	0.96	0.95

Table 5.7: Effects of gender on achievement of space and shape mediated by personal variables

Effect of gender on:	Intrinsic Motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Space and shape
Direct effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	0.08***
Indirect effect	N.A.	N.A.	N.A.	N.A.	N.A.	-0.12***
Total effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	-0.04**

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.3.2.2 Effects of gender on change and relationships achievement mediated by personal variables

In this section, effects of gender on the achievement in the domain of change and relationships will be examined after controlling the effect of SES. Figure 5.7 shows the structural model. The results of the direct and indirect effects of gender on Mathematics achievement in the domain of change and relationships mediated by the five personal variables are shown in Table 5.9. Table 5.8 showed the goodness of fit indices of the model. From Table 5.8, the values of degree of freedom (DF) is 349, the value of Chi-square is 2733.62, the value of RMSEA and its 90% confidence interval are 0.041 and (0.039, 0.042) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.99, 0.99, 0.99, 0.96, and 0.95 respectively. Therefore, the model is considered to be a good model.

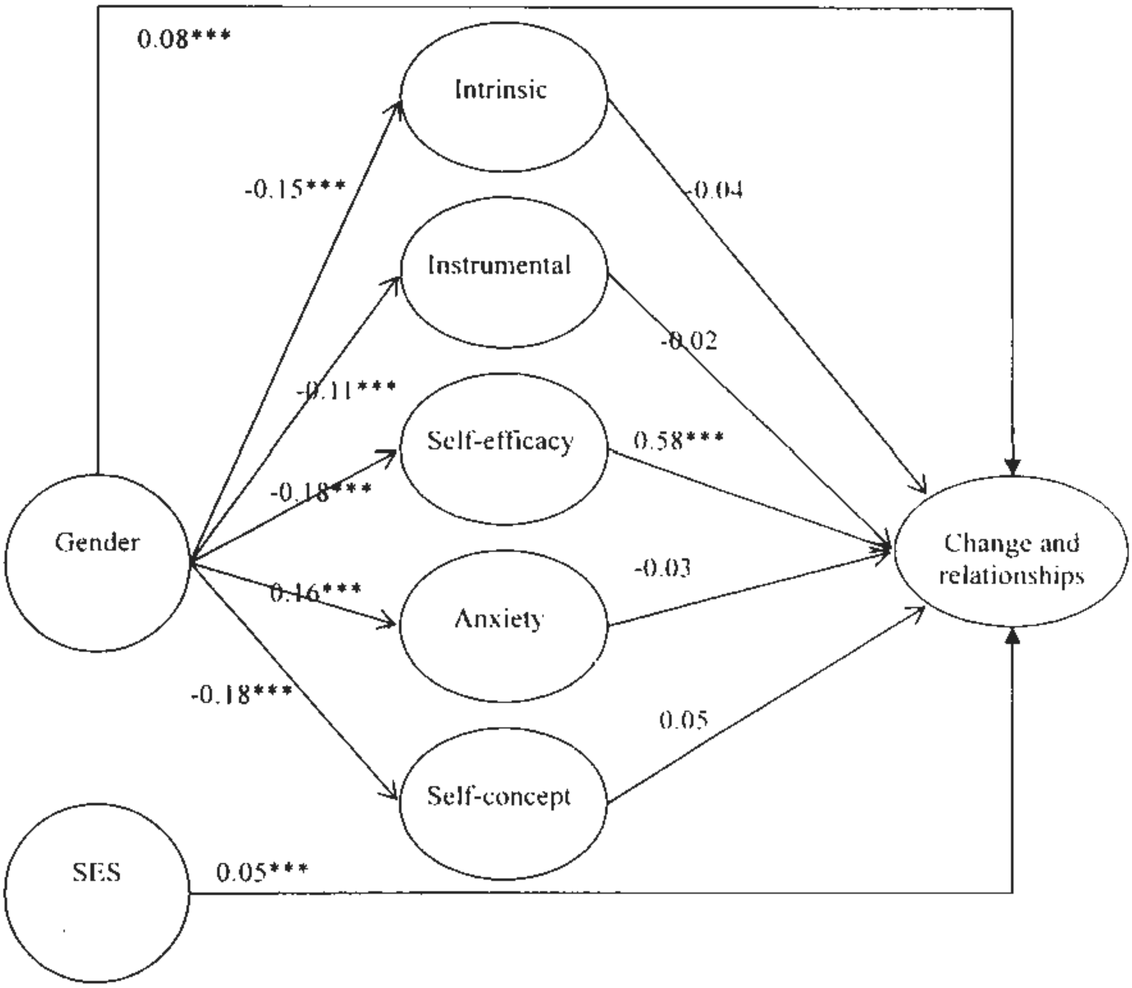
In Figure 5.7, only the path coefficient from self-efficacy to Mathematics achievement in the domain of change and relationships is statistically significant and the value of the path coefficient is 0.58. That means among the five personal variables, only sense of self-efficacy has a significant effect on achievement in the domain of change and relationships.

Look at the effects of gender on the personal variables. The results are more or less the same as the results in section 5.3.2.1. The values of the effect of gender on intrinsic motivation, instrumental motivation, self-efficacy, anxiety and self-concept are -0.15, -0.11, -0.18, 0.16 and -0.18 respectively and all the effects are statistically significant. Therefore, females, have higher anxiety levels in learning Mathematics in the domain of change and relationships but lower intrinsic motivation and instrumental motivation in learning Mathematics than males. Female students also have a lower sense of self-efficacy and self-concept in learning Mathematics in the domain of change and relationships than male students.

The value of the effect of SES on achievement in the domain of change and relationships is 0.05 and is statistically significant. After controlling the effect of SES on the achievement, mediated by the personal variables, the effect of gender on the achievement in the domain of change and relationships is 0.08 and is statistically significant. Therefore, after controlling the effect of SES and equalising the mediating effect of personal variables, females, have an advantage in learning Mathematics in the domain of change and relationships. Comparing with the results in Figure 5.2, the effect of gender is decomposed into direct and indirect effect.

Table 5.9 showed the results of direct effect, indirect effect and total effect of gender on the achievement of change and relationships mediated by personal variables; all the effects are statistically significant. The value of the total effect is -0.03 which is exactly the same as the effect of gender on Mathematics achievement in the domain of change and relationships as shown in Figure 5.2. However, in Figure 5.8, after controlling the effect of SES and mediated by the personal variables, the total effect of gender has been decomposed into direct effect and indirect effect of gender on the achievement in the domain of change and relationships. The value of direct effect is 0.08. That means females, have an advantage in learning Mathematics in the domain of change and relationships. The value of the indirect effect of gender is -0.11. That means males have an advantage when learning Mathematics in the domain of change and relationships through the personal variables. The value of total effect is negative, that is the summation of the value of direct and indirect effect of gender. The value of indirect effect of gender is greater than the value of direct effect of gender. Therefore, although females, have an advantage when learning Mathematics in the domain of change and relationships, the direct effect of gender is not only cancelled out but even surpasses the direct effect by indirect effect in opposite direction. Therefore, the negative value of the total effect of gender is due to the negative value of indirect effect. In other words, the disadvantage for females leaning Mathematics is mainly due to lower motivations, lower sense of self-efficacy, lower self-concept but higher anxiety in learning Mathematics in the domain of change and relationships.

Figure 5.7: Structural model of effect of gender and SES on achievement of change and relationships mediated by personal variables



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.8: Goodness of fit indices of the structural model of effect of on the achievement of change and relationships mediated by personal variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
349	2733.62	0.041 (0.039, 0.042)	0.99	0.99	0.99	0.96	0.95

Table 5.9: Effects of gender on achievement of change and relationships mediated by personal variables

Effect of gender on:	Intrinsic Motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Change and relationships
Direct effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	0.08***
Indirect effect	N.A.	N.A.	N.A.	N.A.	N.A.	-0.11***
Total effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	-0.03*

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.3.2.3 Effects of gender on quantity achievement mediated by personal variables

The effects of gender on quantity achievement mediated by personal variables after controlling the effect of SES will be examined in this section. Figure 5.8 shows the structural model. Table 5.11 shows the results of the direct and indirect effect of gender on Mathematics achievement in the domain of quantity mediated by the five personal variables. The results of goodness of fit indices of the model are shown in Table 5.10. From Table 5.10, the values of degree of freedom (DF) is 349, the value of Chi-square is 2732.81, the value of RMSEA and its 90% confidence interval are 0.041 and (0.039, 0.042) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.99, 0.99, 0.99, 0.96, and 0.95 respectively. All the values of the goodness of fit indices show that it is a good model.

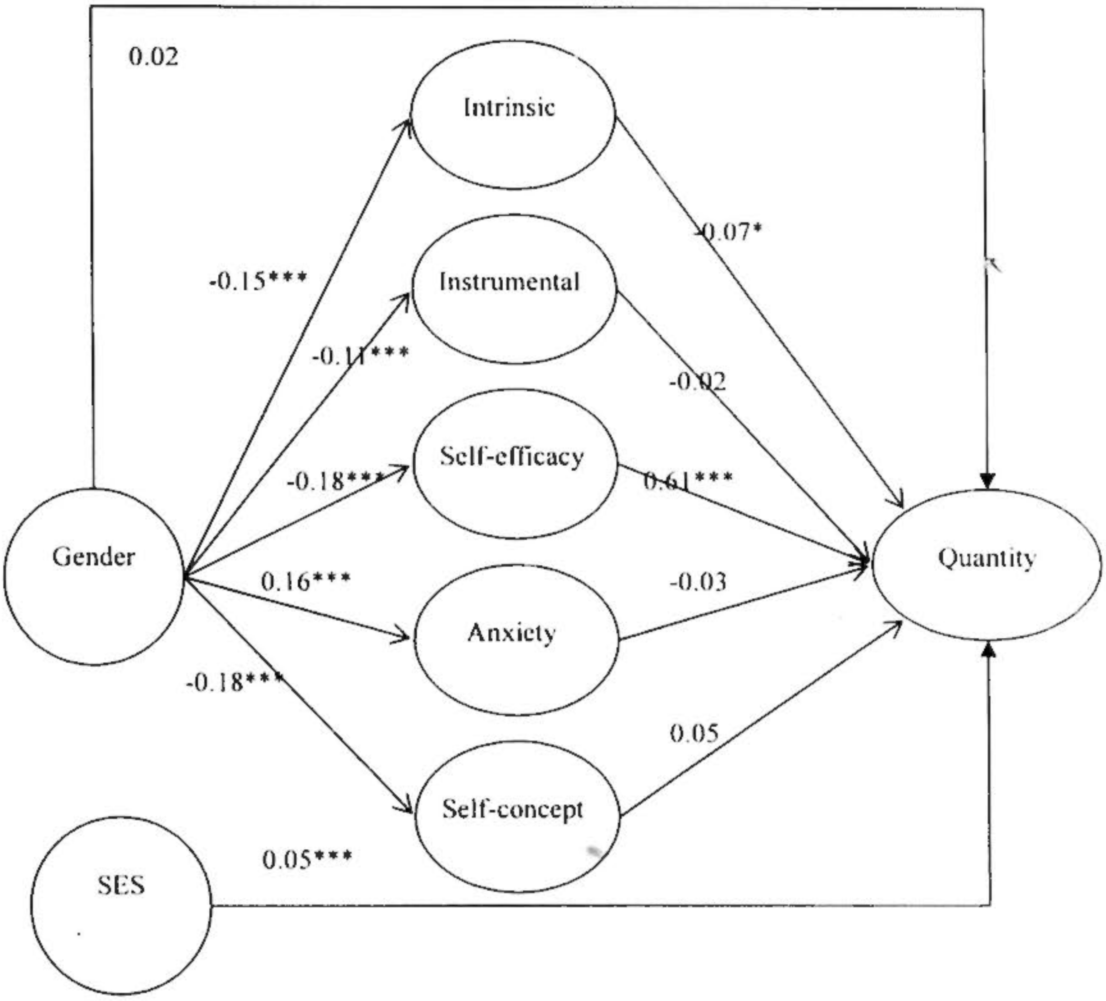
In Figure 5.8, the path coefficients from intrinsic motivation and self-efficacy to Mathematics achievement in the domain of quantity are statistically significant. That means only these two personal variables have significant effect on the achievement in the domain of quantity. The values of the path coefficients from intrinsic motivation and self-efficacy to Mathematics achievement in the domain of quantity are -0.07 and 0.61 respectively, which mean that the higher the intrinsic motivation to learn Mathematics in the domain of quantity, the lower the achievement in the domain of quantity and the higher the sense of self-efficacy, the better the achievement in the domain of quantity. This seems contradictory to the general perception that the higher the intrinsic motivation to learn, the better the result that can be achieved. Further analysis will be conducted in the present study.

The results of another part of the model in Figure 5.8 show the effects of gender on the personal variables. The results are more or less the same as the results in section 5.3.2.1 and 5.3.2.2. The values of the effect of gender on intrinsic motivation, instrumental motivation, self-efficacy, anxiety and self-concept are -0.15, -0.11, -0.18, 0.16 and -0.18 respectively and all the effects are statistically significant. Therefore, females are more anxious in learning Mathematics in the domain of quantity and have lower intrinsic motivation and instrumental motivation towards learning Mathematics than males. Female students also have a lower sense of self-efficacy and self-concept in learning Mathematics in the domain of quantity than male students.

The value of the effect of SES is also 0.05 and is statistically significant in the achievement in the domain of quantity. After controlling the effect of SES and mediating by the personal variables, the value of the effect of gender on Mathematics achievement in the domain of quantity is 0.02, which is not statistically significant. It indicates that females neither have any advantages nor disadvantages in learning Mathematics in the domain of quantity after equalising the mediating effects of personal variables. Similarly, comparing the results of the Figure 5.3, the effect of gender is decomposed into direct and indirect effect.

The results of direct effect, indirect effect and total effect of gender on the achievement of quantity mediated by personal variables are shown in Table 5.11. The value of the total effect of gender is -0.09 and is statistically significant, which is the same as the effect of gender on Mathematics achievement in the domain of quantity as shown in Figure 5.3. But, in Figure 5.8, the total effect of gender has been decomposed into direct and indirect effect on the achievement in the domain of quantity after controlling the effect of SES and mediating by personal variables. The value of direct effect is 0.02 but it is not statistically significant. It shows that the advantage of learning Mathematics in the domain of quantity for females is not significant. The value of indirect effect of gender is -0.11 and is statistically significant. It shows that males have an advantage in learning Mathematics in the domain of quantity through personal variables. As the value of indirect effect of gender is greater than the value of direct effect of gender the indirect effect surpasses the direct effect of gender. Therefore, the disadvantage for females in learning Mathematics is mainly due to the mediating effects of personal variables. In other words, the reasons for females being disadvantaged are mainly lower motivations, lower sense of self-efficacy, lower self-concept and higher anxiety about learning Mathematics in the domain of quantity.

Figure 5.8: Structural model of effect of gender and SES on achievement of quantity mediated by personal variables



"*": p < 0.05; "**": p < 0.01; "***": p < 0.001

Table 5.10: Goodness of fit indices of the structural model of effect of gender on achievement of quantity mediated by personal variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
349	2732.81	0.041 (0.039, 0.042)	0.99	0.99	0.99	0.96	0.95

Table 5.11: Effects of gender effect on achievement of quantity mediated by personal variables

Effect of gender on:	Intrinsic Motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Quantity
Direct effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	0.02
Indirect effect	N.A.	N.A.	N.A.	N.A.	N.A.	-0.11***
Total effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	-0.09***

"*": p < 0.05; "**": p < 0.01; "***": p < 0.001

5.3.2.4 Effects of gender on uncertainty achievement mediated by personal variables

The effects of gender on achievement in the domain of uncertainty after controlling the effect of SES will be examined in this section. Figure 5.9 shows the structural model. The results of direct and indirect effect of gender on Mathematics achievement in the domain of uncertainty mediated by the five personal variables are shown in Table5.13. Table 5.12 shows the results of goodness of fit indices of the model. From Table 5.12, the values of degree of freedom (DF) is 349, the value of Chi-square is 2716.07, the value of RMSEA and its 90% confidence interval are 0.041 and (0.039, 0.042) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.99, 0.99, 0.99, 0.96, and 0.95 respectively. Therefore, all the values of goodness of fit indices show that the model is a good model.

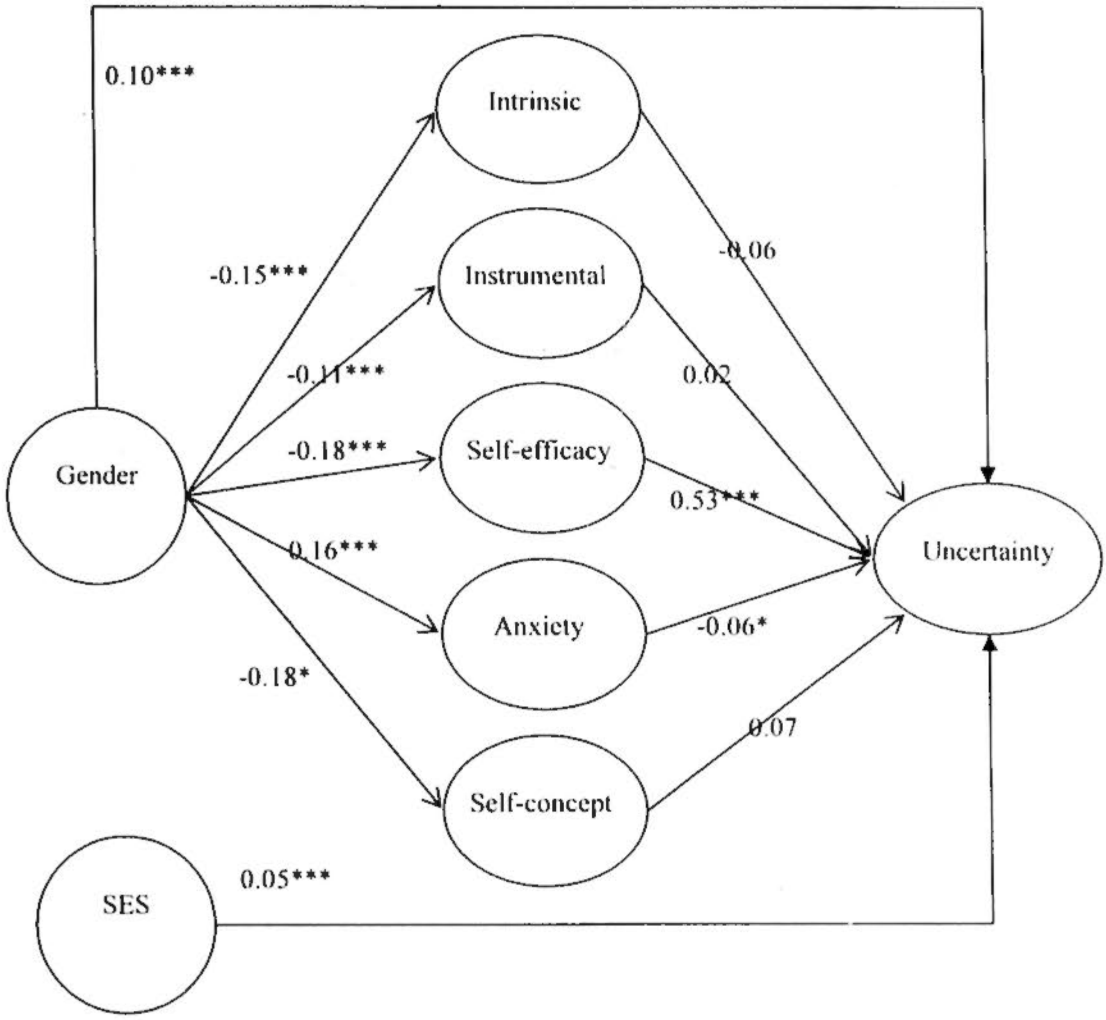
In Figure 5.9, the path coefficients from self-efficacy and anxiety to Mathematics achievement in the domain of uncertainty are statistically significant. Therefore, only these two personal variables have significant effect on achievement in the domain of uncertainty. The values of the effect of self-efficacy and anxiety are 0.53 and -0.06 respectively. That means the higher the sense of self-efficacy, the higher the achievement in the domain of uncertainty and the higher the anxiety level, the lower the achievement in the domain of uncertainty.

The effects of gender on the personal variables are all statistically significant and the results are the same as the results in section 5.3.2.1, 5.3.2.2, and 5.3.2.3. The values of the effect of gender on intrinsic motivation, instrumental motivation, self-efficacy, anxiety and self-concept are -0.15, -0.11, -0.18, 0.16 and -0.18 respectively. Therefore, females are more anxious when learning Mathematics in the domain of quantity and show lower intrinsic motivation and instrumental motivation when learning Mathematics than males. Female students also have a lower sense of self-efficacy and self-concept in learning Mathematics in the domain of quantity than male students.

The value of the effect of SES on achievement in the domain of uncertainty is 0.05 and is statistically significant. After controlling the effect of SES and mediating by the personal variables, the value of the effect of gender on Mathematics achievement in the domain of uncertainty is 0.10 and this is statistically significant. Therefore, females have an advantage when learning Mathematics in the domain of uncertainty after equalising the mediating effects of personal variables and the effect of SES on achievement in the domain of uncertainty. Comparing the results with Figure 5.4, the effect of gender is decomposed into direct and indirect effect.

The results of direct effect, indirect effect and total effect of gender on the achievement in the domain of uncertainty mediated by personal variables are shown in Table 5.13. The value of total effect is -0.01 but it is not statistically significant. Moreover, the result is the same as the result in Figure 5.4. However, the total effect of gender has been decomposed into direct and indirect effect on the achievement in the domain of quantity after controlling the effect of SES and mediated by personal variables in Figure 5.9. The value of direct effect is 0.10 and it is statistically significant. There is a female advantage in learn Mathematics in the domain of uncertainty. The value of the indirect effect of gender is -0.11. Males have an advantage in learning Mathematics in the domain of uncertainty through personal variables. As the value of total effect is 0.01, it is not statistically significant. Therefore, the advantage for females to learn Mathematics is offset by the mediating effect of personal variables. Again, females have a disadvantage, in the domain of uncertainty, because of lower motivations, lower sense of self-efficacy, lower self-concept and higher anxiety about learning Mathematics.

Figure 5.9: Structural model of effect of gender and SES on achievement of uncertainty mediated by personal variables



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.12: Goodness of fit indices of the structural model of gender with SES affecting uncertainty through personal variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
349	2716.07	0.041 (0.039, 0.042)	0.99	0.99	0.99	0.96	0.95

Table 5.13: Gender effect on achievement of uncertainty through personal variables

Effect of gender on:	Intrinsic Motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Uncertainty
Direct effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	0.10***
Indirect effect	N.A.	N.A.	N.A.	N.A.	N.A.	-0.11***
Total effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	-0.01

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.3.2.5 Summary of the findings of effect of gender on Mathematics achievements mediated by personal variables

The effects of gender on Mathematics achievement mediated by personal variables after controlling the effect of SES have been explored in this section in order to answer the second research question. In other words, the total effect of gender has been decomposed into direct and indirect effect of gender. The results are presented in Table 5.14.

From Table 5.14, the results are consistent across the four Mathematics domains. The values of the direct effects of gender on Mathematics achievement in the four domains are all positive and are statistically significant in three out of four Mathematics domains. It indicates that females are at an advantage when learning Mathematics after controlling the effect of SES and mediating the effect of personal variables. The values of the indirect effects of gender on Mathematics achievements in the four domains are all negative and are all statistically significant. It shows that it is to males' advantage to learn Mathematics through personal variables. According to the results in Figure 5.6, Figure 5.7, Figure 5.8 and Figure 5.9, the effects of gender on the five personal variables are consistent in magnitude and direction simultaneously. With higher motivation, higher sense of self-efficacy, higher self-concept and lower anxiety when learn Mathematics, it is obvious that male students can enhance their learning in Mathematics.

Thus, it is clear that the total negative effect of gender is mainly caused by the mediating effect of personal variables. It is because of this that the value of the direct effect of gender is positive once the mediating effects are controlled. However, the values of the total effects of gender on achievement are all negative and are statistically significant in three Mathematics domains as shown in Table 5.14. The mediating effect of gender is decisive in explaining the negative value of total effect of gender. And hence, personal variables are the most critical factors for causing gender differences in learning Mathematics.

Table 5.14: Summary of direct effect, indirect effect and total effect of gender on Mathematics achievements mediated by personal variables

Effect of gender on:	Space and shape	Change and relationships	Quantity	Uncertainty
Direct effect	0.08***	0.08***	0.02	0.10***
Indirect effect	-0.12***	-0.11***	-0.11***	-0.11***
Total effect	-0.04**	-0.03*	-0.09***	-0.01

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.4 Effects of gender on Mathematics achievement mediated by behavioral variables

This section aims to answer the third research question which explores the effect of gender on Mathematics achievement mediated by behavioral variables. This research question is divided into two sub-questions. The first one is whether there are any gender differences in behavioral variables and the second one is how the effects of gender on Mathematics achievement are mediated by behavioral variables. The procedure for answering the question is similar to that which has been used in section 5.3. First of all, the gender differences in behavioral variables will be explored and then the effects of gender on

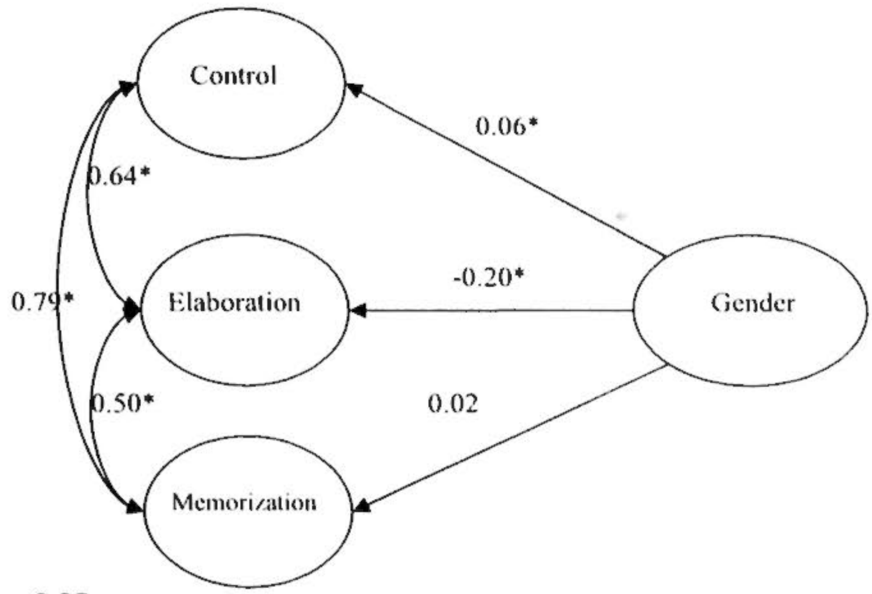
Mathematics achievements in each Mathematics domain mediated by behavioral variables will be investigated. SES will also be considered in the models for analyzing the gender effects on Mathematics achievement mediated by behavioral variables.

5.4.1 Gender difference in behavioral variables

The gender effect of the three behavioral variables, namely control strategies, elaboration strategy, and memorization strategy have been examined in the present study. Figure 5.10 shows the results of effects of gender on each behavioral variable and the results of correlation of each variable are also presented. The results of the goodness of fit indices of the model are shown in Table 5.15. The values of degree of freedom (DF) is 80, the value of Chi-square is 685.61, the value of RMSEA and its 90% confidence interval are 0.042 and (0.040, 0.045) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.98, 0.98, 0.98, 0.98, and 0.97 respectively. All the values of the goodness of fit indices showed that the model is a good model.

In Figure 5.10, the results showed that the values of the gender effects on control strategies and memorization are 0.06 and 0.02 respectively, although only the value of the effect of gender on control strategies is statistically significant. It indicates that females tend to use control strategies and memorization more than males in learning Mathematics. The value of effect of gender on elaboration strategy is -0.20 and is statistically significant. It shows that females have a tendency to use elaboration strategy less than males when learning Mathematics. Therefore, there are gender differences in behavioral variables.

Figure 5.10: Results of effects of gender on behavioral variables



"*": $p < 0.05$

Table 5.15: Goodness of fit indices of the model of gender differences in behavioral variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
80	685.61	0.042 (0.040, 0.045)	0.98	0.98	0.98	0.98	0.97

5.4.2 Effects of gender on Mathematics achievements mediated by behavioral variables

In the following four sub-sections, the effects of gender on Mathematics achievement in each Mathematics domain mediated by behavioral variables will be explored. The model, the values of goodness of fit indices of the model, and the direct effect and indirect effect of gender will be presented.

5.4.2.1 Effects of gender on space and shape achievements mediated by behavioral variables

The effects of gender on the achievement mediated by behavioral variables in the domain of space and shape after controlling the effect of SES will be examined in this section. Figure 5.11 shows the structural model. The results of the direct and indirect effect of gender on Mathematics achievement in the domain of space an shape mediated by the three behavioral variables are shown in Table 5.17. Table 5.16 shows the goodness of fit indices of the model. From Table 5.16, the values of degree of freedom (DF) is 106, the value of Chi-square is 1086.15, the value of RMSEA and its 90% confidence interval are 0.047 and (0.045, 0.050) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.97, 0.97, 0.98, 0.97, and 0.96 respectively. Therefore, the model is considered to be a good model.

In Figure 5.11, the path coefficients from control strategies, elaboration and memorization to Mathematics achievement are all statistically significant. The value of the effect of control strategies, elaboration and memorization are 0.65, 0.13 and -0.59 respectively. This means that the more use of control strategies and elaboration, the better the achievement in the domain of space and shape; whereas the more use of memorization, the worse the achievement in the domain of space and shape. The domain of space and shape is more or less the same as geometry. Therefore, if a student has a stronger spatial feeling, it will be easier for the student to understand the question and hence to solve it. It is hard to solve questions with the same figures. Therefore, memorization strategy may not be helpful. Therefore, it is not worth putting effort into memorizing the question and the answer. Another problem raised is what should be memorized in the domain of space and shape. Different questions have different figures and hence students may use different methods to solve them. What to memorize is another problem. A better understanding of this problem could be the focus of a future study and this is one of the limitations of the present study.

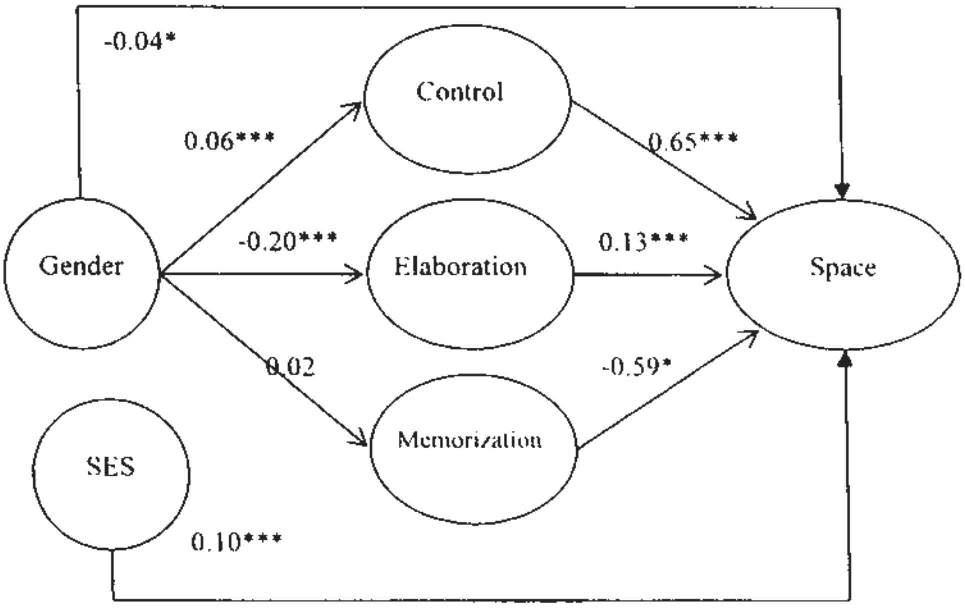
Only the effects of gender on the control strategies and elaboration are statistically significant and the values are 0.06 and -0.20 respectively. Therefore, females prefer to use control strategies more than males and male students prefer to use elaboration more than their female counterparts when learning Mathematics in the domain of space and shape. It may be understandable that there is no gender difference in the use of memorization because East-Asian students are said to be rote learners, so are Hong Kong students. Therefore, this may be one of the reasons that there is no gender difference in the use of memorization strategy. However, the present study cannot provide empirical evidence to show why female students prefer to use control strategies why male students prefer to use elaboration. In order to investigate it, the use of qualitative research methods may help and it can be done in future studies to discover the reasons behind students' preference when using the above strategies.

The value of the effect of SES on achievement in the domain of space and shape is 0.11 and is statistically significant. After controlling the effect of SES and mediation by the behavioral variables, the value of the effect of gender on

Mathematics achievement in the domain of space and shape is -0.04 and this is statistically significant. Therefore, females still have disadvantages when learning Mathematics in the domain of space and shape after equalising the mediating effect of behavioral variables and the effect of SES on achievement in the domain of space and shape.

The results of direct effect, indirect effect and total effect of gender on the achievement in the domain of space and shape mediated by behavioral variables are shown in Table 5.17. The value of total effect is -0.04 and is statistically significant. The result is the same as the result in Figure 5.1. However, the total effect of gender has been decomposed into direct and indirect effect on achievement in the domain of space and shape after controlling the effect of SES and mediated by behavioral variables in Figure 5.11. The value of direct effect is -0.04 and this is statistically significant. It shows that females are at a disadvantage when learning Mathematics in the domain of space and shape. The value of the indirect effect of gender is 0.00. However, the value of the indirect effect of gender is not exactly zero. The exact value should be the sum of the indirect effect of gender on the achievement mediated by the three behavioral variables separately (i.e. 0.06 x 0.65 + -0.20 x 0.13 + 0.02 x -0.59 = 0.0012). So, there is no gender difference in learning Mathematics in the domain of space and shape through behavioral variables. Therefore, the disadvantage for females when learning Mathematics is mainly due to the direct effect.

Figure 5.11: Structural model of effect of gender and SES on achievement of space and shape mediated by behavioral variables



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.16: Goodness of fit indices of the structural model of effect of gender on achievement of space and shape mediated by behavioral variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
106	1086.15	0.047 (0.045, 0.050)	0.97	0.97	0.98	0.97	0.96

Table 5.17: Effects of gender on achievement of space and shape mediated by behavioral variables

Effect of gender on:	Control strategies	Elaboration	Memorization	Space and shape
Direct effect	0.06***	-0. 20***	0.02	-0.04*
Indirect effect	N.A.	N.A.	N.A.	0.00
Total effect	0.06***	-0.20***	0.02	-0.04**

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.4.2.2 Effects of gender on change and relationships achievement mediated by behavioral variables

The effects of gender on achievement mediated by behavioral variables in the domain of change and relationships after controlling the effect of SES will be examined in this section. Figure 5.12 shows the structural model. The results of direct and indirect effect of gender on Mathematics achievement in the domain of change and relationships mediated by behavioral variables are provided in Table 5.19. Table 5.18 shows the goodness of fit indices of the model. In Table 5.18, the values of degree of freedom (DF) is 106, the value of Chi-square is 1095.34, the value of RMSEA and its 90% confidence interval are 0.048 and (0.045, 0.050) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.97, 0.97, 0.98, 0.97, and 0.96 respectively. Therefore, the model is a good model.

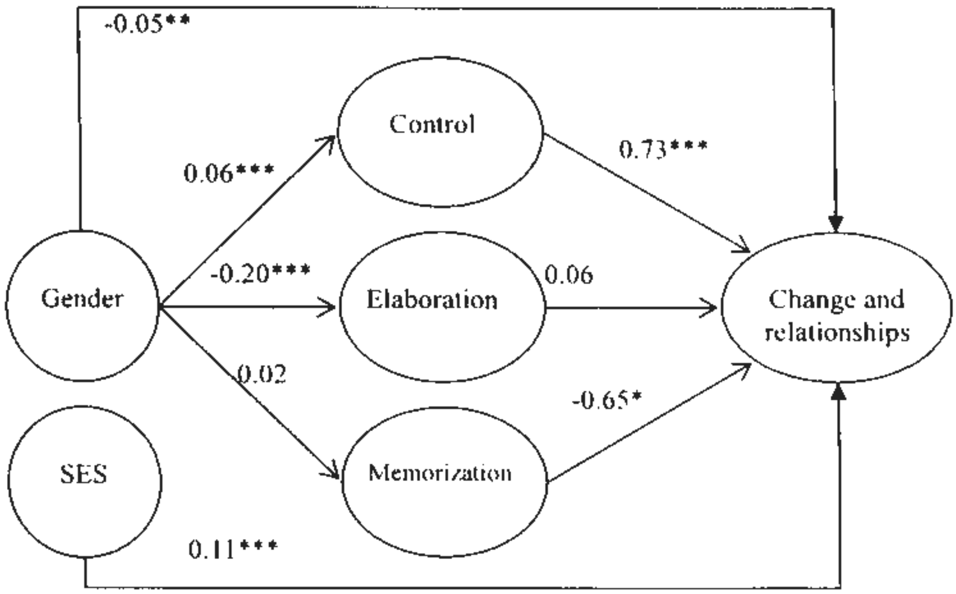
In Figure 5.12, the path coefficients from control strategies and memorization to Mathematics achievement are statistically significant and the values of the path coefficients are 0.73 and -0.65 respectively. Therefore, the more use of control strategies, the better the achievement that can be achieved, but the more use of memorization, the worse the achievement in the domain of change and relationships.

The effect of gender on control strategies and elaboration are statistically significant and the values are 0.06 and -0.20 respectively. The results are the same as the results obtained in section 5.4.2.1. This means that female students prefer to use control strategies more often than male students and males prefer to use elaboration more than females when learning Mathematics in the domain of change and relationships.

The value of the effect of SES on achievement in the domain of change and relationships is 0.11 and it is statistically significant. The result is also the same as that in section 5.4.2.1. After controlling the effect of SES and mediating by behavioral variables, the values of the effect of gender on the achievement in the domain of change and relationships is -0.05 and this effect is statistically significant. It leads to the conclusion that females are at disadvantage when learning Mathematics in the domain of change and relationship after equalising the mediating effect of behavioral variables and the effect of SES.

The results of direct effect, indirect and total effect of gender on achievement in the domain of change and relationships mediated by behavioral variables are shown in Table 5.19. The value of total effect is -0.03 and is statistically significant. The result is the same as the result in Figure 5.2. However, the total effect of gender in the model shown in Figure 5.12 is decomposed into direct and indirect effect. The value of direct effect is -0.05 and is statistically significant. Females have a disadvantage when learning Mathematics in the domain of change and relationships. The value of indirect effect of gender is 0.02 but it is not statistically significant. Females have an advantage of learning Mathematics in the domain of change and relationships through behavioral variables but the effect is not significant.

Figure 5.12: Structural model of effect of gender and SES on achievement of change and relationships mediated by behavioral variables



"*": p < 0.05; "**": p < 0.01; "***": p < 0.001

Table5.18 Goodness of fit indices of the structural model of effect of gender with on achievement of change and relationships mediated by behavioral variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
106	1095.34	0.048 (0.045, 0.050)	0.97	0.97	0.98	0.97	0.96

Table 5.19: Effect of gender on achievement of change and relationships mediated by behavioral variables

Effect of gender on:	Control strategies	Elaboration	Memorization	Change and relationships
Direct effect	0.06***	-0. 20***	0.02	-0.05*
Indirect effect	N.A.	N.A.	N.A.	0.02
Total effect	0.06***	-0.20***	0.02	-0.03*

"*": p < 0.05; "**": p < 0.01; "***": p < 0.001

5.4.2.3 Effects of gender on quantity achievement mediated by behavioral variables

In this section, the effects of gender on achievement mediated by behavioral variables in the domain of quantity after controlling the effect of SES are examined. Figure 5.13 shows the structural model. Table 5.21 shows the results of direct and indirect effect of gender on Mathematics achievement in the domain of quantity mediated by the three behavioral variables. Table 5.20 shows the goodness of fit indices of the model. From Table 5.20, the values of degree of freedom (DF) is 106, the value of Chi-square is 1083.40, the value of RMSEA and its 90% confidence interval are 0.047 and (0.045, 0.050) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.97, 0.97, 0.98, 0.97, and 0.96 respectively. Therefore, the model is considered as a good model.

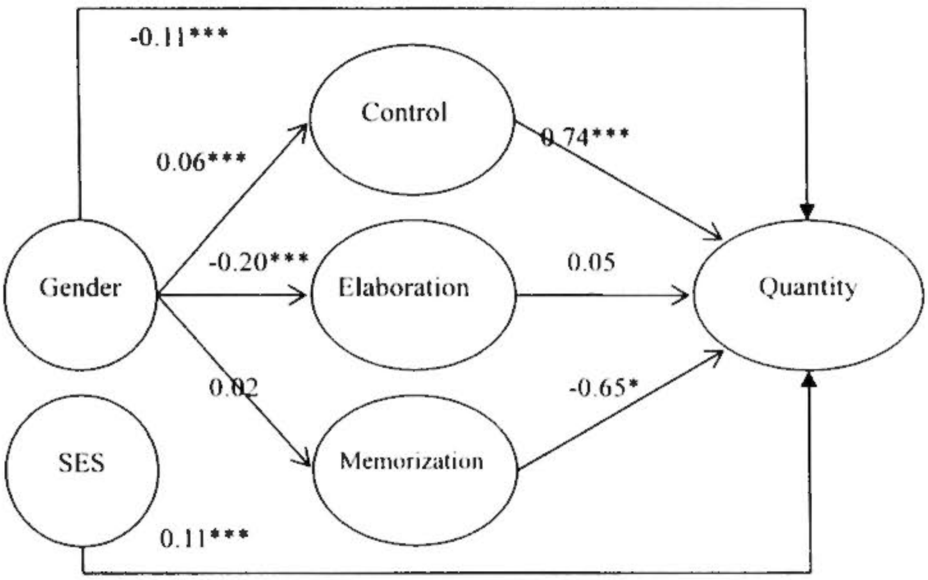
In Figure 5.13, the path coefficients from control strategies and memorization to Mathematics achievement are statistically significant and the values are 0.74 and -0.65 respectively. Thus, the more use of control strategies, the better the achievement, whereas the more use of memorization, the worse the achievement in the domain of quantity.

The effect of gender on control strategies and elaboration are statistically significant and the values are 0.06 and -0.20 respectively. The results are the same as the results obtained in section 5.4.2.1 and in section 5.4.2.2. So, female students prefer to use control strategies more than male students and males prefer to use elaboration more than females when learning Mathematics in the domain of quantity.

The value of the effect of SES on the achievement in the domain of quantity is 0.11 and is statistically significant. After controlling the effect of SES and mediating by the behavioral variables, the values of the effect of gender on Mathematics achievement in the domain of quantity is -0.11 and is statistically significant. So, females are disadvantaged when learning Mathematics in the domain of quantity after equalising the mediating effect of behavioral variables and the effect of SES.

The results of direct effect, indirect effect and total effect of gender on achievement in the domain of quantity mediated by the behavioral variables are shown in Table 5.21. The value of total effect of gender is -0.09 and is statistically significant. The result is the same as the result in Figure 5.3. Nevertheless, the total effect of gender is decomposed into direct and indirect effect of gender in Figure 5.13 after controlling the effect of SES and mediating by the effect of behavioral variables. The value of direct effect is -0.11 and is statistically significant. It shows that females have a disadvantage when learning Mathematics in the domain of quantity. The value of the indirect effect is 0.02 but it is not statistically significant. It shows that females have an advantage when learning Mathematics in the domain of quantity through behavioral variables but the effect is not significant. Since the value of total effect of gender is the sum of the value of direct effect and indirect effect of gender, the direct effect of gender has been alleviated by the indirect effect of gender.

Figure 5.13: Structural model of effect of gender and SES on achievement of quantity mediated by behavioral variables



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.20: Goodness fit indices of the structural model of effect of gender on achievement of quantity mediated by behavioral variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
106	1083.40	0.047 (0.045,0.050)	0.97	0.97	0.98	0.97	0.96

Table 5.21: Effects of gender on achievement of quantity mediated by behavioral variables

Effect of gender on:	Control strategies	Elaboration	Memorization	Quantity
Direct effect	0.06***	-0. 20***	0.02	-0.11***
Indirect effect	N.A.	N.A.	N.A.	0.02
Total effect	0.06***	-0.20***	0.02	-0.09***

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.4.2.4 Effects of gender on uncertainty achievement mediated by behavioral variables

The effects of gender on achievement mediated by behavioral variables in the domain of uncertainty after controlling the effect of SES are examined in this section. Figure 5.14 shows the structural model. Table 5.23 shows the results of direct and indirect effect of gender on Mathematics achievement in the domain of uncertainty mediated by behavioral variables. Table 5.22 shows the goodness of fit indices of the model. It shows that the value of degree of freedom (DF) is 106, the value of Chi-square is 1054.12, the value of RMSEA and its 90% confidence interval are 0.047 and (0.044, 0.049) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.97, 0.97, 0.98, 0.97, and 0.96 respectively. Therefore, the model is considered to be a good model.

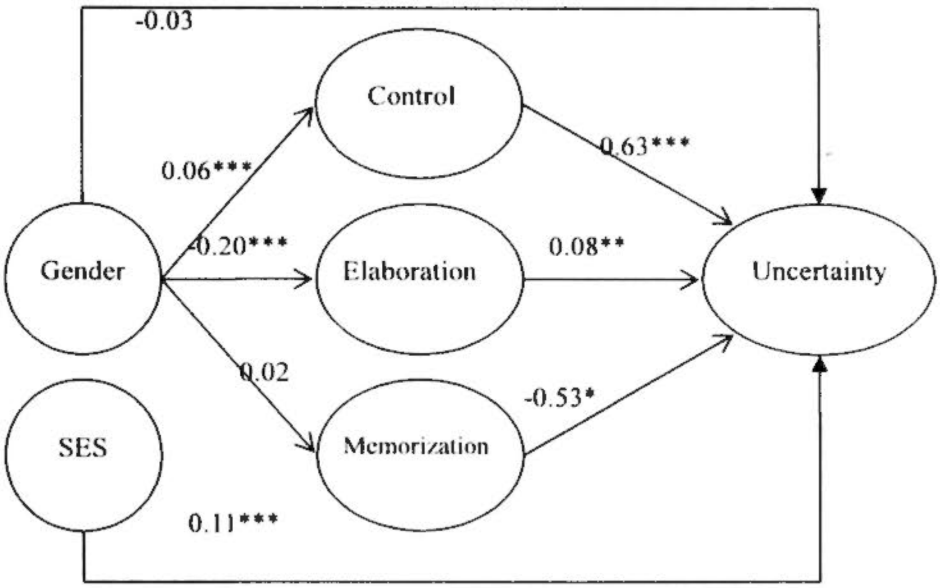
In Figure 5.14, the path coefficients from control strategies, elaboration and memorization to Mathematics achievement are all statistically significant and the values are 0.63, 0.08, and -0.53 respectively. That means the more use of control strategies and elaboration, the better Mathematics achievement can be achieved whereas the more use of memorization, the worse the Mathematics achievement in the domain of uncertainty.

The effects of gender on control strategies and elaboration are statistically significant and the values are 0.06 and -0.20 respectively. The results are the same as the results in section 5.4.2.1, 5.4.2.2 and 5.4.2.3. In other words, female students use control strategies more often than male students and male students prefer to use elaboration more than female students when learning Mathematics, in the domain of uncertainty.

The value of the effect of SES on achievement in the domain of uncertainty is 0.11 and is statistically significant. After controlling the effect of SES and mediating by the behavioral variables, the values of the gender on Mathematics achievement in the domain of uncertainty is -0.03 but this is not statistically significant. Therefore, females are at a disadvantage when learning Mathematics in the domain of uncertainty after equalising the mediating effect of behavioral variables and the effect of SES However, the disadvantage is insignificant.

The results of direct, indirect effect and total effect of gender on achievement in the domain of uncertainty mediated by the behavioral variables are shown in Table 5.23. The value of the total effect of gender is -0.01, which is not statistically significant. The total effect has been decomposed into direct and indirect effect of gender in the model shown in Figure 5.14. The value of direct effect of gender is 0.01 but this is not statistically significant. After controlling the effect of SES and mediating by the effect of behavioral variables, females are at a disadvantage of learning Mathematics in the domain of uncertainty but the disadvantage is not significant. The value of indirect effect of gender is 0.01 but this is not statistically significant. It shows a trend towards females having a slight advantage of the domain of uncertainty through behavioral variables though it is not significant. Since the value of the total effect of gender is the sum of the value of direct effect and indirect effect of gender, the direct effect of gender has been alleviated by the indirect effect of gender.

Figure 5.14: Structural model of effect of gender and SES on achievement of uncertainty mediated by behavioral variables



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.22: Goodness of fit indices of the structural model of effect of gender on achievement of uncertainty mediated by behavioral variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
106	1054.12	0.047 (0.044, 0.049)	0.97	0.97	0.98	0.97	0.96

Table 5.23: Effects of gender on achievement of uncertainty mediated by behavioral variables

Effect of gender on:	Control strategies	Elaboration	Memorization	Uncertainty
Direct effect	0.06***	-0. 20***	0.02	-0.03
Indirect effect	N.A.	N.A.	N.A.	0.01
Total effect	0.06***	-0.20***	0.02	-0.01

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.4.2.5 Summary of the findings of effects of gender on Mathematics achievements mediated by behavioral variables

The effects of gender on Mathematics achievements mediated by the behavioral variables after controlling the effect of SES have been explored in this section to answer the third research question. The results are shown in Table 5.24 and are consistent across the four Mathematics domains. The values of the direct effects of gender on Mathematics achievements in the four domains are all negative. After controlling the effect of SES and mediating the effect of behavioral variables, females are at a disadvantage when learning Mathematics. The values of indirect effects of gender on Mathematics achievement in the four domains are not statistically significant. Males do not have significant advantages in learning Mathematics through behavioral variables. Based on the results presented in Figure 5.11, Figure 5.12, figure 5.13 and Figure 5.14, all the effects of gender on the three behavioral variables are consistent not only in their magnitude but also the direction across the four Mathematics domains. The value of the effect of gender on control strategies is positive and statistically significant and the value of the effect of gender on elaboration is negative and statistically significant. The effect of gender on memorization is positive but not statistically significant. That means female students use control strategies more than male students and male students use elaboration more than female students. However, there is no significant gender difference in using memorization when learning Mathematics. One of the possible reasons that there is no gender difference in using memorization strategy is Hong Kong students, both male and female students are rote learners. However, in order to have a better understanding of the reason, qualitative research methods can be used in future studies to closely investigate the reasons. Therefore, there are still significant differences in direct and total effects after decomposing the total effects into direct and indirect effects of gender. However, the mediating effects of all the behavioral variables are not statistically significant on gender difference in Mathematics achievements.

Table 5.24: Summary of direct effect, indirect effect and total effect of gender on Mathematics achievements mediated by behavioral variables

Effect of gender on:	Space and shape	Change and relationships	Quantity	Uncertainty
Direct effect	-0.04*	-0.05*	-0.11***	-0.03
Indirect effect	0.00	0.02	0.02	0.01
Total effect	-0.04**	-0.03*	-0.09***	-0.01

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.5 Effects of gender on Mathematics achievement mediated by environmental variables

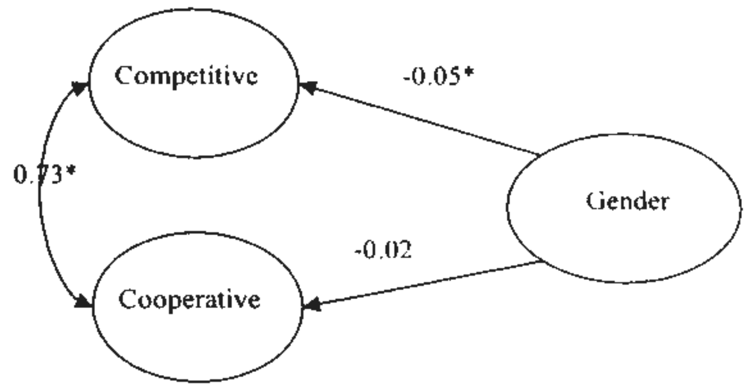
In this section, the fourth research question is going to be answered. The fourth research question is to explore the effect of gender on Mathematics achievements mediated by environmental variables. Also, the research question is split into two sub-questions. The first one is to explore whether there are any gender differences in environmental variables and the second one is to explore how the effects of gender in Mathematics achievement is mediated by environmental variables. The procedure for performing the analyses is similar to those has been done in section 5.3 and section 5.4. Therefore, the gender differences in environmental variables will be explored in the first place and then the effects of gender on Mathematics achievement in each Mathematics domain mediated by environmental variable will be investigated. SES will also be considered in the models for analyzing the second sub-question.

5.5.1 Gender difference in environmental variables

The effects of gender on the two environmental variables, consisting of competitive learning preference and cooperative learning preference, are examined in this section. Figure 5.15 showed the results of effects of gender on the two learning preferences and the results of correlation of each variable are also presented. Table 5.25 shows the goodness of fit indices of the model. From Table 5.25, the values of degree of freedom (DF) is 36, the value of Chi-square is 415.02, the value of RMSEA and its 90% confidence interval are 0.049 and (0.045, 0.053) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.99, 0.98, 0.99, 0.98, and 0.97 respectively. Therefore, the model is considered to be a good model.

In Figure 5.15, the results showed that the values of the effects of gender on competitive learning preference and cooperative learning preference are -0.05 and -0.02 respectively, but only the effect of gender on competitive learning preference is statistically significant. It shows that females are less likely to prefer learning Mathematics in a competitive learning situation than male students. Therefore, the results showed that there is gender difference in the preference of learning environment.

Figure 5.15: Results of effects of gender on environmental variables



"*": $p < 0.05$

Table 5.25: Goodness of fit indices of the model of gender differences in environmental variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
36	415.02	0.049 (0.045, 0.053)	0.99	0.98	0.99	0.98	0.97

5.5.2 Effects of gender on Mathematics achievements mediated by environmental variables

In the following four sub-sections, the effect of gender on Mathematics achievement in each Mathematics domain mediated by environmental variables will be explored. The model, the values of goodness of fit indices of the model, and the direct and indirect effect of gender will be presented.

5.5.2.1 Effects of gender on space and shape achievement mediated by environmental variables

The effects of gender on achievement mediated by the environmental variables in the domain of space and shape after controlling the effect of SES will be examined in this section. Figure 5.16 shows the structural model. The results of direct and indirect effect of gender on Mathematics achievement in the domain of space and shape mediated by the effects of the two environmental variables are presented in Table 5.27. Table 5.26 shows the results of goodness of fit indices of the model. In Table 5.26, the values of degree of freedom (DF) is 55, the value of Chi-square is 585.83, the value of RMSEA and its 90% confidence interval are 0.047 and (0.044, 0.051) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.98, 0.98, 0.98, 0.98, and 0.97 respectively. All the values of the goodness of fit indices show that the model is a good model.

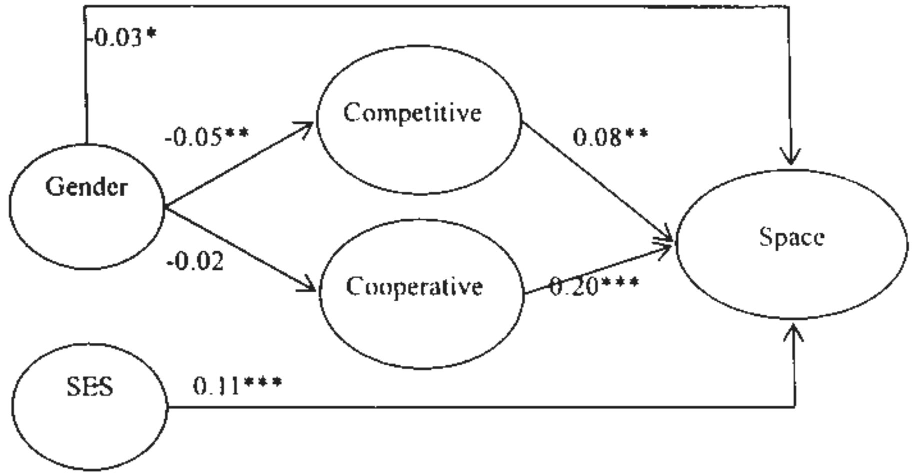
In Figure 5.15, the path coefficients from competitive learning preference and cooperative learning preference to the achievement in the domain of space and shape are both statistically significant and the values are 0.08 and 0.20 respectively. That means the higher preference of competitive learning situation or the higher preference of cooperative learning situation, the better the achievement in the domain of space and shape. The results echo the view of Ho and Hau's (2008) study that competitive learning preference and cooperative leaning preference are not mutually exclusive.

The effect of gender on competitive learning preference is statistically significant and the value is -0.05. It indicates that more males prefer competitive learning situation than females.

The value of effect of SES on achievement in the domain of space and shape is 0.11 and this is statistically significant. The effect of gender on achievement after controlling the effect of SES and the mediating effect of the environmental variables is -0.03 and is statistically significant. After equalising the effect of SES and the mediating effect of environmental variables, females have a disadvantage when learning Mathematics in the domain of space and shape. Comparing the result of the gender effect in Figure 5.1, the results are not consistent because the effect of gender has been decomposed into direct and indirect effect of gender in Figure 5.15.

The results of the direct effect, indirect effect and total effect of gender on achievement in the domain of space and shape mediated by environmental variables and after controlling the effect of SES are provided in Table 5.25. The value of the total effect of gender on achievement is -0.04 and is statistically significant. The value of direct effect is -0.03, which is statistically significant. After controlling the effect of SES and the mediating effect of environmental variables, females are at disadvantage when learning Mathematics in the domain of space and shape. The value of indirect effect is -0.01 and is statistically significant. It shows that females have a disadvantage when learning Mathematics in the domain of space and shape through environmental variables.

Figure 5.16: Structural model of effect of gender and SES on achievement of space and shape mediated by environmental variables



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.26: Goodness of fit indices of the structural model of effect of gender on achievement of space and shape mediated by environmental variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
55	585.83	0.047 (0.044, 0.051)	0.98	0.98	0.98	0.98	0.97

Table 5.27: Effects of gender on achievement of space and shape mediated by environmental variables

Effect of gender on:	Competitive learning preference	Cooperative learning preference	Space and shape
Direct effect	-0.05**	-0.02	-0.03*
Indirect effect	N.A.	N.A.	-0.01*
Total effect	-0.05**	-0.02	-0.04**

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.5.2.2 Effects of gender on change and relationships achievement mediated by environmental variables

In this section, the effects of gender on the achievement mediated by the environmental variables in the domain of change and relationships after controlling the effects of SES will be examined. Figure 5.17 shows the structural model. The results of direct and indirect effect of gender are presented in Table 5.29. Table 5.28 shows the results of goodness of fit indices of the model. In Table 5.28, the values of degree of freedom (DF) is 55, the value of Chi-square is 601.74, the value of RMSEA and its 90% confidence interval are 0.048 and (0.045, 0.051) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.98, 0.98, 0.98, 0.98, and 0.97 respectively. Therefore, the model is considered to be a good model.

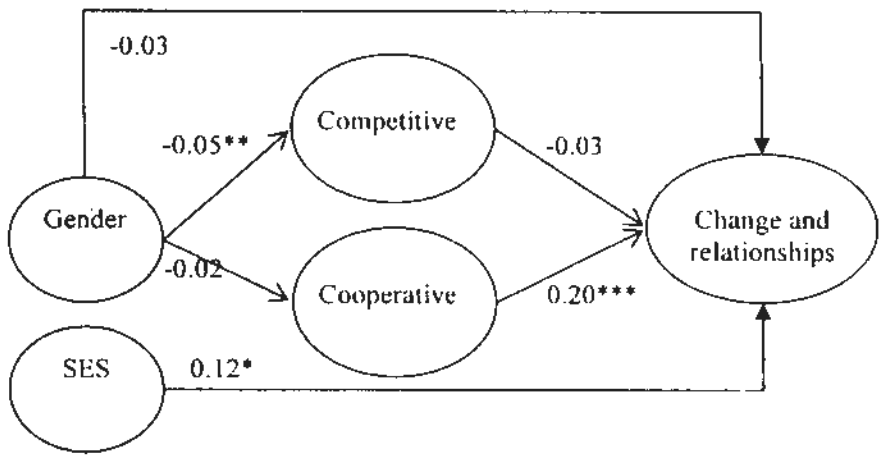
The path coefficient from cooperative learning preference to the achievement in the domain of change and relationships is statistically significant and the value is 0.20. Thus, the higher preference in cooperative learning situations, the better the achievement in the domain of change and relationships.

The effect of gender on competitive learning preference is statistically significant and the value is-0.05. The result is the same as the result in section 5.5.2.1. More male students prefer competitive learning situation than female students.

The value of effect of SES on achievement in the domain of change and relationships is 0.12 and this is statistically significant. The effect of gender on achievement after controlling the effect of SES and the mediating effect of environmental variables is -0.03 but this is not statistically significant. After equalising the effect of SES and the mediating effect of environmental variables, females have a disadvantage when learning Mathematics in the domain of change and relationships. Since the effect of gender has been decomposed into direct and indirect effect of gender, the result in Figure 5.17 is different from the result in Figure 5.2.

The results of the direct effect, indirect effect and total effect of gender on achievement in the domain of change and relationships mediated by environmental variables and after controlling the effect of SES are provided in Table 5.29. The value of the total effect of gender on the achievement is -0.03 and this is statistically significant. The value of the direct effect of gender is -0.03, which is not statistically significant. The value of indirect effect is -0.01 and is also not statistically significant. Therefore, females have a disadvantage when learning Mathematics in the domain of change and relationships directly and indirectly through environmental variables but the disadvantage is not significant. However, when summing up the disadvantages, their disadvantage when learning Mathematics in the domain of change and relationships are significant.

Figure 5.17: Structural model of effect of gender and SES on achievement of change and relationships mediated by environmental variables



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.28: Goodness of fit indices of the structural model of effect of gender on achievement of change and relationships mediated by environmental variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
55	601.74	0.048 (0.045, 0.051)	0.98	0.98	0.98	0.98	0.97

Table 5.29: Effects of gender on achievement of change and relationships mediated by environmental variables

Effect of gender on:	Competitive learning preference	Cooperative learning preference	Change and relationships
Direct effect	-0.05**	-0.02	-0.03
Indirect effect	N.A.	N.A.	-0.01
Total effect	-0.05**	-0.02	-0.03*

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.5.2.3 Effects of gender on quantity achievement mediated by environmental variables

The effects of gender on achievement mediated by the environmental variables in the domain of quantity after controlling the effect of SES will be examined in this section. Figure 5.18 shows the structural model. The results of direct and indirect effect of gender on Mathematics achievement in the domain of quantity mediated by environmental variables are provided in Table 5.31. Table 5.30 shows the results of goodness of fit indices of the model. In Table 5.30, the values of degree of freedom (DF) is 55, the value of Chi-square is 597.02, the value of RMSEA and its 90% confidence interval are 0.048 and (0.044, 0.051) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.98, 0.98, 0.98, 0.98, and 0.97 respectively. All the values of goodness of fit indices of the model show that it is a good model.

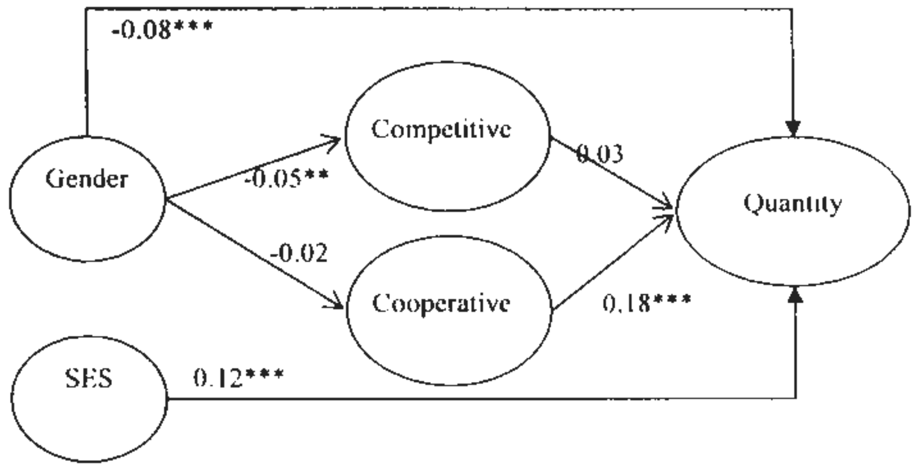
The path coefficient from cooperative learning preference to the achievement is statistically significant and the value is 0.18. Therefore, the higher preference for a cooperative learning situation is, the better the achievement.

The value of the effect of gender on competitive learning preference is -0.05, which is statistically significant. The result is the same as those in section 5.5.2.1 an 5.5.2.2. Therefore, more male students prefer a competitive learning situation than female students.

The value of effect of SES on the achievement in the domain of quantity is 0.12 and this is statistically significant. The effect of gender on the achievement after controlling the effect of SES and the mediating effect of environmental variables is -0.08 and it is statistically significant. After equalising the effect of SES and the mediating effect of environmental variables, females are at a disadvantage in learning Mathematics in the domain of quantity. The effect of gender has been decomposed into direct and indirect effect of gender. The result, therefore, is different from the result in Figure 5.3.

The results of the direct effect, indirect effect and total effect of gender on the achievement in the domain of quantity mediated by environmental variables and after controlling the effect of SES are presented in Table 5.31. The value of total effect of gender is -0.09 and it is exactly the same as the result in Figure 5.3. The value of the direct effect of gender is -0.08 and is statistically significant. The indirect effect of gender is -0.01, but this is not statistically significant. Therefore, females have a disadvantage when learning Mathematics in the domain of quantity through environmental variables although the effect is not significant. However, when summing up the direct and indirect effect, female disadvantages in learning Mathematics in the domain of quantity are increasing.

Figure 5.18: Structural model of effect of gender and SES on achievement of quantity mediated by environmental variables



"*": p < 0.05; "**": p < 0.01; "***": p < 0.001

Table 5.30: Goodness of fit indices of the structural model of effect of gender on achievement of quantity mediated by environmental variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
55	597.02	0.048 (0.044, 0.051)	0.98	0.98	0.98	0.98	0.97

Table 5.31: Effects of gender effect on achievement of quantity mediated by environmental variables

Effect of gender on:	Competitive learning preference	Cooperative learning preference	Quantity
Direct effect	-0.05**	-0.02	-0.08***
Indirect effect	N.A.	N.A.	-0.01
Total effect	-0.05**	-0.02	-0.09***

"*": p < 0.05; "**": p < 0.01; "***": p < 0.001

5.5.2.4 Effects of gender on uncertainty achievement mediated by environmental variables

The effects of gender on the achievement mediated by the environmental variables in the domain of uncertainty will be examined in this section. Figure 5.19 shows the structural model. The results of direct and indirect effect of gender are shown in Table 5.33. Table 5.32 shows the results of goodness of fit indices of the model. In Table 5.32, the values of degree of freedom (DF) is 55, the value of Chi-square is 589.69, the value of RMSEA and its 90% confidence interval are 0.047 and (0.044, 0.051) respectively. The values of NFI, NNFI, CFI, GFI and AGFI are 0.98, 0.98, 0.98, 0.98, and 0.97 respectively. Therefore, the model is considered to be a good model.

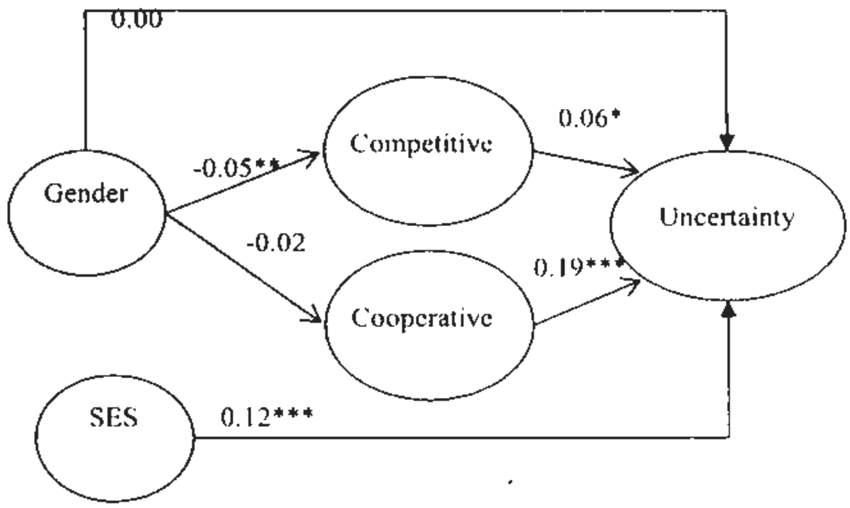
Both the path coefficients from competitive learning preferences and cooperative learning preference to Mathematics achievement in the domain of uncertainty are statistically significant. The values of the path coefficients are 0.06 and 0.19. That means the higher preference of competitive learning situation or the higher preference of cooperative situation, the better the achievement in the domain of uncertainty can be achieved.

The effect of gender on competitive learning preference is statistically significant and the value is -0.05. The result is the same as the results in sections 5.5.2.1, 5.5.2.2 and 5.5.2.3. It shows that more males prefer competitive learning situation than females.

The value of the effect of SES on the achievement in the domain of uncertainty 0.12 and is statistically significant. The effect of gender on achievement after controlling the effect of SES and the mediating effect of environmental variables is 0.00. After equalising the effect of SES and the mediating effect of environmental variables, there is no gender difference on the achievement in the domain of uncertainty.

The results of direct effect, indirect effect and total effect of gender on the achievement in the domain of uncertainty after controlling the effect of SES and mediated by the effect of environmental variables are presented in Table 5.33. The value of total effect of gender is -0.01 and it is not statistically significant. The result is the same as shown in Figure 5.4. The value of direct effect is 0.00 and the value of indirect effect is -0.01. All the effects of gender are statistically insignificant. Therefore, the achievement in the domain of uncertainty, there is no gender difference.

Figure 5.19: Structural model of effect of gender and SES on achievement of uncertainty mediated by environmental variables



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.32: Goodness of fit indices of the structural model of effect of gender on achievement of uncertainty mediated by environmental variables

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
55	589.69	0.047 (0.044, 0.051)	0.98	0.98	0.98	0.98	0.97

Table 5.33: Effects of gender on achievement of uncertainty mediated by environmental variables

Effect of gender on:	Competitive learning preference	Cooperative learning preference	Uncertainty
Direct effect	-0.05**	-0.02	0.00
Indirect effect	N.A.	N.A.	-0.01
Total effect	-0.05**	-0.02	-0.01

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.5.2.5 Summary of the findings of the effects of gender on Mathematics achievements mediated by environmental variables

The effects of gender on Mathematics achievement mediated by the environmental variables after controlling the effect of SES have been explored in this section to answer the fourth research question. A summary of the results is presented in Table 5.34. According to Table 5.34, the results are consistent across the four Mathematics domains. The values of the direct effects of gender on the Mathematics achievements in the four domains are all negative, except in the domain of uncertainty. It indicates that females still show significant negative effects on Mathematics achievements in three of the four domains after controlling the effect of SES and mediated by the effects of environmental variables. The values of the indirect effects of gender are all negative, but only the effect of gender on the achievement in the domain of space and shape is statistically significant. Looking at the effect of gender on the two environmental variables, only the effect of gender on competitive learning preference is statistically significant and the values are all negative. That means more male students prefer a competitive learning situation than female students. Looking at the direct effects, indirect effects and total effects of gender, the directions are consistent in all the four domains. Therefore, there are gender differences. The mediating effects of environmental variables on gender effect are not significant in three out of four Mathematics domains.

Table 5.34: Summary of direct effect, indirect effect and total effect of gender on Mathematics achievements mediated by environmental variables

Effect of gender on:	Space and shape	Change and relationships	Quantity	Uncertainty
Direct effect	-0.03*	-0.03	-0.08***	0.00
Indirect effect	-0.01*	-0.01	-0.01	-0.01
Total effect	-0.04**	-0.03*	-0.09***	-0.01

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.6 Effect of gender on Mathematics achievement mediated by three sets of variables in self-regulated learning theory

In sections 5.3, 5.4 and 5.5, the effects of gender on Mathematics achievements in the four domains after controlling the effect of SES and mediating by the personal, behavioral and environmental variables were considered separately. This section aims to answer the fifth research question of the present study. So, the three sets of variables will be considered altogether in one structural mode. The analyses will be divided into two steps. The first step is to consider the three sets of variables altogether with independent relationships to each other and the second step is with relationships among the three sets of mediating variables as shown in the conceptual framework in Chapter three (Fig. 3.1). The models in step one will be called "intermediate" models and the models in the second step will be called as "full" models. The reason for dividing the analysis into two steps is to examine the unidirectional relationships of the three sets of variables. Since very few researchers (e.g. Liu, 2009) have tried to use all three sets of variables for analysis and no research could be found to explore the interrelationships among the three sets of variables, it is worthwhile conducting the intermediate model because it can be used to compare with the full model so as to provide empirical evidence to support the theory of self-regulated learning.

If the values of good fit of full model are worse than those of the intermediate model, the setting of the interrelationships among the three set of variables may not be appropriate and hence there will be a need to revise the theory of self-regulated learning. If the values of goodness of fit indices of the full model reach the threshold as a good model, it will be important empirical evidence to support the existence of the interrelationships among the three sets of variables and therefore support the theory of self-regulated learning. Therefore, it is worthwhile to examine the unidirectional relationships among the three sets of variables in one model.

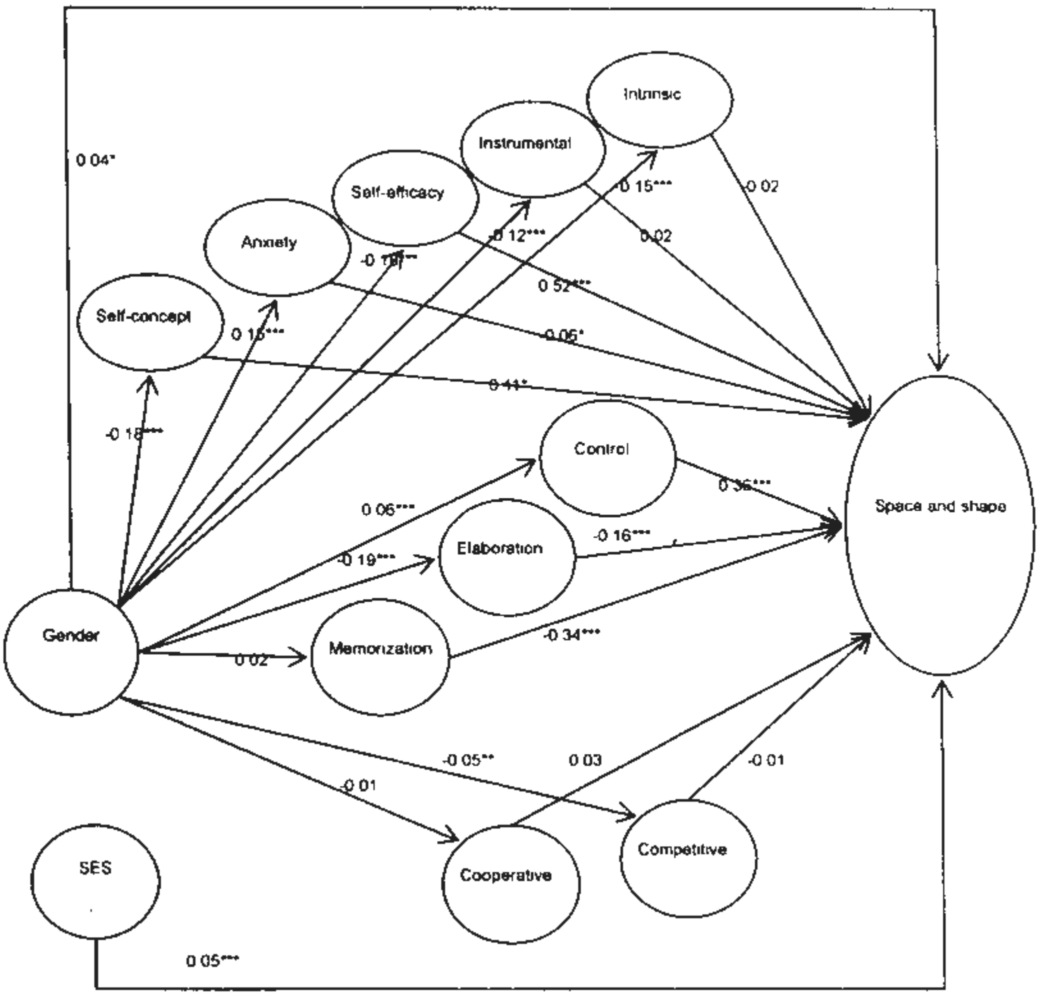
5.6.1.1 Effects of gender on space and shape achievement in intermediate model

In this section, the effects of gender on achievement in space and shape in the intermediate model are explored. Figure 5.20 shows the intermediate model. Table 5.35 shows the values of goodness of fit indices of the model. Since the intermediate model is complicated, the values of the path coefficients have also been shown in Table 5.36. The direct, indirect and total effect of gender on the achievement in the domain of space and shape are shown in Table 5.37.

From Table 5.35, the values of good fit of the model show that it is an acceptable model. The values of RMSEA, the 90% of confidence interval of RMSEA, NFI, NNFI, CFI, and GFI are 0.046, (0.045, 0.047), 0.98, 0.98, 0.98, and 0.90 respectively. All these values of goodness of fit indices show that the model is a good model. However, the value of AGFI is 0.89, which is smaller than 0.90, means that the model cannot achieve the threshold as a good model. Therefore, this intermediate model is only an acceptable model.

After considering all the variables, only three of the five personal variables, self-efficacy, anxiety, and self-concept, have direct effects on the achievement of space and shape and the effects are statistically significant. The values of the direct effect of self-efficacy, anxiety, self-concept, control strategies, elaboration, and memorization are 0.52, -0.06, 0.11, 0.36, -0.16, and -0.34 respectively. None of the environmental variables have a statistically significant direct effect on the achievement of shape and shape. The value of direct effect of SES on the achievement is 0.05 and the effect is statistically significant. Gender also has a direct effect on the achievement and this effect is statistically significant. Besides cooperative learning preference and memorization, gender also has a direct effect on all other variables. The values of the direct effect of gender on intrinsic motivation, instrumental motivation, self-efficacy, anxiety, self-concept, control strategies, elaboration, competitive learning preference are -0.15, -0.12, -0.18, 0.15, -0.18, 0.06, -0.19, and -0.05 respectively. From Table 5.37, the values of direct effect, indirect effect and total effect of gender on the achievement on space and shape are 0.04, -0.08 and -0.04 respectively, and all the effects are statistically significant.

Figure 5.20: Intermediate model of effects of gender on achievement of space and shape



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.35: Goodness of fit indices of the intermediate model on achievement of space and shape

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
1254	12403.72	0.046 (0.045, 0.047)	0.98	0.98	0.98	0.90	0.89

Table 5.36: Path coefficients of intermediate model on achievement of space and shape

	Space and Shape	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference
Gender	0.04*	-0.15***	-0.12***	-0.18***	0.15***	-0.18***	0.06***	-0.19***	0.02	-0.05**	-0.01
Intrinsic motivation	-0.02										
Instrumental motivation	0.02										
Self-efficacy	0.52***										
Anxiety	-0.06*										
Self-concept	0.11*										
Control strategies	0.36***										
Elaboration	-0.16***										
Memorization	-0.34***										
Competitive learning preference	-0.01										
Cooperative learning preference	0.03										
SES	0.05***										

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.37: Effects of gender in intermediate model on space and shape achievement

Effect of gender on:	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Math concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference	Space and shape
Direct effect	-0.15***	-0.12***	-0.18***	0.15***	-0.18***	0.06***	-0.19***	0.02	-0.05**	-0.01	0.04*
Indirect effect	N.A.	N.A.	N.A.	N.A	N.A.	N.A	N.A	N.A	N.A.	N.A.	-0.08***
Total effect	-0.15***	-0.12***	-0.18***	0.15***	-0.18***	0.06***	-0.19***	0.02	-0.05**	-0.01	-0.04**

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.6.1.2 Effects of gender on space and shape achievement in full model

In this section, the full model of the effect of gender on the achievement of space and shape is explored. Figure 5.21 shows the full model. Table 5.38 shows the values of goodness of fit indices of the model. The values of path coefficients are also shown in Table 5.39. The direct, indirect and total gender effect on the achievement of space and shape are shown in Table 5.40.

From Table 5.38, the values of RMSEA, the 90% of confidence interval of RMSEA, NFI, NNFI, CFI, GFI, and AGFI are 0.033, (0.033, 0.034), 0.99, 0.99, 0.99, 0.94 and 0.93 respectively. It shows that it is a good model. When comparing the results of the values of goodness of fit indices in section 5.6.1.1 of the intermediate model, the full model is better. Therefore, it is more appropriate and suitable to allow the effects of personal variables on behavioral variables and the effects of behavioral variables on environmental variables.

Among the three sets of variables in the full model, only two of the five personal variables, self-efficacy and self-concept, have direct effects on the achievement of space and shape and the effects are statistically significant. The values of the direct effect of self-efficacy, self-concept, control strategies, elaboration, and memorization are 0.45, 0.24, 0.44, -0.24, and -0.41 respectively. The value of direct effect of SES on the achievement is 0.05 and the effect is statistically significant.

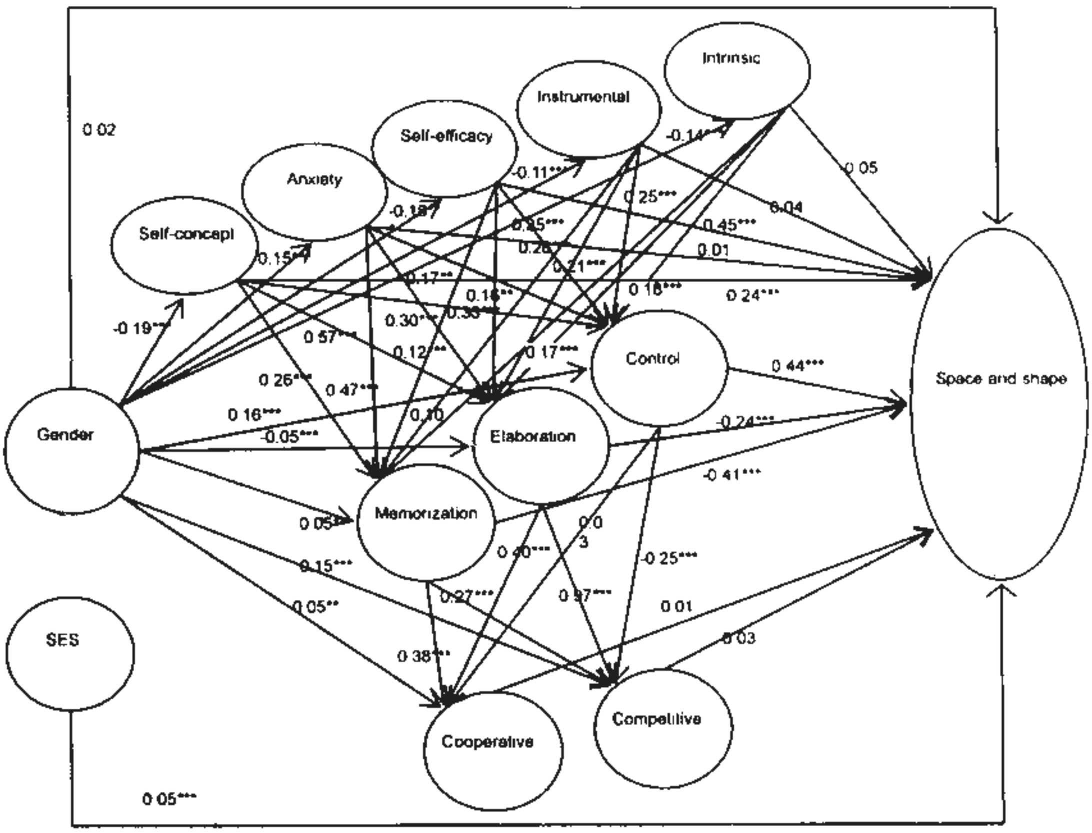
After controlling for the mediating effects of the three sets of variables, gender does not have a statistically significant direct effect on the achievement. However, gender has statistically significant direct effect on the three sets of mediating variables. The values of the effect of gender on intrinsic motivation, instrumental motivation, self-efficacy, anxiety, self-concept, control strategies, elaboration, memorization, competitive learning preference, and cooperative learning preference are -0.14, -0.11, -0.18, 0.15, -0.19, 0.16, -0.05, 0.05, 0.15 and 0.05 respectively. Therefore, there are differences in learning characteristics between females and males.

The full model also illustrates the effects of personal variables on behavioral variables and the effects of behavioral variables on environmental variables. From Table 5.39, the values of the effects of personal variables on behavioral variables are all positive and statistically significant, except the effect of intrinsic motivation on memorization. Therefore, personal factors may enhance the use of learning strategies in general. The values of the effects of behavioral variables on environmental variables are all statistically significant, except for the effect of memorization on cooperative learning preference. As memorization is a learning strategy that involves the learner itself, it is understandable that the effect of memorization on cooperative learning preference is not significant. The effect of control strategies on competitive learning preference is negative and is statistically significant. A one point increase in control strategies, holding the effects of all other variables constant, led to a decrease in competitive learning preference of 0.25 points. In other words, the more use of control strategies, the less preference in a competitive learning situation because control strategy is a learning strategy that is used to check whether the learner has achieved his learning goal or not, not to compete with others. For other effects of behavioral variables on environmental variables, learning strategies may affect the preference in learning environment in general.

Table 5.40 shows the direct effects, indirect effects and total effects of gender. Looking closely to the direct effects of gender on personal variables and both direct effects and indirect effects of gender on behavioral and environmental variables, there is a consistent pattern. All the values of direct effects of gender on personal variables are negative, except on anxiety. And, all the effects of gender on personal variables are statistically significant. This shows that male students have higher motivations, higher sense of self-efficacy and self-concept to learn Mathematics and lower anxiety when learning Mathematics. The values of indirect effects of gender on behavioral variables and environmental variables are all negative and statistically significant. But nearly all the values of direct effects of gender on behavioral variables and environmental variables are positive except on elaboration.

From Table 5.40, the values of direct effect, indirect effect and total effect of gender on the achievement of space and shape are 0.02, -0.06 and -0.04 respectively, and only the indirect effect and the total effect of gender are statistically significant. It can be seen that the total effect of gender is the sum of the direct and indirect effect of gender. The results of direct effect indicate that, after controlling the mediated effects of the three sets of variables and the effect of SES, females do not have a significant disadvantage in learning Mathematics in the domain of space and shape. Moreover, the significant negative value of indirect effect of gender indicated that females have a disadvantage in learning Mathematics through the learning process in the present study. Therefore, the significant negative total gender effect in value on the achievement in the domain of space and shape is mainly from the indirect effect of gender.

Figure 5.21: Full model of effects of gender on space and shape achievement



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.38: Goodness of fit indices of effect of gender on space and shape achievement in full model

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
1231	6578.68	0.033 (0.033, 0.034)	0.99	0.99	0.99	0.94	0.93

Table 5.39: Path coefficients of the full model of effects of gender on space and shape achievement

	Space and Shape	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference
Gender	0.02	-0.14***	-0.11***	-0.18***	0.15***	-0.19***	0.16***	-0.05***	0.05**	0.15***	0.05**
Intrinsic motivation	-0.05						0.18***	0.17***	0.10		
Instrumental motivation	0.04						0.25***	0.21***	0.26***		
Self-efficacy	0.45***						0.35***	0.16***	0.12***		
Anxiety	0.01						0.33***	0.30***	0.47***		
Self-concept	0.24***						0.17**	0.57***	0.26***		
Control strategies	0.44***									-0.25***	0.38***
Elaboration	-0.24***									0.97***	0.40***
Memorization	-0.41***									0.27***	0.03
Competitive learning preference	0.01										
Cooperative learning preference	0.03										
SES	0.05***										

"**": p < 0.05; "***": p < 0.01; "****": p < 0.001

Table 5.40: Effects of gender on space and shape achievement in full model

Effect of gender on:	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Math concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference	Space and shape
Direct effect	-0.14***	-0.11***	-0.18***	0.15***	-0.19***	0.16***	-0.05***	0.05**	0.15***	0.05**	0.02
Indirect effect	N.A.	N.A.	N.A.	N.A.	N.A.	-0.10***	-0.14***	-0.04***	-0.20***	-0.05***	-0.06***
Total effect	-0.14***	-0.11***	-0.18***	0.15***	-0.19***	0.06***	-0.19***	0.01	-0.05**	-0.01	-0.04**

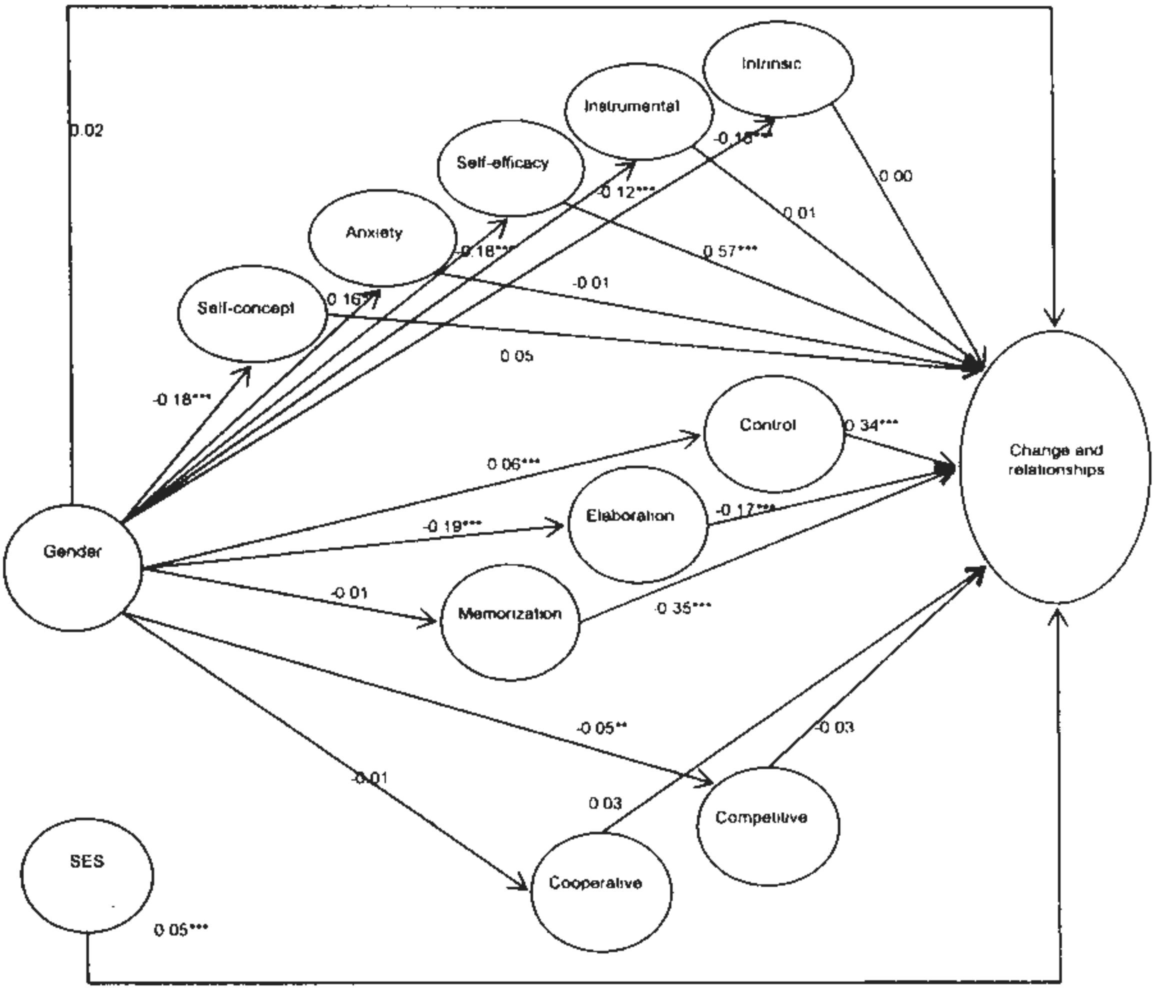
"**": p < 0.05; "***": p < 0.01; "****": p < 0.001

5.6.2.1 Effects of gender on change and relationships achievement in intermediate model

In this section, the effect of gender on the achievement of change and relationships in the intermediate model is explored. Figure 5.22 shows the intermediate model. Table 5.41 shows the values of goodness of fit indices of the model. The values of path coefficients have also been shown in Table 5.42. The direct, indirect and total gender effect on the achievement of change and relationships are shown in Table 5.43.

From Table 5.41, the values of goodness of fit indices of the model showed that it is an acceptable model. The values of RMSEA, the 90% of confidence interval of RMSEA, NFI, NNFI, CFI, and GFI are 0.046, (0.045, 0.047), 0.98, 0.98, 0.98, and 0.90 respectively. Except the value of AGFI, which is smaller than 0.90, all other values of good fit show that the model is a good model. Therefore, this intermediate model is an acceptable model. After considering all the variables, self-efficacy and the three behavioral variables are the only variables that have direct effects on achievement in the domain change and relationships and the effects are statistically significant. The values of the direct effect of self-efficacy, control strategies, elaboration, and memorization are 0.57, 0.34, -0.17, and -0.35 respectively. None of the environmental variables have a statistically significant direct effect on achievement. The value of direct effect of SES on achievement is 0.05 and is statistically significant. Gender does not have statistically significant direct effect on achievement. Besides, cooperative learning preference and memorization, gender also has a direct effect on all other variables. The values of the direct effect of gender on intrinsic motivation, instrumental motivation, self-efficacy, anxiety, self-concept, control strategies, elaboration, competitive learning preference are -0.15, -0.12, -0.18, 0.16, -0.18, 0.06, -0.19, and -0.05 respectively. From Table 5.43, the values of direct effect, indirect effect and total effect of gender on achievement on change and relationships are 0.02, -0.05 and -0.03 respectively, and all the effects are statistically significant.

Figure 5.22: Intermediate model of effects of gender on achievement of change and relationships



"*": p < 0.05; "**": p < 0.01; "***". p < 0.001

Table 5.41: Goodness of fit indices of the intermediate model on achievement of change and relationships

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
1253	12475.57	0.046 (0.045, 0.047)	0.98	0.98	0.98	0.90	0.89

Table 5.42: Path coefficients of intermediate model on achievement of change and relationships

	Change and relationships	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference
Gender	0.02	-0.15***	-0.12***	-0.18***	0.16***	-0.18***	0.06***	-0.19***	-0.01	-0.05**	-0.01
Intrinsic motivation	0.00										
Instrumental motivation	0.01										
Self-efficacy	0.57***										
Anxiety	-0.01										
Self-concept	0.05										
Control strategies	0.34***										
Elaboration	-0.17***										
Memorization	-0.35***										
Competitive learning preference	-0.03										
Cooperative learning preference	0.03										
SES	0.05***										

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.43: Effects of gender in intermediate model on change and relationships achievement

Effect of gender on.	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Math concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference	Change and relationships
Direct effect	-0.15***	-0.12***	-0.18***	0.16***	-0.18***	0.06***	-0.19***	-0.01	-0.05**	-0.01	0.02*
Indirect effect	N.A.	N.A	N.A.	N.A	N.A	N.A	N.A	N.A	N.A.	N.A	-0.05***
Total effect	-0.15***	-0.12***	-0.18***	0.16***	-0.18***	0.06***	-0.19***	-0.01	-0.05**	-0.01	-0.03*

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.6.2.2 Effects of gender on achievement in change and relationship in full model

In this section, the effect of gender on the achievement in the domain of change and relationships in the full model is explored. Figure 5.23 shows the full model. Table 5.44 shows the values of goodness of fit indices of the model. The values of path coefficients have also been shown in Table 5.45. The direct, indirect and total effect of gender on the achievement in the domain of change and relationships are shown in Table 5.46.

From Table 5.44, the values of goodness of fit indices of the model showed that it is a good model. The values of RMSEA, the 90% of confidence interval of RMSEA, NFI, NNFI, CFI, GFI, and AGFI are 0.033, (0.033, 0.034), 0.99, 0.99, 0.99, 0.94 and 0.93 respectively .This shows that the model is a good model. When comparing the results of the values of good fit in section 5.6.2 of the intermediate model, the full model is a better model. Therefore, it is much more appropriate and suitable to consider the effects of personal variables on behavioral variables and the effects of behavioral variables on environmental variables in the full model.

Among the three sets of variables in the full model, only two of the five personal variables, self-efficacy and self-concept, all three behavioral variables, have direct effects on the achievement of change and relationships and the effects are statistically significant. The values of the direct effect of self-efficacy, self-concept, control strategies, elaboration, and memorization are 0.48, 0.12, 0.35, -0.18, and -0.37 respectively. The value of direct effect of SES on achievement is 0.05 and the effect is statistically significant.

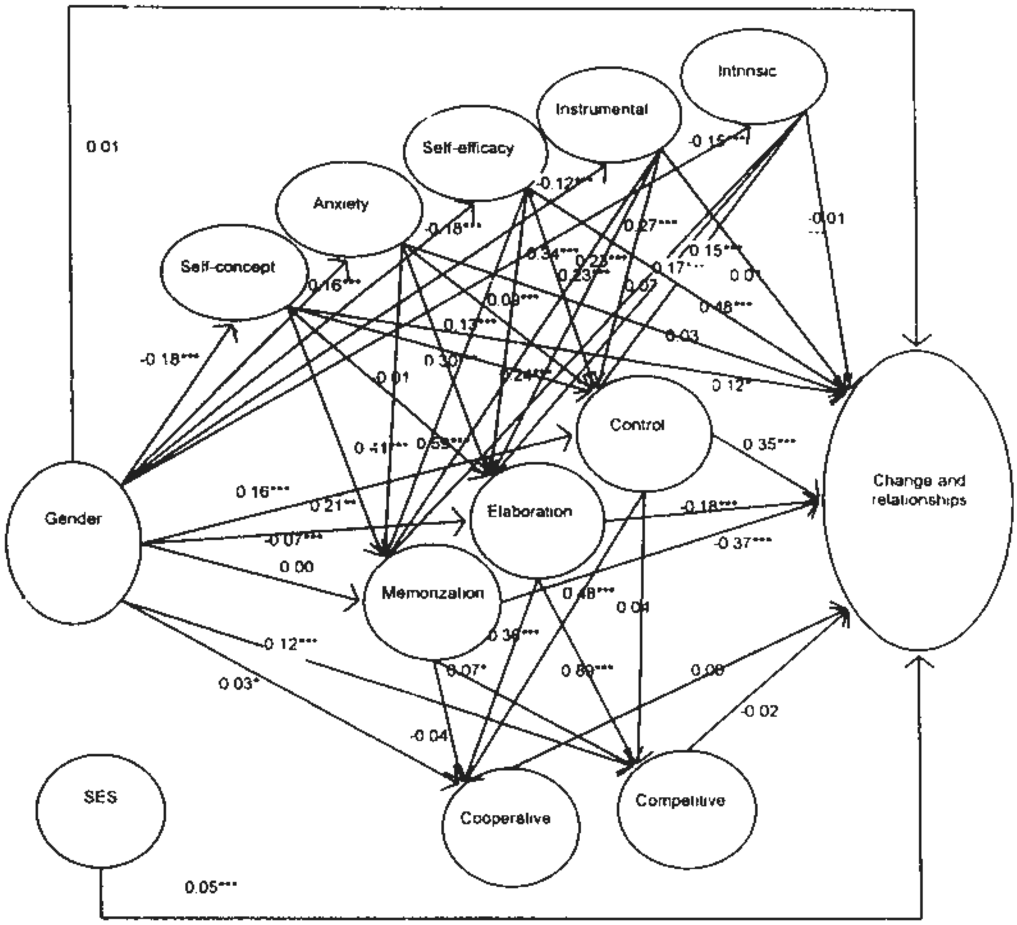
After controlling the mediating effects of the three sets of variables, the effect of gender on achievement is not statistically significant. However, gender has a statistically significant direct effect on all the variables except on memorization. The values of the direct effect of gender on intrinsic motivation, instrumental motivation, self-efficacy, anxiety, self-concept, control strategies, elaboration, competitive learning preference, and cooperative learning preference are -0.15, -0.12, -0.18, 0.16, -0.18, 0.16, -0.07, 0.12 and 0.03 respectively. Therefore, there are gender differences in the learning characteristics.

The full model includes the effects of personal variables on behavioral variables, and the effects of behavioral variables on environmental variables. In Table 5.45, the values of the effects of personal variables on behavioral variables are all positive and statistically significant. It indicates that personal factors may enhance the use of learning strategies. The values of the effects of behavioral variables on environmental variables are all positive and statistically significant, except the effect of control strategies on competitive learning preference and the effect of memorization on cooperative learning preference are both not statistically significant. So, the use of learning strategies may affect the preference in learning environment in general.

The direct effects, indirect effects and total effects of gender are shown in Table 5.46. There is a consistent pattern. All the values of direct effects of gender on personal variables are negative, except on anxiety. And the effects are statistically significant. It shows that females have lower motivations, lower sense of self-efficacy and self-concept but higher anxiety to learn Mathematics. The values of the indirect effect of gender on behavioral variables and environmental variables are all negative. Except on memorization, all the indirect effects of gender are statistically significant. All the direct effects of gender on behavioral variables and environmental variables are positive except the direct effect of gender on elaboration.

From Table 5.46, the values of direct effect, indirect effect and total effect of gender on the achievement of change and relationships are 0.01, -0.04 and -0.03 respectively, and only the indirect effect and the total effect of gender are statistically significant. As the total effect of gender is the sum of the direct and indirect effect of gender, the results of direct effect of gender on the achievement in the domain of change and relationships indicates that females do not have a significant disadvantage in learning Mathematics in the domain of change and relationships after controlling the mediating effects of the three sets of variables. On the other hand, the significant negative value of indirect effect of gender showed that females have a disadvantage in learning Mathematics through the learning process in this study. Therefore, the negative significant total effect of gender in value on the achievement in the domain of change and relationships mainly comes from the indirect effect of gender.

Figure 5.23: Full model of effects of gender on change and relationships achievement



"*": p < 0.05; "**": p < 0.01; "***": p < 0.001

Table 5.44: Goodness of fit indices of effect of gender on change and relationships achievement in full model

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
1235	6661.18	0.033 (0.033, 0.034)	0.99	0.99	0.99	0.94	0.93

Table 5.45: Path coefficients of the full model of effects of gender on change and relationships achievement

	Change and relationships	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference
Gender	0.01	-0.15***	-0.12***	-0.18***	0.16***	-0.18***	0.16***	-0.07***	0.00	0.12***	0.03*
Intrinsic motivation	-0.01						0.15***	0.17***	0.07		
Instrumental motivation	0.01						0.27***	0.23***	0.23***		
Self-efficacy	0.48***						0.34***	0.09***	0.13***		
Anxiety	0.03						0.39***	0.30***	0.41***		
Self-concept	0.12*						0.24***	0.59***	0.21**		
Control strategies	0.35***									0.04	0.48***
Elaboration	-0.18***									0.89***	0.36***
Memorization	-0.37***									0.07*	-0.04
Competitive learning preference	-0.02										
Cooperative learning preference	0.00										
SES	0.05***										

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.46: Effects of gender on change and relationships achievement in full model

Effect of gender on:	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Math concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference	Change and relationships
Direct effect	-0.15***	-0.12***	-0.18***	0.16***	-0.18***	0.16***	-0.07***	0.00	0.12***	0.03**	0.01
Indirect effect	N.A.	N.A	N.A	N.A.	N.A	-0.10***	-0.13***	-0.01	-0.17***	-0.04**	-0.04*
Total effect	-0.15***	-0.12***	-0.18***	0.16***	-0.18***	0.06***	-0.20***	-0.01	-0.05**	-0.01	-0.03*

"*": $p < 0.05$; "**": $p < 0.01$, "***": $p < 0.001$

5.6.3.1 Effects of gender on quantity achievement in intermediate model

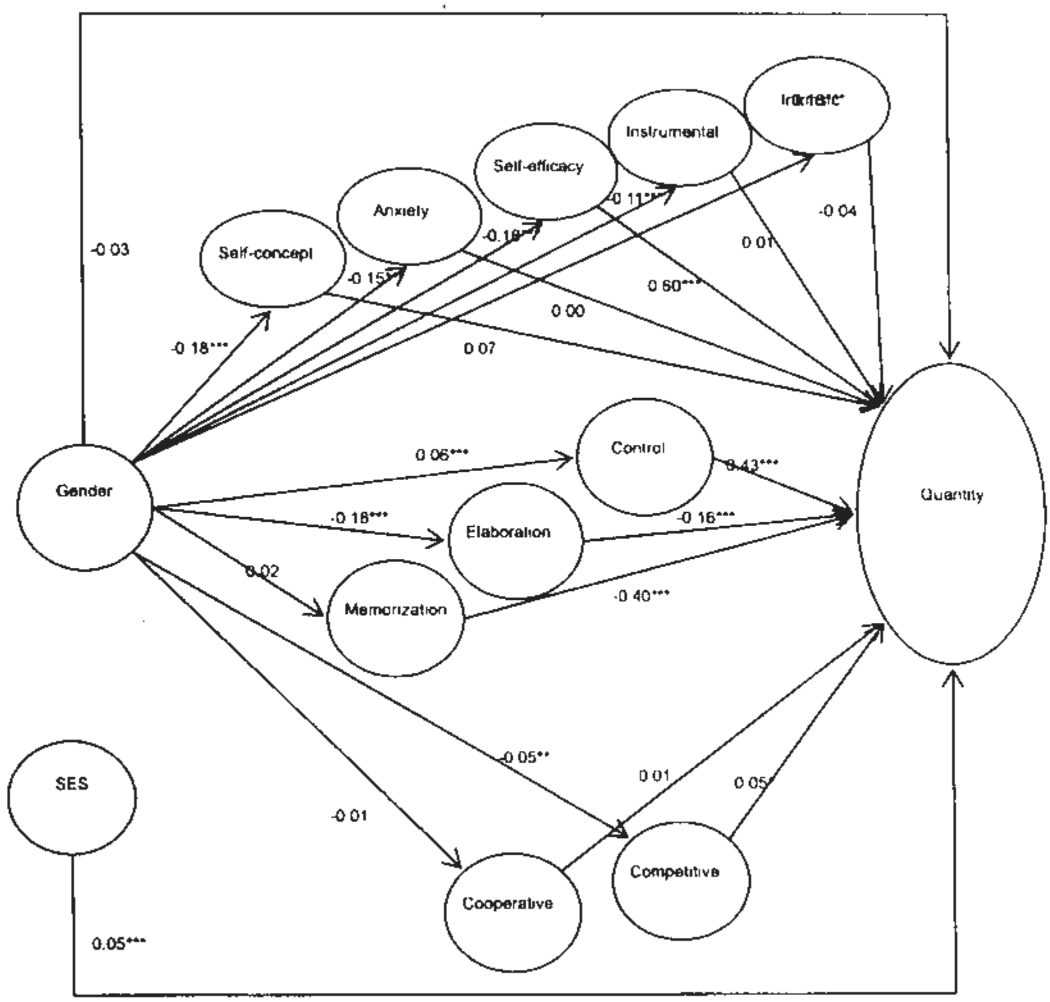
In this section, the effect of gender on the achievement of quantity in the intermediate model is explored. Figure 5.24 shows the intermediate model. Table 5.47 shows the values of goodness of fit indices of the model. The values of path coefficients have also been shown in Table 5.48. The direct, indirect and total gender effect on the achievement of quantity are shown in Table 5.49.

From Table 5.47, the values of goodness of fit indices of the model showed that it is an acceptable model. The values of RMSEA, the 90% of confidence interval of RMSEA, NFI, NNFI, CFI, GFI and AGFI are 0.046, (0.045, 0.046), 0.98, 0.98, 0.98, 0.90, 0.89 respectively. As the value of AGFI cannot achieve the threshold of a good model, the intermediate model is only an acceptable model. Self-efficacy, the three behavioral variables and competitive learning preference, have direct effects on the achievement of quantity and the effects are statistically significant. The values of the direct effect of self-efficacy, control strategies, elaboration, memorization, and competitive learning preference are 0.60, 0.43, -0.16, -0.40, and -0.05 respectively. The value of direct effect of SES on achievement is 0.05 and is statistically significant. Gender does not have a statistically significant direct effect on achievement.

Besides, cooperative learning preference and memorization, gender also has a direct effect on all other variables. The values of the direct effect of gender on intrinsic motivation, instrumental motivation, self-efficacy, anxiety, self-concept, control strategies, elaboration, competitive learning preference are

-0.15, -0.11, -0.18, 0.16, -0.18, 0.06, -0.18, and -0.05 respectively. From Table 5.50, the values of direct effect, indirect effect and total effect of gender on the achievement of quantity are -0.02, -0.06 and -0.09 respectively, and only the indirect effect and the total effect of gender are statistically significant.

Figure 5.24: Intermediate model of effects of gender on achievement of quantity



"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.47: Goodness of fit indices of the intermediate model on achievement of quantity

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
1253	12163.18	0.046 (0.045, 0.046)	0.98	0.98	0.98	0.90	0.89

Table 5.48: Path coefficients of intermediate model on achievement of quantity

	Quantity	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference
Gender	-0.03	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	0.06***	-0.18***	0.02	-0.05**	-0.01
Intrinsic motivation	-0.04										
Instrumental motivation	0.01										
Self-efficacy	0.60***										
Anxiety	0.00										
Self-concept	0.07										
Control strategies	0.43***										
Elaboration	-0.16***										
Memorization	-0.40***										
Competitive learning preference	-0.05*										
Cooperative learning preference	0.01										
SES	0.05***										

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.49: Effects of gender in intermediate model on quantity achievement

Effect of gender on:	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Math concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference	Quantity
Direct effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	0.06***	-0.18***	0.02	-0.05**	-0.01	-0.03
Indirect effect	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	-0.06***
Total effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	0.06***	-0.18***	0.02	-0.05**	-0.01	-0.09***

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.6.3.2 Effects of gender on quantity achievement in full model

In this section, the full model of the effect of gender on achievement in quantity is explored. Figure 5.25 shows the full model. Table 5.50 shows the values of goodness of fit indices of the model. The values of path coefficients have also been shown in Table 5.51. The direct effect, indirect effect and total gender effect on the achievement of quantity are shown in Table 5.52.

In Table 5.50, the values of RMSEA, the 90% of confidence interval of RMSEA, NFI, NNFI, CFI, GFI, and AGFI are 0.033, (0.033, 0.034), 0.99, 0.99, 0.99, 0.94 and 0.93 respectively. All these values of goodness of fit indices showed that the model is a good model. When comparing the results of the values of goodness of fit indices in section 5.6.3 of the intermediate model, the full model is better. Therefore, the effects of personal variables on behavioral variables and the effects of behavioral variables on environmental variables should be considered in the full model.

Among the three sets of variables in the full model, only self-efficacy, self-concept and all three behavioral variables have direct effects on the achievement of quantity and the effects are statistically significant. The values of the direct effect of self-efficacy, self-concept, control strategies, elaboration, and memorization are 0.51, 0.12, 0.36, -0.16, and -0.37 respectively. The value of direct effect of SES on the achievement is 0.05 and the effect is statistically significant.

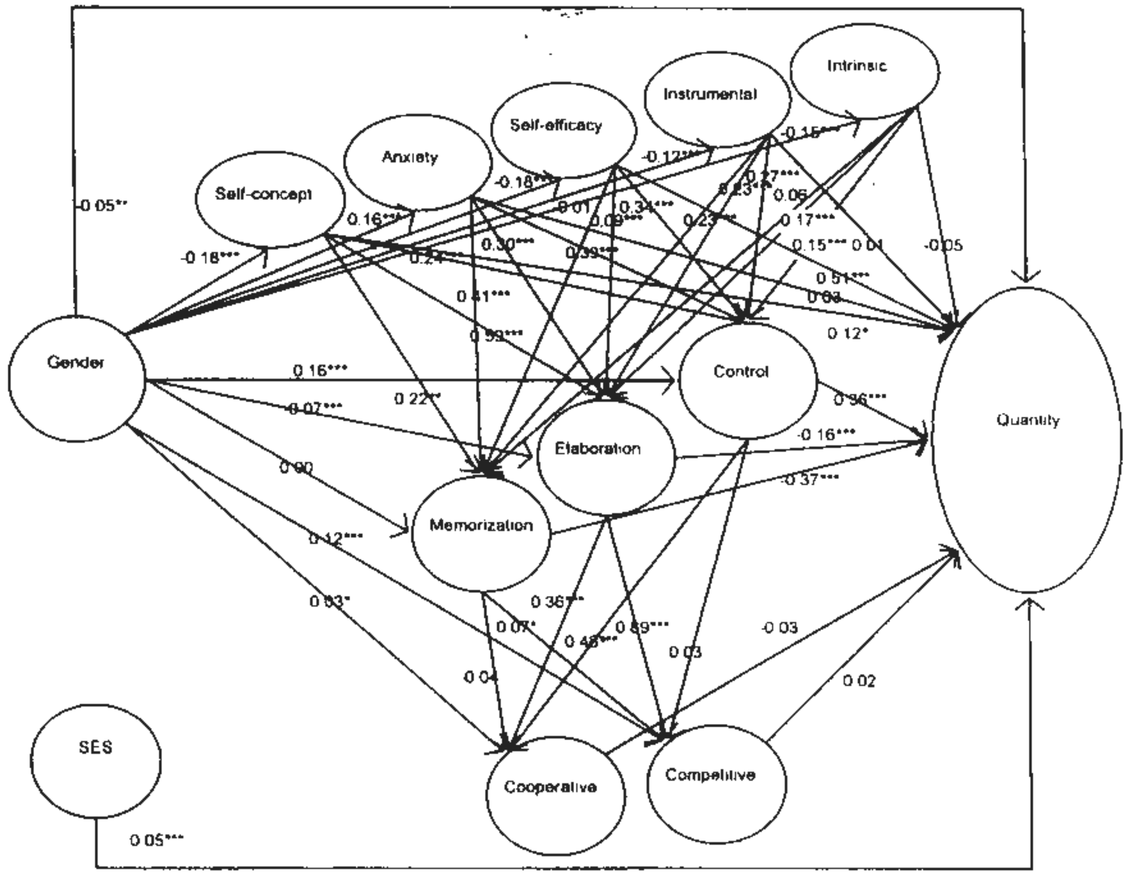
After controlling the mediating effects of the three sets of variables, gender has a statistically significant direct effect on achievement and the value of the direct effect is -0.05. Moreover, gender also has a statistically significant direct effect on all three sets of mediating variables except memorization. The values of the direct effect of gender on intrinsic motivation, instrumental motivation, self-efficacy, anxiety, self-concept, control strategies, elaboration, competitive learning preference, and cooperative learning preference are -0.15, -0.12, -0.18, 0.16, -0.18, 0.16, -0.07, 0.12 and 0.03 respectively. Therefore, there are differences in learning characteristics for both females and males.

The full model also enables the effects of personal variables on behavioral variables and the effects of behavioral variables on environmental variables to be shown. According to Table 5.51, the values of the effects of personal variables on behavioral variables are all positive and statistically significant, except the effect of intrinsic motivation on memorization and the effect of self-efficacy on memorization. These two effects are not statistically significant. Therefore, personal variables may enhance the use of learning strategies. The values of the effects of behavioral variables on environmental variables are all positive and statistically significant, except the effect of control strategies on competitive learning preference and the effect of memorization on cooperative learning preference. Similar but different in the domain of space and shape, control strategy is the strategy that monitors the learning progress of the learner but not to compete with others. Memorization is a learning strategy that involves the learner himself/herself. Therefore, it is understandable that they are not statistically significant.

Table 5.52 shows the direct effects, indirect effects and total effects of gender. In the domain of space and shape and in the domain of change and relationships, there is a consistent pattern. All the values of direct effects of gender on personal variables are negative, except on anxiety. Moreover, all the effects of gender on the personal variables are statistically significant. This means, females have lower motivations, lower sense of self-efficacy and self-concept and higher anxiety to learn Mathematics. The values of indirect effects of gender on behavioral variables and environmental variables are all negative and statistically significant. Also, all the values of direct effects of gender on behavioral variables and environmental variables are positive except on elaboration.

From Table 5.52, the values of direct effect, indirect effect and total effect of gender on the achievement of quantity are -0.05, -0.04 and -0.09 respectively, and all the three effects are statistically significant, as the value of total effect of gender is the sum of the direct and indirect effect of gender. The results of direct effect of gender indicates that females are at a disadvantage of learning Mathematics in the domain of quantity after controlling the mediating effects of the three sets of variables and the effect of SES. The significant negative value of the indirect effect of gender shows that females have a disadvantage in learning Mathematics through the learning process.

Figure 5.25: Full model of effects of gender on quantity achievement



"*": p < 0.05; "**" p < 0.01; "***": p < 0.001

Table 5.50: Goodness of fit indices of effect of gender on quantity achievement in full model

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
1235	6643.30	0.033 (0.033, 0.034)	0.99	0.99	0.99	0.94	0.93

Table 5.51: Path coefficients of the full model of effects of gender on quantity achievement

	Quantity	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference
Gender	-0.05**	-0.15***	-0.12***	-0.18***	0.16***	-0.18***	0.16***	-0.07***	0.00	0.12***	0.03*
Intrinsic motivation	-0.05						0.15***	0.17***	0.06		
Instrumental motivation	0.01						0.27***	0.23***	0.23***		
Self-efficacy	0.51***						0.34***	0.09***	-0.01		
Anxiety	0.03						0.39***	0.30***	0.41***		
Self-concept	0.12*						0.24***	0.59***	0.22**		
Control strategies	0.36***									0.03	0.48***
Elaboration	-0.16***									0.89***	0.36***
Memorization	-0.37***									0.07*	-0.04
Competitive learning preference	-0.02										
Cooperative learning preference	-0.03										
SES	0.05***										

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 5.52: Effects of gender on quantity achievement in full model

Effect of gender on.	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Math concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference	Quantity
Direct effect	-0.15***	-0.12***	-0.18***	0.16***	-0.18***	0.16***	-0.07***	0.00	0.12***	0.03*	-0.05**
Indirect effect	N.A.	N.A	N.A	N.A.	N.A.	-0.10***	-0.13***	-0.01	-0.17***	-0.04**	-0.04**
Total effect	-0.15***	-0.12***	-0.18***	0.16***	-0.18***	0.06***	-0.20***	-0.01	-0.05**	-0.01	-0.09***

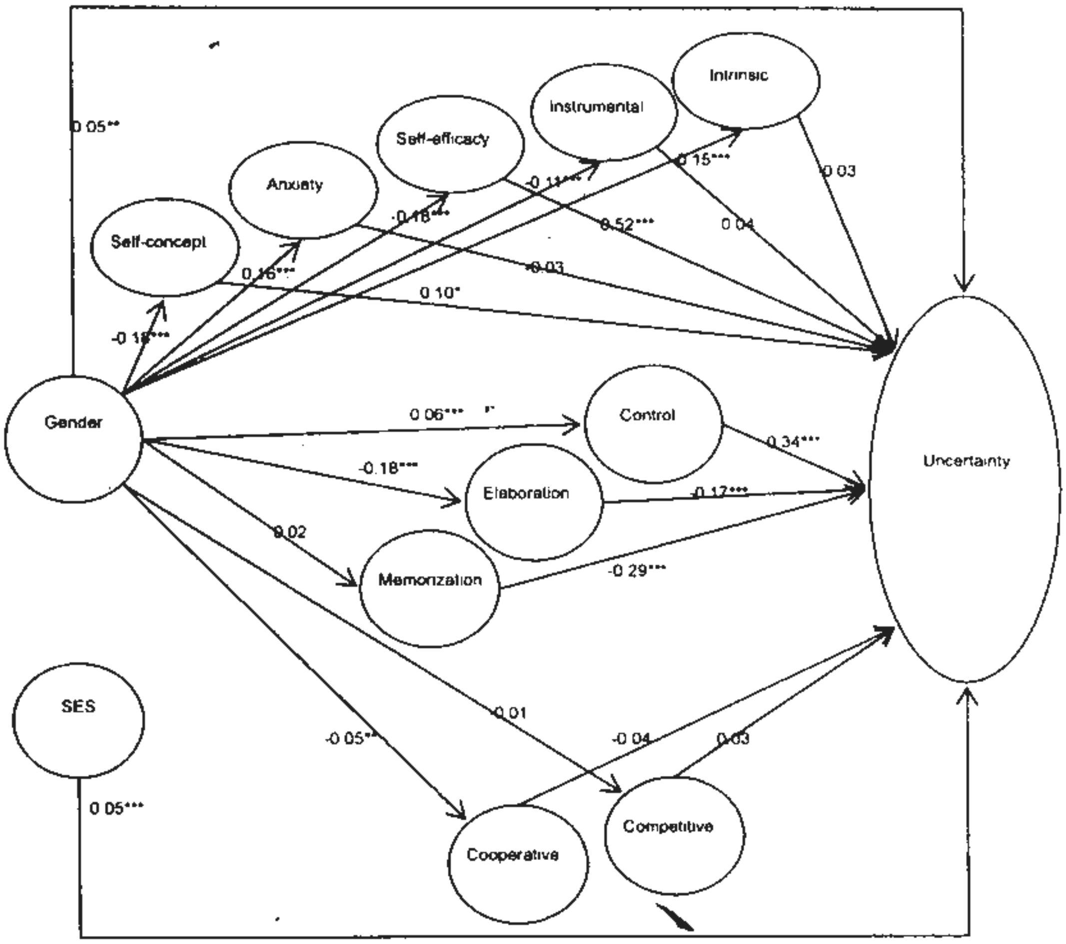
"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.6.4.1 Effects of gender on uncertainty achievement in intermediate model

In this section, the effects of gender on the achievement of uncertainty in the intermediate model are explored. Figure 5.26 shows the intermediate model Table 5.53 shows the values of goodness of fit indices of the model. The values of path coefficients are showed in Table 5.54. Table 5.55 shows the direct, indirect and total gender effect on the achievement of uncertainty.

From Table 5.53, the values of goodness of fit indices of the model showed that it is an acceptable model. The values of RMSEA, the 90% of confidence interval of RMSEA, NFI, NNFI, CFI, GFI, and AGFI are 0.046, (0.045, 0.046), 0.98, 0.98, 0.98, 0.90, 0.89 respectively. All these values of goodness of fit indices showed that the model is a good model, except the value of AGFI, which is smaller than 0.90. Therefore, the model cannot achieve the threshold as a good model. That means the intermediate model is considered to be an acceptable model. After considering all the variables, self-efficacy, self-concept, and all three behavioral variables, have direct effects on achievement of uncertainty and the effects are statistically significant. The values of the direct effect of self-efficacy, self-concept, control strategies, elaboration, and memorization are 0.52, 0.10, 0.34, -0.17, and -0.29 respectively. The value of direct effect of SES on achievement is 0.05 and is statistically significant. Gender also has a statistically significant direct effect on the achievement. Besides cooperative learning preference and memorization, gender also has direct effect on all other variables. The values of the direct effect of gender on intrinsic motivation, instrumental motivation, self-efficacy, anxiety, self-concept, control strategies, elaboration, competitive learning preference are -0.15, -0.11, -0.18, 0.16, -0.18, 0.06, -0.18, and -0.05 respectively. From Table 5.56, the values of direct effect, indirect effect and total effect of gender on the achievement of uncertainty are 0.05, -0.07 and -0.01 respectively, and only the direct effect and the indirect effect of gender are statistically significant.

Figure 5.26: Intermediate model on achievement of uncertainty



"*": p*< 0.05; "**": p < 0.01; "***": p < 0.001

Table 5.53: Goodness of fit indices of intermediate model on achievement of uncertainty

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
1253	12116.31	0.046 (0.045, 0.046)	0.98	0.98	0.98	0.90	0.89

Table 5.54: Path coefficients of intermediate model on achievement of uncertainty

	Uncertainty	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference
Gender	0.05***	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	0.06***	-0.18***	0.02	-0.05**	-0.01
Intrinsic motivation	-0.03										
Instrumental motivation	0.04										
Self-efficacy	0.52***										
Anxiety	-0.03										
Self-concept	0.10*										
Control strategies	0.34***										
Elaboration	-0.17***										
Memorization	-0.29***										
Competitive learning preference	-0.04										
Cooperative learning preference	0.03										
SES	0.05***										

"*": p < 0.05; "**": p < 0.01; "***" p < 0.001

Table 5.55: Effects of gender in intermediate model on uncertainty achievement

Effect of gender on:	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Math concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference	Uncertainty
Direct effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	0.06***	-0.18***	0.02	-0.05**	-0.01	0.05**
Indirect effect	N.A.	N.A.	N.A	N.A.	N.A.	N.A	N.A	N.A	N.A.	N.A.	-0.07***
Total effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	0.06***	-0.18***	0.02	-0.05**	-0.01	-0.01

"*": p < 0.05; "**": p < 0.01; "***" p < 0.001

5.6.4.2 Effects of gender on uncertainty achievement in full model

In this section, the effects of gender on the achievement of uncertainty in the full model are explored. Figure 5.27 shows the full model. Table 5.56 shows the values of goodness of fit indices of the model. The values of path coefficients have also been shown in Table 5.57. The direct, indirect and total gender effects on achievement of uncertainty are shown in Table 5.58.

From Table 5.56, the values of goodness of fit indices of the model showed that it is a good model. The values of RMSEA, the 90% of confidence interval of RMSEA, NFI, NNFI, CFI, GFI, and AGFI are 0.033, (0.033, 0.034), 0.99, 0.99, 0.99, 0.94 and 0.93 respectively. All these values of goodness of fit indices showed that the model is a good model. When comparing the results of the values of good fit of the intermediate model in section 5.6.4.1, the full model is a better model.

Among the three sets of variables in the full model, three of the five personal variables, instrumental motivation, self-efficacy and self-concept, and all three behavioral variables, have direct effects on the achievement of uncertainty and the effects are statistically significant. The values of the direct effect of instrumental motivation, self-efficacy, self-concept, control strategies, elaboration, and memorization on the achievement are 0.05, 0.46, 0.18, 0.30, -0.20, and -0.27 respectively. The value of direct effect of SES on the achievement is 0.05 and the effect is statistically significant.

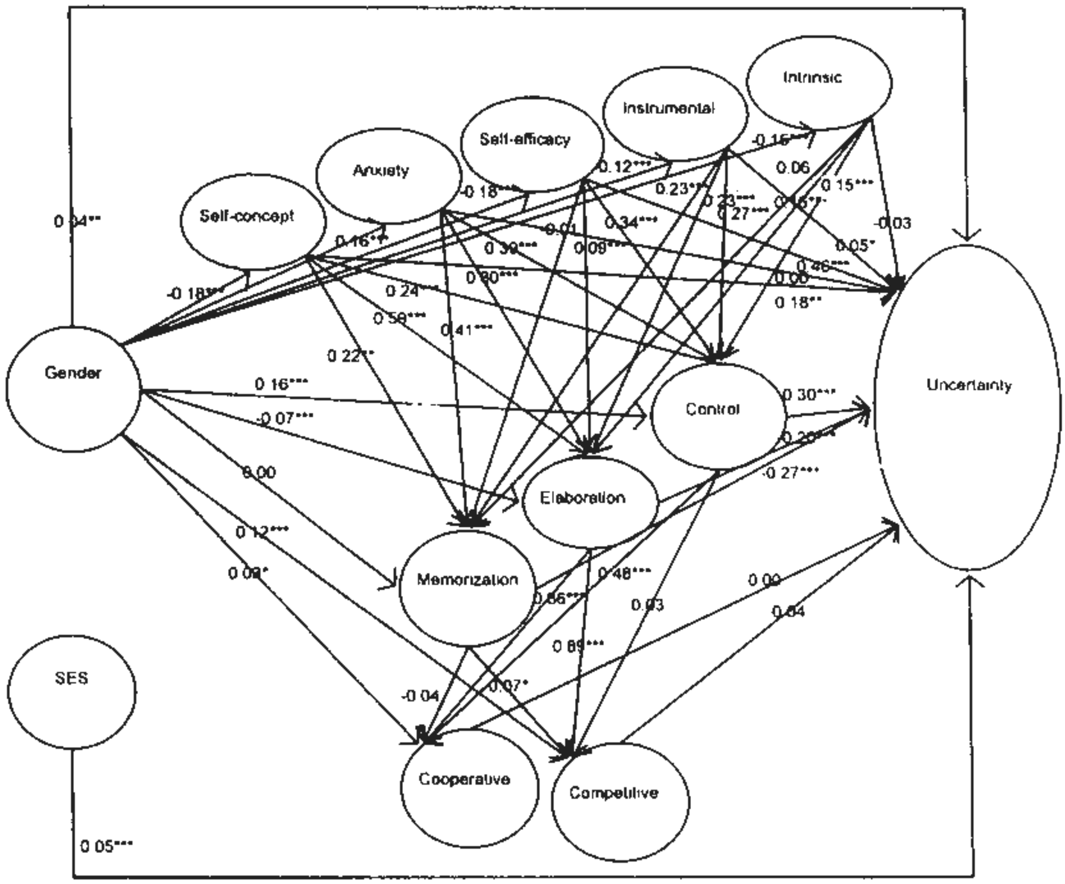
After controlling the mediating effects of the three sets of variables and the effect of SES, gender has a statistically significant direct effect on achievement and the value of the direct effect is 0.04. Moreover, gender has a statistically significant direct effect on all the variables except memorization. The values of the direct effect of gender on intrinsic motivation, instrumental motivation, self-efficacy, anxiety, self-concept, control strategies, elaboration, competitive learning preference, and cooperative learning preference are -0.15, -0.12, -0.18, 0.16, -0.18, 0.16, -0.07, 0.12 and 0.03 respectively. Therefore, there are differences in the learning characteristics for both females and males.

The full model also enables the effects of personal variables on behavioral variables and the effects of behavioral variables on environmental variables. From Table 5.57, the values of the effects of personal variables on behavioral variables are all positive and statistically significant, except the effect of intrinsic motivation on memorization and the effect of self-efficacy on memorization. Therefore, personal variables may enhance the use of learning strategies in general. The values of the effects of behavioral on environmental variables are all statistically significant, except the effect of control strategies on competitive learning preference and the effect of memorization on cooperative learning preference. This result is the same as the result in domain of the domain of change and relationships and the domain of quantity.

Table 5.58 shows the direct effects, indirect effects and total effects of gender. There is a consistent pattern. All the values of direct effects of gender on personal variables are negative, except on anxiety. All the effects are statistically significant. Therefore, females have lower motivations, lower sense of self-efficacy and lower self-concept and higher anxiety when learning Mathematics. The values of indirect effects of gender on behavioral variables and environmental variables are all negative and statistically significant, except on memorization. Moreover, the values of direct effects of gender on behavioral variables and environmental variables are all positive, except on elaboration and memorization.

From Table 5.58, the values of direct effect, indirect effect and total effect of gender on the achievement of uncertainty are 0.04, -0.05 and -0.01 respectively, and only the direct effect and the indirect effect of gender are statistically significant. Looking at the total effect of gender on achievement, females do not have a significant disadvantage of leaning Mathematics. As the value of total effect of gender is the sum of the effect of direct and indirect effect of gender. The results of the direct effect of gender indicates that females possess an advantage of learning Mathematics after controlling the mediating effect of the three sets of variables and indirect effect of gender. However, the advantage has been offset by the indirect effect of gender. Therefore, gender difference exists in learning Mathematics in the domain of uncertainty and the difference mainly comes from the indirect effect of gender.

Figure 5.27: Full model of effects of gender on uncertainty achievement



"*": p < 0.05; "**": p < 0.01; "***": p < 0.001

Table 5.56: Goodness of fit indices of effect of gender on uncertainty achievement in full model

DF	Chi-square value	RMSEA (90% CI)	NFI	NNFI	CFI	GFI	AGFI
1235	6614.38	0.033 (0.033, 0.034)	0.99	0.99	0.99	0.94	0.93

Table 5.57: Path coefficients of the full model of effects of gender on uncertainty achievement

	Uncertainty	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference
Gender	0.04**	-0.15***	-0.12***	-0.18***	0.16***	-0.18***	0.16***	-0.07***	0.00	0.12***	0.03*
Intrinsic motivation	-0.03						0.15***	0.16***	0.06		
Instrumental motivation	0.05*						0.27***	0.23***	0.23***		
Self-efficacy	0.46***						0.34***	0.09***	-0.01		
Anxiety	0.00						0.39***	0.30***	0.41***		
Self-concept	0.18**						0.24***	0.59***	0.22**		
Control strategies	0.30***									0.03	0.48***
Elaboration	-0.20***									0.89***	0.36***
Memorization	-0.27***									0.07*	-0.04
Competitive learning preference	-0.04										
Cooperative learning preference	0.00										
SES	0.05***										

*: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$

Table 5.58: Effects of gender on uncertainty achievement in full model

Effect of gender on:	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Math concept	Control strategies	Elaboration	Memorization	Competitive learning preference	Cooperative learning preference	Uncertainty
Direct effect	-0.15***	-0.12***	-0.18***	0.16***	-0.18***	0.16***	-0.07***	0.00	0.12***	0.03*	0.04**
Indirect effect	N.A.	N.A.	N.A.	N.A.	N.A.	-0.10***	-0.13***	-0.01	-0.18***	-0.04**	-0.05***
Total effect	-0.15***	-0.12***	-0.18***	0.16***	-0.18***	0.06***	-0.20***	-0.01	-0.05**	-0.01	-0.01

*: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$

5.6.5 Summary of findings of the effects of gender on Mathematics achievements in full model

The effects of gender on Mathematics achievements mediated by the three sets of variables with the relationships that personal variables affect behavioral variables and behavioral variables further affect environmental variables, in a condition that SES acts as a control variable, are explored in this section to answer the fifth research question. The summary of the results is presented in Table 5.59. According to Table 5.59, there are some patterns that are consistent across the four Mathematics domains. The values of indirect effects of gender are all negative and statistically significant. It indicates that females are at a disadvantage in learning Mathematics through the three sets of variables in all the four domains. The direct effects of gender, after equalising the mediating effect of the three sets of variables and the effect of SES, are all positive except in the domain of quantity. Only the direct effects of gender on quantity and uncertainty are statistically significant, no conclusion can be drawn as a result. On the other hand, the values of the total effects of gender are all negative and all the effects are statistically significant except in the domain of uncertainty. The values of total effects of gender are the sum of the direct effects and indirect effects of gender. Therefore, the indirect effects of gender offset the advantages of females in learning Mathematics or further aggravate the learning condition Mathematics for females. It can be concluded that females are at a disadvantage in learning Mathematics due to the differences in the learning process.

Table 5.59: Summary of direct effect, indirect effect and total effect of gender on Mathematics achievements in full model

Effect of gender on:	Space and shape	Change and relationships	Quantity	Uncertainty
Direct effect	0.02	0.01	-0.05**	0.04**
Indirect effect	-0.06***	-0.04*	-0.04**	-0.05***
Total effect	-0.04**	-0.03*	-0.09***	-0.01

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

5.7 Summary

In order to answer the research questions, two statistical techniques, including regression and structural equation modeling, are used for analysis to explore the gender differences in the four Mathematics domains mediated by the effects of personal variables, behavioral variables, and environmental variables.

In section 5.2, the gender differences in Mathematics achievements are explored by means of multiple regression to explore the gender effect on the achievements in four domains. The results are consistent that the gender effect significantly favored male students in all the four Mathematics domains except in the domain of uncertainty. Females are at a disadvantage in learning Mathematics in the four domains.

In section 5.3, five personal variables were added to explore the direct effect and indirect effect of gender on the four Mathematics domains, and SES was also included as controlled variable. The results showed that gender has a significant direct effect on the achievement of space and shape, change and relationships and uncertainty mediated by the personal variables and all the direct effects favored girls. After controlling the mediating effect of the personal variables, female students have an advantage in learning Mathematics. However, gender has a significant indirect effect on all the four Mathematics domains through personal variables and all the effects favored boys. Therefore, females are at a disadvantage in learning Mathematics through the personal variables. After considering both direct and indirect effect, the total effect of gender was only significant for the achievement of space and shape, change and relationships, and quantity. Therefore, gender does make a difference.

In section 5.4, the effects of gender on Mathematics achievement mediated by behavioral variables are explored and consistent results are obtained. The results showed that after controlling the mediating effects of behavioral variables, gender had a significant direct effect on the achievement of space and shape, change and relationships, and quantity and all the effects favor male students. However, there is no significant indirect gender effect in any of the four Mathematics domains although all the effects favored female students. Therefore, the mediating effects of behavioral variables do not have a strong effect of gender when compared with the mediating effect of personal variables. The total effects of gender are only significant on the achievement of space and shape, change and relationships, and quantity.

Section 5.5 aims to answer the fourth research question. Therefore, the effects of gender on the Mathematics achievements mediated by environmental variables are explored. Similar results to section 5.4 are obtained. The results showed that gender has significant direct effect only on the achievements of space and shape and quantity by controlling the mediating effects of environmental variables and all the effects favored male students, except that there was no direct effect of gender on the achievement of uncertainty. Gender only had significant indirect effect on the achievement of space and shape and all the indirect effect favored male students. The reason for having no direct effect of gender on the achievement of uncertainty is that environmental variables cannot significantly decompose the total effect of gender on Mathematics achievements and at the same time, the values of total effect of gender on the achievements of uncertainty were not statistically significant. That means, there are no significant gender differences in learning Mathematics through environmental variables. Similar to mediating by behavioral variables, the mediating effects of environmental variables do not have a strong effect on gender when compared with the mediating effect of personal variables. Therefore, the negative values of total effects are due to the negative values of direct effects of gender and the negative values of direct effects of gender may come from the negative values of direct effects of personal variables. A clearer picture can be obtained in section 5.6.

In order to answer the last research question, a two-step analysis was conducted; intermediate models and full models of the gender differences on the Mathematics achievements mediated by all the three sets of variables are considered. In the analysis, intermediate models are found to be acceptable models. So, it is necessary to consider the full models.

After controlling the mediating effects of the three sets of variables and the effect SES in the full model, the direct effects of gender significantly favored female students in the Mathematics domain of uncertainty and significantly favored male students in the domain of quantity. No significant direct effects on the other two domains could be found. There fore, no consistent pattern can be obtained among the direct effects. However, gender has a significant indirect effect on all the four Mathematics domains and all the effects favored male students. In other words, females are at a disadvantage in learning Mathematics through learning process. Therefore, the indirect effects of gender are the main source of gender differences in learning Mathematics.

Chapter 6

Conclusions and Implications

6.1 Introduction

This Chapter summarizes and discusses the major findings generated from the analysis in Chapter 4 and Chapter 5. It aims to answer the question of whether there are gender differences across the four Mathematics domains and states the reasons for contributing to the gender differences in learning Mathematics. Implications, limitations and recommendations for future study are also discussed.

6.2 Summary of findings

Gender effects on learning Mathematics are investigated in this thesis. The results showed that there are significant negative effects of gender on the achievements in three of the four domains. It means that females are at a disadvantage in learning Mathematics in three of the four domains.

Total effects of gender on the four domains of Mathematics achievements have then been decomposed into direct effects of gender and indirect effects of gender by adopting three sets of mediating variables in self-regulated learning theory. Results of Table 6.1 shows that once personal variables are taken into consideration as mediating variables, disadvantages commonly found among females in learning Mathematics are reversed. After controlling the mediating effects of the personal variables and the effect of SES, the values of the direct effects of gender on Mathematics achievements in all four domains changed from negative to positive. Three domains out of four are statistically significant. That means that disadvantage for females in learning Mathematics is mainly due to personal variables. From the results of the present study, females have lower intrinsic motivation and lower instrumental motivation to learn Mathematics, lower sense of self-efficacy when facing Mathematics problems, lower self-concept in learning Mathematics comparing with their male counterparts. Female students are also more anxious in learning Mathematics than male students. Therefore, an important implication is that disadvantage in learning Mathematics for females can be changed. For instance, Mathematics teachers can give more compliments to female students so as to increase their intrinsic motivation; parents can give awards to female students when they have performed well in Mathematics tests or exams to increase their instrumental motivation; Mathematics teachers can make use of graded exercises and assignments so as to improve female students' self-efficacy and self-concept and reduce their anxiety simultaneously. This finding also sheds light on the biological reasons for the disadvantage in learning Mathematics for female students. From the finding, originally, the total effects of gender on Mathematics achievements are all negative and in three out of the four domains, the effects are statistically significant. However, once personal variables are added as mediating variables into the models, the values of direct effects of gender on Mathematics achievements become positive in all the four domains and the values are statistically significant in three out of the four domains. Therefore, the question of biological reasons for the disadvantage of learning Mathematics for females is raised. Another implication is the question of the existence of female students' adverse affective situations. If the reasons could be found, the unfavorable situation for girls could be changed. Thus, it is worth using qualitative research methods to uncover the reasons in future studies.

On the other hand, the indirect effects of gender on Mathematics achievement are all negative in values and statistically significant. The findings also confirm the advantage of learning Mathematics for male students through personal variables and leads to the question of the reasons for the existence of high intrinsic motivation, high instrumental motivation, high sense of self-efficacy, high self-concept and low anxiety when learning Mathematics in males. However, again, the present study cannot provide an answer to this question. This can be one of the suggestions for a future study.

Table 6.2 shows a different picture if considering behavioral variables as mediating variables. The values of direct effects and total effects of gender on achievements are all negative and statistically significant in three of the four domains whereas indirect effects of gender on achievement are all statistically insignificant. In brief, no significant mediating effects of the three behavioral variables can be found in the gender effect on Mathematics achievements. The reason is that the indirect effects of gender on Mathematics achievements mediated by each behavioral variable offset each other. For example, in Figure 5.12, the overall value of effect of gender on achievement of change and relationships mediated by the three behavioral variables is equal to the sum of the indirect effect of gender on achievement mediated by each behavioral variable, i.e. 0.06 x 0.73 + -0.20 x 0.06 + 0.02 x -0.65 = 0.0018. As a result, there is little evidence in using behavioral variables to explain females' disadvantages in learning Mathematics. From this finding, it can be seen that male and female students use different learning strategies. However, the present study cannot provide an explanation as to male students prefer to use elaboration strategy and female students prefer to use control strategies. This is a limitation of the quantitative research method. Qualitative research methods may help to find out the reasons for this and this can be a direction for future study.

Similar results to behavioral variables are obtained when considering environmental variables as mediating variables. Results in Table 6.3 indicate that the values of total effects of gender are all negative and three of them are statistically significant. The indirect effects of gender via the two environmental variables on achievement are very weak and only marginally significant in the domain of space and shape. In a word, it is not possible to explain female disadvantage in learning Mathematics through the learning situations measured in the present study. The reason is that only the effect of gender on competitive learning preference is statistically significant and at the same time, the effects of environmental variables on Mathematics achievement are not strong enough. Hence the overall indirect effect of gender on Mathematics achievement mediated by environmental variables will not be great. For example, in Figure 5.18, the structural model of effect of gender on change and relationships achievement mediated by environmental variables, the overall value of indirect effect of gender equals the sum of the value of indirect effect of gender on change and relationships achievements mediated by competitive learning preference and the value of indirect effect of gender on change and relationships achievements mediated by cooperative learning preference (-0.05 x 0.03 + -0.02 x 0.20 = -0.0055).

The summary of the results of the direct effects, indirect effects and total effects of gender are presented in Table 6.4 where all the three sets of variables are considered in the full models. The results indicate that the indirect effects of gender on achievement are all negative and statistically significant. Therefore, females are at a disadvantage in learning Mathematics through the process of self-regulated learning. Although the present study has confirmed that females are at a disadvantage when learning Mathematics, the adverse situation can be changed because the disadvantage is due to the learning process. Once the learning process is changed, by for instance, the use of small group and mixed ability group teaching female students' anxiety will reduce. Females may then have an advantage in learning Mathematics. This is one of the most important findings of the present study.

Once the indirect effects of gender and the effect of SES on achievements are controlled the values of the direct effects of gender on Mathematics achievement are not significant on achievement in the two domains of 'space and shape' and 'change and relationships. This shows that females do not have any direct disadvantages in learning Mathematics in these two domains. The value of the direct effect of gender on achievement in the domain of uncertainty is 0.04 and is statistically significant. It appears that females possess advantages in learning Mathematics in the domain of uncertainty after controlling the mediating effects of the three sets of variables and the effect of SES. The value of the direct effect of gender on the domain of quantity is -0.05 and is statistically significant. This finding suggests that female students are still at disadvantages in learning Mathematics in the domain of quantity, even after controlling the mediating effects of the three sets of variables and the effect of SES. Therefore, no consistent conclusion can be drawn on whether gender has a direct effect on Mathematics achievement. The reasons that lead to inconsistent results in the direct effects of gender on Mathematics achievement in the four domains may be due to other factors that have not been considered in the present study. For example, Reiss (2005) has found out that female students have the advantage when learning Mathematics through linguistic factors. Questions in the domain of uncertainty are related to Probability and Statistics and they are generally longer than other domains. Therefore, female students may have an advantage of solving these questions. Questions in the domain of quantity are related to arithmetic computations. So, questions in this domain are generally shorter than other domains. Therefore, male students may have an advantage when solving the questions in this domain. This may be one of the reasons why the effects of gender on Mathematics achievement in the domain of quantity and in the domain of uncertainty favor male and female students respectively. This may also help explain why the results of the direct effect of gender on Mathematics achievement across the four domains are inconsistent.

If more factors were to be considered, a better understanding of how male and female students learn could be obtained.

Another inconsistent pattern shown in Table 6.4 is a sign to show that the direct effect and indirect effect of gender is not consistent across the four domains. For example, the direct effects of gender on Mathematics achievement are positive and not statistically significant in the domain of space and shape and in the domain of change and relationships. At the same time, the indirect effects of gender in these two domains are negative and statistically significant. However, in the domain of quantity and in the domain of uncertainty, there are different patterns. The possible reason may be due to the linguistic factors or other factors as mentioned above, such as the design of the curriculum in these two domains or the instruments focused to assess students in these two domains. This is not the focus of the present study and therefore it may be a focus for future study.

According to the conceptual framework of the theory of self-regulated learning, personal factors can act as the initiative factors in affecting learning. Unlike the previous research studies, the present study offers causal models to account for gender differences in Mathematics achievement through the learning process. Since the effects of gender on Mathematics achievement mediated by the three sets of variables are quantified to show that the disadvantages for females are due to the learning process, improvement can be operationalized as a result. For instance, as shown in Figure 5.21, (the full model of effects of gender on space and shape achievement,) self-efficacy not only has a direct effect achievement but also has significant effects on the use of control strategies and this further affects the performance. Therefore, increasing students' sense of self-efficacy not only enhances their performance directly but can also enhance the use of learning strategies to further improve their performance. However, females have a lower sense of self-efficacy than males and this need to be raised in order to enhance their performance.

Table 6.1: Summary of effects of gender on achievements mediated by personal variables

Effect of gender on:	Intrinsic motivation	Instrumental motivation	Self-efficacy	Anxiety	Self-concept	Space and shape	Change and relationships	Quantity	Uncertainty
Direct effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	0.08***	0.08***	0.02	0.10***
Indirect effect	N.A.	N.A.	N.A.	N.A.	N.A.	-0.12***	-0.11***	-0.11***	-0.11***
Total effect	-0.15***	-0.11***	-0.18***	0.16***	-0.18***	-0.04**	-0.03*	-0.09***	-0.01

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 6.2: Summary of effects of gender on achievements mediated by behavioral variables

Effect of gender on:	Control strategies	Elaboration	Memorization	Space and shape	Change and relationships	Quantity	Uncertainty
Direct effect	0.06***	-0. 20***	0.02	-0.04*	-0.05*	-0.11***	-0.03
Indirect effect	N.A.	N.A.	N.A.	0.00	0.02	0.02	0.01
Total effect	0.06***	-0.20***	0.02	-0.04**	-0.03*	-0.09***	-0.01

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 6.3: Summary of effects of gender on achievements mediated by environmental variables

Effect of gender on:	Competitive learning preference	Cooperative learning preference	Space and shape	Change and relationships	Quantity	Uncertainty
Direct effect	-0.05**	-0.02	-0.03*	-0.03	-0.08***	0.00
Indirect effect	N.A.	N.A.	-0.01*	-0.01	-0.01	-0.01
Total effect	-0.05**	-0.02	-0.04**	-0.03*	-0.09***	-0.01

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

Table 6.4: Effects of gender on achievement of the four Mathematics domains in full models

Effect of gender on:	Space and shape	Change and relationships	Quantity	Uncertainty
Direct effect	0.02	0.01	-0.05**	0.04**
Indirect effect	-0.06***	-0.04*	-0.04**	-0.05***
Total effect	-0.04**	-0.03*	-0.09***	-0.01

"*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$

6.3 Implications

The findings of the present study have confirmed not only the existence of gender differences in Mathematics achievement but also in the learning process. It provides empirical evidence confirming the single unidirectional effect between personal variables, behavioral variables and environmental variables on the ways to enhance Mathematics learning via self-regulated learning theory. Theoretical implications, practical implications, policy implications and ideological implications will be discussed in this section.

6.3.1 Theoretical implications

Since the present study has shown that the four full models the theory of self-regulated learning in various Mathematics domains are good models, it is not sufficient to look at the three kinds of variables discretely. The first implication is that personal variables, behavioral variables and environmental variables should be considered together rather than considered individually. The second implication is that when considering the three sets of variables, the interrelationships between the three sets of variables should also be considered. Since the models are fit and significant values can be found, such a model is useful for future similar studies.

6.3.2 Practical implications

A practical implication is that gender differences can be reduced by using the path diagram practically. As the path diagram can show the values of the effect of gender on the variables, teachers can easily design or adjust their teaching strategies for the sake of benefit to the student. For instance, it can be shown from the path diagram that boys have a higher sense of self-efficacy than girls. Therefore, a teacher should plan strategies to enhance girls' sense of self-efficacy and to further boost boys' self-efficacy. Different levels of questions, starting from the easiest to the most difficult, can be set for girls so as to establish their sense of satisfaction and enhance self-efficacy and teachers can give more compliments even when the questions are very easy. On the other hand, boys can be given more challenging questions as they have higher self-efficacy.

6.3.3 Policy implications

The first policy implication is the inclusion of gender differences in learning Mathematics in the curriculum of teachers' training institutes. The reason for doing so is to avoid student teachers having a perception of gender stereotype while teaching in classrooms as the present study has confirmed that gender differences in learning Mathematics stem mainly from the learning processes instead of from the nature of gender itself.

The second policy implication is the need for the Education Bureau to regularly organize seminars on designing teaching strategies based on gender differences. As shown from the results of the present study, the effect of gender can be reduced by regulating the learning processes of boys and girls motivationally, metacognitively and behaviorally. Apart from student teachers, teachers who are currently teaching Mathematics also need to be equipped with the above knowledge. Seminars can be held to talk about the gender differences in learning styles and processes. Moreover, strategies to increase students' motivation, conduct metacognitive training and control students' behaviour should also be introduced to teachers with the aim of designing Mathematics lessons which can alleviate the actual gender differences and maximize benefit to students at the same time.

The third policy implication is reconsideration of providing single-sex schools or single-sex classes so as to allow boys and girls to learn separately. Since there are differences in the learning processes and learning styles, offering single-sex learning environments may handle the differences more efficiently. Teachers in coeducational classes have to use various teaching strategies so as to cater for different learning styles and preferences of boys and girls. On the other hand, it is easier for teachers in single-sex class to cater for student needs.

6.3.4 Ideological implications

A university professor said in the public that boys outperform girls in Mathematics and this is mentioned at the beginning of the present study (News from Apple Daily on 25/3/2009). Such belief has led to an ideological implication that gender does make a difference in learning processes, learning styles and preferences but the differences can not directly made on achievement. Therefore, the common belief of "boys outperform girls in Mathematics" should be eradicated after studying the results of the present study.

Referring to the results in the previous sections, it cannot be denied that indirect effect of gender consistently favors boys but still it cannot be said that boys perform better at Mathematics. A fact which cannot be ignored is that the indirect effects of gender reflecting the differences in learning styles, preferences and processes can all be nurtured, regulated and taught. Even though girls are in an adverse situation, they can change that situation by putting effort in themselves. They can adjust their affective situation, they can learn effective learning strategies from teachers and peers, and they can actively choose their preferred learning situation. In short, girls can perform equally well once they regulate their learning processes motivationally, metacognitively and behaviorally. Again, the idea of "boys outperform girls in Mathematics cannot be established.

6.4 Limitations and recommendations for future research

6.4.1 Limitations of the present study

In order to better know how students learn Mathematics, other areas such as focusing on how higher achievers or low achievers learn Mathematics, should be investigated. This could be one of the directions for future research.

First and foremost, the results of the study cannot perfectly match every individual student. The present study uses a quantitative research method to analyze the learning characteristics of students. Although the sampling method is comprehensive and the results could show a general picture of how students learn Mathematics, caution must be taken when applying the results to students' learning as every student is unique. It does not mean that the implication and application of the results of the study are perfectly suitable for every student. In order to cater for every student's needs, one must look into every student's unique situation. In addition, it is suggested that students can be divided into high achieving groups and low achieving groups. By doing so, more detailed results can be generated to learn students learn Mathematics in better ways.

Another limitation is the deficiency of only using quantitative research methods, leading to a less holistic picture of learning situations. As mentioned above, quantitative research method could only give a general picture or a cross-section of the reality. Even though a causal model is constructed to investigate how students learn, the questions of how gender differences in learning processes appear and develop; and why there are gender differences in learning characteristics cannot be found. Although the present study has found out that females have a lower sense of self-efficacy than males in general, it is believed that there are girls who may have a high sense of self-efficacy. It is worth investigating why this happens. Questions such as the reason why no consistent pattern of direct effects of gender across the four domains emerged after controlling the indirect effect of gender cannot be answered by the present study due to the limitation of the quantitative research method.

Another limitation is that several factors are taken into consideration together due to the focus of the present study. The focus of the present study is to give a fundamental understanding and empirical evidence of how

Mathematics achievement is affected by the learning characteristics of students, and hence the technique used in the present study focused on the learning characteristics of students at an individual level only. Other background factors and factors at other levels, such as classroom level and school level factors have not been involved.

The present study is inclined to gender differences without focusing on gender similarities which may result in intensifying gender stereotyping. According to Hyde (2005), it is suggested that if the discourse about gender differences is re-opened, it is better to focus on gender similarities together with gender differences instead of just focusing on gender differences alone. As the aim of the present study is to explore gender differences, it has put its focus on analyzing different models of gender differences. The results of the study could only help confirm and overemphasize the differences between males and females. Consequently, such results might be embedded in or might become mainstream beliefs. Stereotyping of gender differences would be further intensified.

The coverage of the present study may extend further to explore the possibilities of having similar gender differences in other subjects so as to facilitate students' learning. Since the focus of the study is on learning Mathematics solely, there is the possibility that similar gender differences could be found in learning other subjects. If such things happen, the study results could be widely used to help different stakeholders understand gender differences in learning different subjects and inspire them to develop suitable teaching methods to cater for students' needs.

Although the present study adopted a theory of self-regulated learning as the conceptual framework, the effect of each set of variables on achievement in self-regulated learning theory and the interrelationships among them are briefly investigated and discussed because the focus of the present study is gender difference in learning Mathematics in self-regulated learning process. In order to investigate the effect of each set of variables in self-regulated learning theory, another research design should be adopted.

6.4.2 Recommendations for future study

To respond to the limitations of the present study, the following recommendations for future study are suggested. First and foremost, mixed methods, including both qualitative and quantitative research approaches, should be used to provide a more holistic investigation into the development of gender differences in learning process of Mathematics. To summarize the research findings, one of the most important discoveries is that personal variables are the most influential of the variables. Male and females students have a tendency to incline to certain learning strategies. Thus, it is worthwhile to find out the reasons behind their inclination and its effect on learners. Another important discovery is that intervention can be made in personal variables so as to allow students to change their learning processes metacognitively and behaviourally. Digging out the reasons and the effect of intervening in personal variables cannot be found from the present study. It is highly recommended that quantitative and qualitative research methods should be used together so as to uncover the reasons. To aid further understanding of how male and female student learn and hence improve their learning, research studies on exploring the gender differences in curriculum design of various Mathematics domains and the gender differences in the instruments of the assessments in various Mathematics domains can be conducted in the future.

Another suggestion for future study is the use of multi-level path analysis research method for investigating the gender effects and the influences on Mathematics achievements. Many research studies (Caldas & Bankston, 1997; Ma & Klinger, 2000; Ho & Willms, 1996) have shown that school level factors, such as school level SES, are strong predictors of academic achievement. It is recommended that factors of other areas, such as school mean SES, schools' disciplinary climate, etc, should be considered in future studies. Only a limited number of research studies have used this method and hence few references can be found. Therefore, it is suggested that a series of small scale research studies with small number of factors should be conducted first before conducting a comprehensive one while using this analyzing method.

Next, a longitudinal study can also be conducted in the future. One of the deficiencies of the present study is that the subjects are ninth-graders which mean the results only reflect student performance at a particular stage. If a longitudinal study is used, more detailed information can be drawn. As students are being observed for a period of time, patterns of learning style and changes over stages can be observed. With such information, it is easy to find out when gender differences appear; what factors cause the appearance of gender differences and which particular factor is the most influential at a particular stage. It is believed that the above information can help various stakeholders, such as Education Bureau, Curriculum Development Council, schools and teachers to take controlling measures so as to maximize the benefits for students.

Apart from using different research methods, it would be interesting to investigate the situation of single-sex schools in exploring gender differences more closely. What will be the differences in boy-schools and girl-schools? Will the results be the same as the present study? If the results are not the same or similar, what factors affect the results? However, caution must be taken when such research studies are conducted because in Hong Kong, single-sex schools are not simply different in gender but cultural factors and historical factors are fused together to form a complicated system. Therefore, careful clarification of these factors must be done before investigation.

It is suggested that nation-wide samples could be used for comparing the situation with local samples. The present study uses the Hong Kong samples for analysis. Therefore, the results only represent the situation of gender differences in Hong Kong. It is worth replicating the present study by using data from other nations so as to compare the situation of gender difference across nations. For example, will other East Asian countries show similar results? Or will Western countries show different results? Cross nation comparisons are necessary because lessons from different nations may provide information in improving learning and narrowing the gender gap.

Another recommendation for further study is to explore the gender differences in learning other subjects, such as English, Science, or Humanities. The models used in and the results of the present study can be a reference or be reused for future research studies. Researchers can compare and contrast gender differences across subjects or can explore whether similar learning patterns can be found across subjects. If the above results can be drawn upon, it may lead to better understanding of differences in learning for boys and girls and practical implications for teaching and learning may result.

Investigation could be done on the role or the effect of each set of variables in self-regulated learning theory. The present study adopted the theory of self-regulated learning as the conceptual framework and aimed at the gender differences in learning Mathematics. The role or the effect of each set of variables in self-regulated learning theory has not been investigated. In order to discover the effect of each set of variables in self-regulated learning theory on achievement another research design should be adopted. One suggestion for the research design is a three stages design. The first stage is to find out the effects of each set of variables on achievements. The second stage is to add the behavioral variables to the models involving environmental variables from the first stage. Personal variables can be further added to the models in the second stage. By comparing the direct and indirect effects of the models in the three stages, the effects or the role of each set of variables can be obtained. This can be a direction for future study.

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Appendix A: Student Questionnaire of PISA 2003

Q30 *Thinking about your views on Mathematics:* **To what extent do you agree with the following statements?**

(Please <tick> only one box in each row.)

		Strongly agree	*Agree*	*Disagree*	*Strongly disagree*
a)	I enjoy reading about Mathematics.	☐ 1	☐ 2	☐ 3	☐ 4
b)	Making an effort in Mathematics is worth it because it will help me in the work that I want to do later on.	☐ 1	☐ 2	☐ 3	☐ 4
c)	I look forward to my Mathematics lessons.	☐ 1	☐ 2	☐ 3	☐ 4
d)	I do Mathematics because I enjoy it.	☐ 1	☐ 2	☐ 3	☐ 4
e)	Learning Mathematics is worthwhile for me because it will improve my career <prospects, chances>.	☐ 1	☐ 2	☐ 3	☐ 4
f)	I am interested in the things I learn in Mathematics	☐ 1	☐ 2	☐ 3	☐ 4
g)	Mathematics is an important subject for me because I need it for what I want to study later on.	☐ 1	☐ 2	☐ 3	☐ 4
h)	I will learn many things in Mathematics that will help me get a job.	☐ 1	☐ 2	☐ 3	☐ 4

Q31 How confident do you feel about having to do the following Mathematics tasks?

(Please <tick> only one box in each row.)

		Very confident	*Confident*	*Not very confident*	*Not at all confident*
a)	Using a <train timetable> to work out how long it would take to get from one place to another.	☐ 1	☐ 2	☐ 3	☐ 4
b)	Calculating how much cheaper a TV would be after a 30% discount.	☐ 1	☐ 2	☐ 3	☐ 4
c)	Calculating how many square metres of tiles you need to cover a floor.	☐ 1	☐ 2	☐ 3	☐ 4
d)	Understanding graphs presented in newspapers	☐ 1	☐ 2	☐ 3	☐ 4
e)	Solving an equation like $3x+5=17$.	☐ 1	☐ 2	☐ 3	☐ 4
f)	Finding the actual distance between two places on a map with a 1:10,000 scale.	☐ 1	☐ 2	☐ 3	☐ 4
g)	Solving an equation like $2(x+3)=(x+3)(x-3)$.	☐ 1	☐ 2	☐ 3	☐ 4
h)	Calculating the petrol consumption rate of a car	☐ 1	☐ 2	☐ 3	☐ 4

Q32 *Thinking about studying Mathematics:* **To what extent do you agree with the following statements?**

(Please <tick> only one box in each row)

		Strongly agree	*Agree*	*Disagree*	*Strongly disagree*
a)	I often worry that it will be difficult for me in Mathematics classes.	☐ 1	☐ 2	☐ 3	☐ 4
b)	I am just not good at Mathematics.	☐ 1	☐ 2	☐ 3	☐ 4
c)	I get very tense when I have to do Mathematics homework.	☐ 1	☐ 2	☐ 3	☐ 4
d)	I get good <marks> in Mathematics	☐ 1	☐ 2	☐ 3	☐ 4
e)	I get very nervous doing Mathematics problems.	☐ 1	☐ 2	☐ 3	☐ 4
f)	I learn Mathematics quickly.	☐ 1	☐ 2	☐ 3	☐ 4
g)	I have always believed that Mathematics is one of my best subjects.	☐ 1	☐ 2	☐ 3	☐ 4
h)	I feel helpless when doing a Mathematics problem.	☐ 1	☐ 2	☐ 3	☐ 4
i)	In my Mathematics class, I understand even the most difficult work.	☐ 1	☐ 2	☐ 3	☐ 4
j)	I worry that I will get poor <marks> in Mathematics.	☐ 1	☐ 2	☐ 3	☐ 4

Q34 *There are different ways of studying Mathematics.* **To what extent do you agree with the following statements?**

(Please <tick> only one box in each row.)

		Strongly agree	*Agree*	*Disagree*	*Strongly disagree*
a)	When I study for a Mathematics test, I try to work out what are the most important parts to learn.	☐ 1	☐ 2	☐ 3	☐ 4
b)	When I am solving Mathematics problems, I often think of new ways to get the answer.	☐ 1	☐ 2	☐ 3	☐ 4
c)	When I study Mathematics, I make myself check to see if I remember the work I have already done.	☐ 1	☐ 2	☐ 3	☐ 4
d)	When I study Mathematics, I try to figure out which concepts I still have not understood properly.	☐ 1	☐ 2	☐ 3	☐ 4
e)	I think how the Mathematics I have learnt can be used in everyday life.	☐ 1	☐ 2	☐ 3	☐ 4
f)	I go over some problems in Mathematics so often that I feel as if I could solve them in my sleep.	☐ 1	☐ 2	☐ 3	☐ 4
g)	When I study for Mathematics, I learn as much as I can off by heart.	☐ 1	☐ 2	☐ 3	☐ 4
h)	I try to understand new concepts in Mathematics by relating them to things I already know.	☐ 1	☐ 2	☐ 3	☐ 4
i)	In order to remember the method for solving a Mathematics problem, I go through examples again and again.	☐ 1	☐ 2	☐ 3	☐ 4
j)	When I cannot understand something in Mathematics, I always search for more information to clarify the problem.	☐ 1	☐ 2	☐ 3	☐ 4
k)	When I am solving a Mathematics problem, I often think about how the solution might be applied to other interesting questions.	☐ 1	☐ 2	☐ 3	☐ 4
l)	When I study Mathematics, I start by working out exactly what I need to learn.	☐ 1	☐ 2	☐ 3	☐ 4
m)	To learn Mathematics, I try to remember every step in a procedure.	☐ 1	☐ 2	☐ 3	☐ 4
n)	When learning Mathematics, I try to relate the work to things I have learnt in other subjects.	☐ 1	☐ 2	☑ 3	☐ 4

Q37 *Thinking about your <Mathematics> classes:* **To what extent do you agree with the following statements?**

(Please <tick> only one box in each row.)

		Strongly agree	*Agree*	*Disagree*	*Strongly disagree*
a)	I would like to be the best in my class in Mathematics.	☐ 1	☐ 2	☐ 3	☐ 4
b)	In Mathematics I enjoy working with other students in groups.	☐ 1	☐ 2	☐ 3	☐ 4
c)	I try very hard in Mathematics because I want to do better in the exams than the others.	☐ 1	☐ 2	☐ 3	☐ 4
d)	When we work on a project in Mathematics, I think that it is a good idea to combine the ideas of all the students in a group.	☐ 1	☐ 2	☐ 3	☐ 4
e)	I make a real effort in Mathematics because I want to be one of the best.	☐ 1	☐ 2	☐ 3	☐ 4
f)	I do my best work in Mathematics when I work with other students.	☐ 1	☐ 2	☐ 3	☐ 4
g)	In Mathematics I always try to do better than the other students in my class.	☐ 1	☐ 2	☐ 3	☐ 4
h)	In Mathematics, I enjoy helping others to work well in a group.	☐ 1	☐ 2	☐ 3	☐ 4
i)	In Mathematics I learn most when I work with other students in my class.	☐ 1	☐ 2	☐ 3	☐ 4
j)	I do my best work in Mathematics when I try to do better than others.	☐ 1	☐ 2	☐ 3	☐ 4

Appendix B: Missing values

Just like taxes and death, missing quantitative data in any educational research is inevitable. Given the high cost of collecting data, it is impossible to re-collect the missing data of a research, so as to obtain complete information, rather, a more reasonable way of dealing with missing data in a research is to consider how to analyze the incomplete data set. First of all, it's better to know the reasons for the occurrence of missing data. According to Pigott (2001), during the phase of data collection, the researcher has the opportunity to observe the possible explanations for missing data, evidence that will help guide the decision about what missing data method is appropriate for the analysis because various strategies for handling missing data are based on different assumptions. Rubin (1976) defined three "mechanisms": (1) missing completely at random (MCAR) for which the missing values on a particular variable are unrelated to other variables in the data set as well as the underlying values of the variable itself; (2) missing at random (MAR) for which the missing values on a variable can be related to other measured variables but still may be unrelated to the underlying values of the variable itself; (3) missing not at random (MNAR) for which the probability of missing values of a variable is related to the underlying values of the variable itself, that can be thought of as a probable explanation for why data is missing. However, it is difficult to obtain empirical evidence to judge whether the data belongs to MCAR or MAR (Pigott, 2001) and there is no way to distinguish between the MAR and MNAR cases (Sinharay, Stern, and Russell, 2001). Only recording reasons for missing data can allow the researcher to justify the method used for dealing with missing data (Sinharay, Stern, and

Russell, 2001).

The most widely used methods for handling missing values in the data set are complete case analysis (listwise deletion), available case analysis (pairwise deletion), single-value imputation (e.g. mean imputation), maximum likelihood (ML) estimation, and multiple imputation (MI). According to Yuan (2000) and Sinharay, Stern, and Russell (2001), complete case analysis, which is a method including only individuals with complete information on all the variables in the analysis, may lead to inaccurate results especially when there is a small number of complete cases; available case analysis, which is a method stipulating only individuals with no missing values on the variables are used, may lead to inaccurate results and the occurrence of non-positive definite correlation matrix; single-value imputation, which is a method replacing the missing values by the mean, may lead to the estimated variances and covariances biased toward zero; ML estimation, which is a method for obtaining maximum likelihood estimates of the missing data for specific model; and multiple imputation, which is a method replacing each missing value by a set of $m > 1$ plausible values to generate m apparently complete data sets and then combining to give parameter estimates and standard errors.

In the present study, MI will be adopted because MI has addressed the uncertainty due to the missing values, the computation is simpler than maximum likelihood estimation (Sinharay, Stern, and Russell, 2001), and is an unbiased estimate when the data is MAR or MCAR (Peugh and Enders, 2004). The assumption of the observed complete cases are a random sample of the originally targeted sample, i.e. in Rubin's (1976) terminology, the missing data are MCAR (Pigott, 2001). According to Pigott (2001), Peugh, & Enders (2004), Cohen, and Cohen (2003) when a data set has only a few missing observations, the assumption of MCAR data is more likely to apply, and there is a greater chance of he complete cases representing the population when only a few cases are missing. The number of missing cases handled by MI for each question has been shown in table A1. LISREL 8.8 will be used for the MI computation of the missing values.

Table A1: No. of missing cases of HK sample in PISA 2003 data

Code	No. of missing	Percentage (%)		No. of missing	Percentage (%)
ST30Q01	14	.3	ST34Q01	19	.4
ST30Q02	0	.3	ST34Q02	0	.4
ST30Q03	5	.4	ST34Q03	6	.5
ST30Q04	8	.5	ST34Q04	6	.5
ST30Q05	2	.3	ST34Q05	5	.5
ST30Q06	10	.5	ST34Q06	9	.6
ST30Q07	1	.3	ST34Q07	6	.5
ST30Q08	2	.4	ST34Q08	4	.5
ST31Q01	19	.4	ST34Q09	2	.4
ST31Q02	2	.4	ST34Q10	8	.6
ST31Q03	7	.5	ST34Q11	12	.7
ST31Q04	13	.7	ST34Q12	9	.6
ST31Q05	4	.4	ST34Q13	2	.5
ST31Q06	3	.4	ST34Q14	3	.5
ST31Q07	0	.4	ST37Q01	15	.3
ST31Q08	2	.4	ST37Q02	3	.4
ST32Q01	18	.0	ST37Q03	1	.4
ST32Q02	3	.0	ST37Q04	4	.4
ST32Q03	12	.0	ST37Q05	4	.5
ST32Q04	2	.4	ST37Q06	4	.5
ST32Q05	6	.0	ST37Q07	4	.4
ST32Q06	6	.5	ST37Q08	5	.5
ST32Q07	3	.4	ST37Q09	4	.5
ST32Q08	6	.0	ST37Q10	1	.4
ST32Q09	5	.5	ESCS	30	.7
ST32Q10	1	.0			

Total no. of cases in Hong Kong is 4478.

Appendix C: Covariance Matrix

	ST30Q01	ST30Q02	ST30Q03	ST30Q04	ST30Q05	ST30Q06	ST30Q07	ST30Q08	ST31Q01
ST30Q01	0.61								
ST30Q02	0.25	0.52							
ST30Q03	0.41	0.28	0.64						
ST30Q04	0.43	0.27	0.48	0.69					
ST30Q05	0.19	0.33	0.23	0.24	0.45				
ST30Q06	0.45	0.29	0.48	0.51	0.25	0.66			
ST30Q07	0.29	0.37	0.32	0.33	0.34	0.35	0.59		
ST30Q08	0.25	0.35	0.27	0.26	0.30	0.28	0.38	0.55	
ST31Q01	0.17	0.12	0.16	0.19	0.12	0.19	0.16	0.12	0.55
ST31Q02	0.14	0.10	0.13	0.15	0.11	0.15	0.14	0.10	0.26
ST31Q03	0.21	0.12	0.19	0.23	0.13	0.23	0.19	0.14	0.33
ST31Q04	0.12	0.07	0.11	0.14	0.08	0.13	0.12	0.08	0.27
ST31Q05	0.15	0.10	0.15	0.17	0.11	0.18	0.14	0.10	0.19
ST31Q06	0.24	0.13	0.22	0.26	0.13	0.25	0.21	0.15	0.34
ST31Q07	0.28	0.16	0.27	0.31	0.15	0.31	0.21	0.17	0.25
ST31Q08	0.23	0.12	0.19	0.23	0.11	0.23	0.18	0.15	0.30
ST32Q01	-0.23	-0.09	-0.21	-0.24	-0.07	-0.24	-0.13	-0.11	-0.13
ST32Q02	0.37	0.19	0.35	0.39	0.16	0.40	0.24	0.19	0.20
ST32Q03	-0.18	-0.09	-0.17	-0.20	-0.08	-0.20	-0.13	-0.09	-0.13
ST32Q04	0.32	0.16	0.29	0.33	0.14	0.34	0.21	0.18	0.18
ST32Q05	-0.14	-0.06	-0.12	-0.14	-0.05	-0.15	-0.09	-0.06	-0.10
ST32Q06	0.30	0.17	0.28	0.33	0.14	0.33	0.21	0.18	0.18
ST32Q07	0.43	0.21	0.40	0.44	0.17	0.45	0.29	0.23	0.19
ST32Q08	-0.28	-0.15	-0.27	-0.30	-0.13	-0.31	-0.20	-0.16	-0.17
ST32Q09	0.29	0.15	0.27	0.31	0.13	0.31	0.20	0.18	0.17
ST32Q10	-0.22	-0.08	-0.18	-0.21	-0.04	-0.22	-0.10	-0.09	-0.13
ST34Q01	0.07	0.08	0.09	0.09	0.10	0.09	0.09	0.09	0.08
ST34Q02	0.21	0.14	0.20	0.23	0.12	0.23	0.16	0.15	0.14
ST34Q03	0.11	0.12	0.14	0.15	0.13	0.14	0.13	0.11	0.09
ST34Q04	0.10	0.12	0.13	0.15	0.13	0.14	0.14	0.10	0.10
ST34Q05	0.20	0.17	0.19	0.19	0.15	0.20	0.18	0.20	0.10
ST34Q06	0.21	0.14	0.21	0.25	0.13	0.25	0.18	0.16	0.14
ST34Q07	0.07	0.07	0.08	0.07	0.08	0.08	0.08	0.08	0.05
ST34Q08	0.22	0.16	0.21	0.25	0.14	0.25	0.18	0.16	0.16
ST34Q09	0.09	0.10	0.11	0.11	0.10	0.11	0.12	0.11	0.07
ST34Q10	0.22	0.16	0.22	0.25	0.15	0.25	0.19	0.18	0.13
ST34Q11	0.23	0.16	0.20	0.23	0.13	0.23	0.18	0.18	0.12
ST34Q12	0.11	0.11	0.13	0.13	0.13	0.14	0.13	0.11	0.10
ST34Q13	0.05	0.07	0.07	0.06	0.07	0.05	0.07	0.09	0.02
ST34Q14	0.20	0.15	0.18	0.21	0.12	0.21	0.17	0.18	0.12
ST37Q01	0.20	0.18	0.21	0.23	0.18	0.23	0.23	0.18	0.13
ST37Q02	0.15	0.13	0.18	0.18	0.14	0.19	0.16	0.14	0.10
ST37Q03	0.20	0.18	0.24	0.24	0.18	0.25	0.22	0.19	0.12
ST37Q04	0.15	0.14	0.16	0.17	0.14	0.18	0.16	0.16	0.10
ST37Q05	0.23	0.19	0.26	0.26	0.18	0.26	0.24	0.21	0.11
ST37Q06	0.15	0.13	0.16	0.17	0.14	0.17	0.15	0.15	0.09
ST37Q07	0.19	0.14	0.21	0.21	0.12	0.21	0.16	0.15	0.10
ST37Q08	0.21	0.16	0.22	0.25	0.15	0.24	0.19	0.17	0.13
ST37Q09	0.12	0.12	0.15	0.16	0.13	0.15	0.15	0.13	0.11
ST37Q10	0.20	0.15	0.20	0.21	0.14	0.21	0.18	0.17	0.11
space1	25.11	12.83	21.08	27.89	16.11	27.20	22.20	12.96	33.25
change1	20.28	9.92	16.36	23.74	13.76	22.81	18.76	9.98	31.74
quanti1	18.80	8.86	14.51	21.31	12.71	20.32	17.28	8.84	31.40
uncert1	19.48	10.55	16.57	22.72	14.04	21.38	18.48	10.58	28.88
gender	-0.08	-0.03	-0.04	-0.04	-0.02	-0.05	-0.04	-0.04	-0.06
SES	0.05	0.01	0.05	0.06	0.02	0.06	0.04	0.04	0.10

	ST31Q02	ST31Q03	ST31Q04	ST31Q05	ST31Q06	ST31Q07	ST31Q08	ST32Q01	ST32Q02
ST30Q01									
ST30Q02									
ST30Q03									
ST30Q04									
ST30Q05									
ST30Q06									
ST30Q07									
ST30Q08									
ST31Q01									
ST31Q02	0.46								
ST31Q03	0.36	0.67							
ST31Q04	0.23	0.31	0.59						
ST31Q05	0.23	0.25	0.17	0.46					
ST31Q06	0.29	0.41	0.32	0.26	0.82				
ST31Q07	0.26	0.33	0.23	0.38	0.39	0.81			
ST31Q08	0.22	0.33	0.27	0.16	0.38	0.31	0.68		
ST32Q01	-0.09	-0.16	-0.10	-0.09	-0.19	-0.22	-0.19	0.60	
ST32Q02	0.16	0.25	0.14	0.17	0.29	0.34	0.26	-0.42	0.76
ST32Q03	-0.11	-0.16	-0.10	-0.11	-0.17	-0.21	-0.14	0.30	-0.34
ST32Q04	0.14	0.21	0.13	0.15	0.26	0.30	0.22	-0.28	0.46
ST32Q05	-0.09	-0.12	-0.07	-0.08	-0.12	-0.15	-0.11	0.25	-0.27
ST32Q06	0.14	0.21	0.15	0.15	0.24	0.27	0.22	-0.27	0.38
ST32Q07	0.15	0.24	0.11	0.17	0.28	0.35	0.26	-0.34	0.54
ST32Q08	-0.13	-0.20	-0.12	-0.13	-0.22	-0.28	-0.21	0.31	-0.42
ST32Q09	0.11	0.20	0.13	0.12	0.22	0.25	0.22	-0.27	0.36
ST32Q10	-0.07	-0.14	-0.08	-0.07	-0.18	-0.19	-0.18	0.37	-0.42
ST34Q01	0.08	0.09	0.08	0.09	0.09	0.10	0.06	0.02	0.04
ST34Q02	0.10	0.14	0.11	0.10	0.16	0.17	0.17	-0.12	0.18
ST34Q03	0.09	0.11	0.09	0.09	0.11	0.13	0.09	-0.02	0.09
ST34Q04	0.10	0.12	0.10	0.11	0.12	0.14	0.08	-0.03	0.10
ST34Q05	0.07	0.11	0.08	0.06	0.13	0.11	0.15	-0.09	0.13
ST34Q06	0.11	0.17	0.12	0.11	0.19	0.21	0.18	-0.16	0.24
ST34Q07	0.05	0.05	0.05	0.07	0.07	0.10	0.05	0.00	0.04
ST34Q08	0.13	0.19	0.14	0.11	0.19	0.20	0.19	-0.15	0.21
ST34Q09	0.06	0.08	0.06	0.08	0.07	0.09	0.06	0.01	0.04
ST34Q10	0.11	0.15	0.12	0.12	0.17	0.19	0.17	-0.11	0.20
ST34Q11	0.08	0.12	0.10	0.08	0.15	0.16	0.17	-0.12	0.18
ST34Q12	0.09	0.11	0.09	0.10	0.10	0.13	0.09	-0.02	0.08
ST34Q13	0.00	0.01	0.01	0.03	0.00	0.02	0.02	0.05	-0.01
ST34Q14	0.07	0.13	0.10	0.08	0.16	0.16	0.19	-0.12	0.16
ST37Q01	0.11	0.15	0.10	0.13	0.17	0.20	0.14	-0.06	0.19
ST37Q02	0.08	0.11	0.10	0.10	0.12	0.13	0.11	-0.03	0.10
ST37Q03	0.12	0.16	0.10	0.14	0.16	0.21	0.13	-0.06	0.19
ST37Q04	0.08	0.10	0.09	0.09	0.11	0.13	0.09	-0.04	0.10
ST37Q05	0.08	0.13	0.08	0.11	0.15	0.20	0.13	-0.08	0.19
ST37Q06	0.09	0.12	0.08	0.09	0.12	0.12	0.10	-0.03	0.10
ST37Q07	0.07	0.11	0.08	0.08	0.13	0.14	0.13	-0.11	0.19
ST37Q08	0.11	0.16	0.11	0.12	0.17	0.19	0.16	-0.12	0.21
ST37Q09	0.09	0.12	0.09	0.10	0.13	0.13	0.10	-0.02	0.08
ST37Q10	0.09	0.13	0.09	0.09	0.14	0.15	0.14	-0.10	0.20
space1	31.94	41.17	29.57	26.34	43.45	38.94	30.14	-21.47	34.71
change1	31.07	39.53	29.26	25.31	41.48	37.21	27.94	-16.98	28.64
quanti1	30.42	38.18	28.45	24.08	40.38	34.94	27.64	-16.08	26.60
uncert1	27.96	35.12	25.91	23.23	36.46	33.21	24.81	-16.07	27.59
gender	-0.03	-0.06	-0.05	-0.01	-0.06	-0.02	-0.06	0.04	-0.07
SES	0.06	0.11	0.13	0.06	0.11	0.14	0.08	-0.05	0.06

	ST32Q03	ST32Q04	ST32Q05	ST32Q06	ST32Q07	ST32Q08	ST32Q09	ST32Q10	ST34Q01
ST30Q01									
ST30Q02									
ST30Q03									
ST30Q04									
ST30Q05									
ST30Q06									
ST30Q07									
ST30Q08									
ST31Q01									
ST31Q02									
ST31Q03									
ST31Q04									
ST31Q05									
ST31Q06									
ST31Q07									
ST31Q08									
ST32Q01									
ST32Q02									
ST32Q03	0.55								
ST32Q04	-0.23	0.59							
ST32Q05	0.40	-0.17	0.52						
ST32Q06	-0.22	0.35	-0.17	0.54					
ST32Q07	-0.26	0.52	-0.20	0.41	0.90				
ST32Q08	0.32	-0.30	0.27	-0.29	-0.36	0.64			
ST32Q09	-0.19	0.33	-0.16	0.35	0.40	-0.28	0.55		
ST32Q10	0.27	-0.32	0.25	-0.25	-0.37	0.33	-0.27	0.80	
ST34Q01	0.00	0.05	0.02	0.06	0.06	-0.03	0.06	0.02	0.36
ST34Q02	-0.08	0.18	-0.07	0.20	0.22	-0.15	0.21	-0.11	0.13
ST34Q03	-0.03	0.10	0.00	0.10	0.10	-0.08	0.09	0.00	0.15
ST34Q04	-0.05	0.10	-0.02	0.09	0.10	-0.08	0.08	0.00	0.13
ST34Q05	-0.04	0.14	-0.03	0.15	0.17	-0.12	0.16	-0.08	0.10
ST34Q06	-0.11	0.24	-0.08	0.23	0.28	-0.19	0.24	-0.16	0.08
ST34Q07	0.01	0.05	0.03	0.05	0.04	-0.04	0.05	0.02	0.10
ST34Q08	-0.11	0.20	-0.08	0.22	0.22	-0.17	0.21	-0.13	0.11
ST34Q09	0.01	0.06	0.02	0.06	0.05	-0.04	0.07	0.02	0.13
ST34Q10	-0.08	0.18	-0.04	0.19	0.21	-0.16	0.19	-0.10	0.11
ST34Q11	-0.07	0.17	-0.05	0.18	0.22	-0.13	0.19	-0.11	0.09
ST34Q12	-0.04	0.09	-0.02	0.09	0.09	-0.07	0.08	-0.01	0.14
ST34Q13	0.05	0.01	0.04	0.02	0.01	0.01	0.02	0.03	0.11
ST34Q14	-0.06	0.17	-0.04	0.17	0.21	-0.13	0.19	-0.11	0.07
ST37Q01	-0.07	0.19	-0.04	0.16	0.25	-0.13	0.17	-0.03	0.10
ST37Q02	-0.05	0.11	-0.03	0.11	0.12	-0.09	0.11	-0.02	0.08
ST37Q03	-0.07	0.18	-0.03	0.16	0.22	-0.14	0.16	-0.02	0.13
ST37Q04	-0.04	0.11	-0.01	0.11	0.13	-0.09	0.11	-0.02	0.09
ST37Q05	-0.06	0.20	-0.02	0.16	0.26	-0.13	0.17	-0.05	0.10
ST37Q06	-0.02	0.11	-0.01	0.12	0.13	-0.07	0.11	-0.02	0.11
ST37Q07	-0.06	0.19	-0.04	0.18	0.22	-0.12	0.20	-0.10	0.08
ST37Q08	-0.10	0.19	-0.07	0.19	0.23	-0.16	0.19	-0.10	0.08
ST37Q09	-0.03	0.10	-0.01	0.11	0.10	-0.06	0.10	-0.10	0.09
ST37Q10	-0.06	0.19	-0.05	0.19	0.23	-0.13	0.20	-0.10	0.09
space1	-23.35	28.74	-16.09	26.46	31.25	-26.54	23.28	-19.95	7.92
change1	-18.70	23.64	-12.20	20.95	25.14	-21.31	17.86	-14.76	7.75
quanti1	-17.85	21.99	-11.85	20.08	23.33	-19.58	16.88	-14.44	6.95
uncert1	-18.63	22.62	-12.87	20.67	24.14	-21.17	17.82	-14.11	6.87
gender	0.03	-0.05	0.03	-0.06	-0.07	0.04	-0.06	0.07	0.01
SES	-0.04	0.08	0.00	0.07	0.03	-0.05	0.07	-0.02	0.02

	ST34Q02	ST34Q03	ST34Q04	ST34Q05	ST34Q06	ST34Q07	ST34Q08	ST34Q09	ST34Q10
ST30Q01									
ST30Q02									
ST30Q03									
ST30Q04									
ST30Q05									
ST30Q06									
ST30Q07									
ST30Q08									
ST31Q01									
ST31Q02									
ST31Q03									
ST31Q04									
ST31Q05									
ST31Q06									
ST31Q07									
ST31Q08									
ST32Q01									
ST32Q02									
ST32Q03									
ST32Q04									
ST32Q05									
ST32Q06									
ST32Q07									
ST32Q08									
ST32Q09									
ST32Q10									
ST34Q01									
ST34Q02	0.49								
ST34Q03	0.15	0.41							
ST34Q04	0.12	0.18	0.36						
ST34Q05	0.19	0.13	0.10	0.51					
ST34Q06	0.17	0.13	0.12	0.16	0.56				
ST34Q07	0.07	0.14	0.09	0.08	0.15	0.57			
ST34Q08	0.21	0.15	0.13	0.21	0.19	0.10	0.47		
ST34Q09	0.09	0.16	0.13	0.10	0.11	0.17	0.13	0.50	
ST34Q10	0.19	0.18	0.16	0.18	0.18	0.11	0.23	0.17	0.52
ST34Q11	0.22	0.13	0.10	0.24	0.18	0.07	0.22	0.10	0.21
ST34Q12	0.11	0.15	0.15	0.11	0.12	0.11	0.14	0.14	0.16
ST34Q13	0.08	0.12	0.06	0.10	0.07	0.16	0.07	0.17	0.11
ST34Q14	0.18	0.12	0.07	0.23	0.16	0.08	0.22	0.09	0.17
ST37Q01	0.14	0.12	0.14	0.12	0.14	0.08	0.15	0.10	0.15
ST37Q02	0.12	0.12	0.11	0.11	0.11	0.08	0.12	0.10	0.13
ST37Q03	0.17	0.16	0.16	0.14	0.16	0.12	0.18	0.15	0.20
ST37Q04	0.12	0.13	0.12	0.15	0.14	0.10	0.14	0.11	0.17
ST37Q05	0.17	0.16	0.13	0.16	0.18	0.12	0.17	0.14	0.21
ST37Q06	0.13	0.13	0.11	0.12	0.14	0.11	0.15	0.14	0.15
ST37Q07	0.16	0.11	0.08	0.15	0.17	0.10	0.15	0.11	0.16
ST37Q08	0.17	0.13	0.12	0.15	0.17	0.10	0.18	0.11	0.19
ST37Q09	0.12	0.12	0.13	0.11	0.11	0.10	0.12	0.11	0.15
ST37Q10	0.17	0.11	0.10	0.15	0.18	0.09	0.16	0.11	0.16
space1	13.33	9.86	16.20	6.63	17.01	2.22	21.11	3.70	14.46
change1	10.07	8.58	15.53	4.30	13.08	1.58	18.18	2.47	12.48
quanti1	9.96	8.02	14.43	4.26	12.67	0.91	17.15	2.27	11.63
uncert1	10.13	8.45	14.31	4.18	13.40	2.50	16.72	3.93	12.16
gender	-0.05	0.01	0.01	-0.05	-0.03	0.02	-0.03	0.00	-0.02
SES	0.06	0.05	0.04	0.03	0.07	0.04	0.07	0.04	0.07

	ST34Q11	ST34Q12	ST34Q13	ST34Q14	ST37Q01	ST37Q02	ST37Q03	ST37Q04	ST37Q05
ST30Q01									
ST30Q02									
ST30Q03									
ST30Q04									
ST30Q05									
ST30Q06									
ST30Q07									
ST30Q08									
ST31Q01									
ST31Q02									
ST31Q03									
ST31Q04									
ST31Q05									
ST31Q06									
ST31Q07									
ST31Q08									
ST32Q01									
ST32Q02									
ST32Q03									
ST32Q04									
ST32Q05									
ST32Q06									
ST32Q07									
ST32Q08									
ST32Q09									
ST32Q10									
ST34Q01									
ST34Q02									
ST34Q03									
ST34Q04									
ST34Q05									
ST34Q06									
ST34Q07									
ST34Q08									
ST34Q09									
ST34Q10									
ST34Q11	0.48								
ST34Q12	0.12	0.38							
ST34Q13	0.11	0.12	0.55						
ST34Q14	0.25	0.10	0.11	0.52					
ST37Q01	0.14	0.11	0.06	0.12	0.64				
ST37Q02	0.12	0.11	0.09	0.11	0.18	0.50			
ST37Q03	0.16	0.15	0.12	0.14	0.31	0.19	0.52		
ST37Q04	0.14	0.13	0.09	0.14	0.15	0.20	0.18	0.47	
ST37Q05	0.19	0.13	0.12	0.17	0.31	0.16	0.34	0.18	0.57
ST37Q06	0.14	0.13	0.11	0.12	0.16	0.23	0.20	0.19	0.20
ST37Q07	0.17	0.09	0.09	0.15	0.19	0.13	0.22	0.13	0.25
ST37Q08	0.18	0.12	0.06	0.16	0.19	0.21	0.21	0.22	0.22
ST37Q09	0.12	0.13	0.10	0.11	0.14	0.23	0.17	0.19	0.17
ST37Q10	0.18	0.12	0.10	0.16	0.22	0.13	0.22	0.15	0.24
space1	8.98	12.65	-9.15	11.70	17.81	11.78	17.05	10.58	11.99
change1	6.47	11.38	-11.04	9.71	15.19	10.34	14.14	9.51	8.85
quanti1	6.66	10.58	-10.24	9.00	13.92	8.86	12.40	7.75	7.29
uncert1	6.72	11.16	-7.52	8.97	14.56	9.82	13.77	8.54	8.95
gender	-0.06	0.01	-0.01	-0.05	-0.02	0.00	0.00	0.02	-0.01
SES	0.05	0.03	-0.03	0.05	0.03	0.02	0.04	0.04	0.06

	ST37Q06	ST37Q07	ST37Q08	ST37Q09	ST37Q10	space1	change1	quanti1	uncert1	gender	SES
ST30Q01											
ST30Q02											
ST30Q03											
ST30Q04											
ST30Q05											
ST30Q06											
ST30Q07											
ST30Q08											
ST31Q01											
ST31Q02											
ST31Q03											
ST31Q04											
ST31Q05											
ST31Q06											
ST31Q07											
ST31Q08											
ST32Q01											
ST32Q02											
ST32Q03											
ST32Q04											
ST32Q05											
ST32Q06											
ST32Q07											
ST32Q08											
ST32Q09											
ST32Q10											
ST34Q01											
ST34Q02											
ST34Q03											
ST34Q04											
ST34Q05											
ST34Q06											
ST34Q07											
ST34Q08											
ST34Q09											
ST34Q10											
ST34Q11											
ST34Q12											
ST34Q13											
ST34Q14											
ST37Q01											
ST37Q02											
ST37Q03											
ST37Q04											
ST37Q05											
ST37Q06	0.49										
ST37Q07	0.17	0.50									
ST37Q08	0.21	0.22	0.49								
ST37Q09	0.27	0.14	0.22	0.49							
ST37Q10	0.19	0.27	0.21	0.16	0.54						
space1	9.56	7.85	18.00	12.94	11.68	11738.17					
change1	7.43	3.51	14.80	10.64	8.06	9792.95	10914.18				
quanti1	6.61	3.49	13.27	9.25	7.57	9666.69	9571.57	9799.04			
uncert1	7.39	4.47	14.20	10.46	8.37	9676.91	9000.00	8684.07	9440.31		
gender	-0.01	-0.04	-0.01	-0.01	-0.04	-2.23	-1.81	-4.52	-0.67	0.25	
SES	0.03	0.05	0.03	0.03	0.05	15.82	15.97	14.85	14.45	-0.01	1.30

Appendix D: Means and standard errors of mathematics achievements

The following table shows the value of means and standard errors of the four Mathematics domains and the overall Mathematics performance of PISA 2003 Hong Kong sample for both male and female students.

Means and values of standard error in various domains by gender

Domains	Male Mean (SE)	Female Mean (SE)
Shape and space	560.491 (6.789)	556.359 (4.952)
Change and relationships	540.198 (6.833)	539.164 (4.774)
Uncertainty	564.137 (6.565)	552.372 (4.578)
Quantity	543.903 (6.046)	546.456 (4.118)
Overall	552.405 (6.529)	548.347 (4.557)