An Investigation of the Formation Process of Chinese High School Students' Science Career Intentions

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Abstract

High school students' lack of science career intentions has attracted the attention of stakeholders and researchers in many fields. Studies relevant to the formation of science career perceptions and the development of science careers have played crucial roles in the science education research field. The current study draws on two widely applied theories in investigating students' science career intentions: social cognitive career theory (SCCT) and science capital theory. The study employs quantitative-dominant mixed methods, including structural equation modelling and case studies. Through the construction of models, this study demonstrates the processes by which Chinese high school students (age 16-18) form their science career intentions. These formation processes consist of a set of interactions between contextual factors (family science capital) and personal cognitive factors (e. g. self-efficacy, interest). This study provides evidence of the applicability of both science capital theory and SCCT in the Chinese context. In addition, at the theoretical level, the current study complements science capital theory and SCCT. It reveals that aspects of personal agency, for example self-efficacy, can mediate the relation between students' family science capital and their science career intentions. Science capital theory posits an indirect relationship between family science capital and science career intentions; the current study's findings complement this observation and strengthen its explanation. For SCCT, the present study investigates the disputed questions from previous literature about some key variables: self-efficacy, interest, and learning experiences; and it refines the understanding of these variables. This study offers insights to help understand the formation processes of Chinese high school students' science career intentions. The study thereby contributes to the development and refinement of relevant theories and it also provides applied implications for educational policy and future studies.

Key words: family science capital, science career intentions, Chinese high school students, SCCT

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Acknowledgements

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Since I was in my high school, I had a dream of working as an education researcher. I deeply believed that education is an instrument that helps to enhance human being's well-being. Motivated by this philosophy, I came across the ocean from the China to the UK to learn the top-level education. The four years education and research time in the University of York not only taught me the knowledge and skills of being a researcher, but also witnessed the development of my mental maturity.

In the end, I want to show my love for my beloved family, my husband (Fangyu Li), my father, my mother, my father in law, and my mother in law. Under this special situation of Covid-19, my family gave me unbelievable power to face and overcome many challenges. I love them so much.

Declaration

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as References.

Chapter 1 Introduction

1.1 Research Background

During school years, numerous students lose their scientific career intentions (Osborne & Dillon, 2008; Krapp & Prenzel, 2011). The Programme for International Student Assessment (PISA) is a triennial survey targeted at 15-year-olds. PISA2015 and PISA2018 investigated 15-year-old students' career expectations among all the OECD countries and some counties not in OECD (such as China). Overall, the results showed that students who graduated in humanities, social sciences, law, and education were much more numerous than those in science, technology, engineering, and mathematics (STEM).

The shortage of qualified professionals in the science area has been argued to significantly influence the development of countries. For example, the UK Commission for Employment and Skills has claimed that the shortage of science-related graduates has negatively influenced the UK economy (Bosworth et al, 2013). Similarly, in the US, the requirement for more human resources in science in the labour market has been claimed by the government, and coupled with that, the earnings of science professionals were expected to grow (Bureau of Labor Statistics, 2012). Lyons and Quinn (2010) have also stated that the enrollment rate of high school students selecting pure science (e. g. physics, biology, and chemistry) has been constantly declining from 1976 to 2007. The Director of the Australian Council of Deans of Science stated the potential risk of the lack of science endeavour:

> Participating in global economic transformation, whose competitiveness depends on riding huge waves of technological change, and whose survival depends on innovative responses (Lyons & Quinn, 2010, p. 3).

The lack of scientific endeavour was not only a problem for Western countries. China also faces a similar and even more serious problem. In the past, China has once been considered the human resources export country which has exported its best STEM doctoral students to the US for a long time (Smith, 2010). In the past decades, since 1995, the Chinese government has implemented the strategy of "national rejuvenation through science and education" (Qiu, 2004). From then on, the Chinese government enhanced investment in science research and the construction of higher education in science at a national level (Wang & Xu, 2019). However, students' attitudes and intentions in science were not positively corresponding to these implementations. According to the data from PISA2015 and PISA2018, the situation in China seemed more severe than the average level of OECD countries, given that the students participating in the PISA2015 and PISA2018 project from China expressed interest in science careers lower than the average science career interest of all the participants in the OECD countries (OECD, 2016, 2019). Concerning Chinese students' lack of interest in science, studies investigating the formation process of Chinese students' science career intentions are needed.

Students' lack of engagement in science (science careers) has attracted many researchers' attention in the last decades. They have discussed the potential factors which influence students' science career intentions through both sociological and psychological lenses. For example, from a sociological perspective, gender, race, and family science capital were potential influencing factors that have been widely discussed (e. g. Mau & Li, 2018; Archer et al., 2013a). What should be emphasised here is that those factors are either in-person unchangeable characteristics or privileged resources which are more likely to be clustered in some social groups. Therefore, students who lack those factors may have a disadvantaged role in science. For those disadvantaged students, interventions to mitigate the influence of those factors may contribute to social equality. In addition to sociological factors, researchers have also paid attention to the importance of personal agency (self-direction) in the development of science career intentions (e.g. Hackett & Betz, 1981), taking the view that people's choices are not just the products of the environment (e.g. Bandura, 1986). By contrast, many studies have discussed the pivotal influential effects of self-efficacy, self-concept, and interest on science career intentions (e. g. Lent, Hackett & Brown, 1994).

In addition, most of those theories investigating students' science career intentions have been developed and empirically supported in Western countries, such as the US and UK. As Brown (2002) said in his book-C*areer Choice and Development*, carefully developed theories should be useful for people from all cultural groups. Therefore, those theories developed based on the context of Western countries need applicability testing in different cultural contexts.

1.2 Research Aim and Rationale

In this study, the processes leading to the formation of Chinese high school students' science career intentions have been investigated. As discussed before, the issue of students' lack of interest and engagement in science was serious, as shown by the PISA project (OECD, 2016, 2019). The current study contributes to the understanding of Chinese students' science career choice process and provides implications for interventions for the enhancement of students' science career intentions.

Specifically, two theories - social cognitive career theory and science capital theory - have been involved in the current study. Social cognitive career theory (SCCT) focuses on the important role of personal agency, for example self-efficacy, in the decision process of career choices. Science capital theory posits that students with high science capital are more likely to have science aspirations. Although each of these two theories provides a significant contribution to the understanding of students' science career intentions, none of the previous studies have integrated those two theories to construct a more comprehensive analytic model to explain the mechanism of the development of students' science career intentions.

In addition, the educational policies and cultural characteristics are saliently different between China and other western countries (the details about those differences will be discussed in the literature review chapter later). The applicability testing of the theories, which were constructed and developed in western countries, in the Chinese cultural context provides contributions to the generality of the theories.

In summary, the current study aims at explaining the development of Chinese high school students' science career intentions, with the help of SCCT and science capital theory and also aims at examining the applicability of these theories in a particular non-Western cultural context.

1.3 Research Question and Research Methods

To achieve the research aim, the current study has designed two hypothetical models: model I and model II (shown in Figure 1.1 and Figure 1.2). Model I involves the variables family science capital, learning experiences, self-efficacy, interest in science, and science career intentions. The only difference between model II and model I is that model II replaces the self-efficacy variable in model I with self-concept. The comparison between self-efficacy and self-concept has been discussed by many studies, but it's not clear which is the most useful construct in terms of modelling career choice processes. Hence, model II is the comparative model, which is designed to conduct the comparison between these two similar self-perceived capability variables: self-efficacy and self-concept.

The **research questions** of the current study are shown below:

RQ1: In what ways do family science capital, learning experiences, self-efficacy/self-concept, interest act individually as potential factors influencing Chinese high school students' science career intentions?

RQ2: How do these potential factors interact with each other in influencing Chinese high school students' science career intentions?

RQ2a: How do statistical models of high school students' science career intentions developed in Western socio-economic contexts require adjustment for a Chinese context?

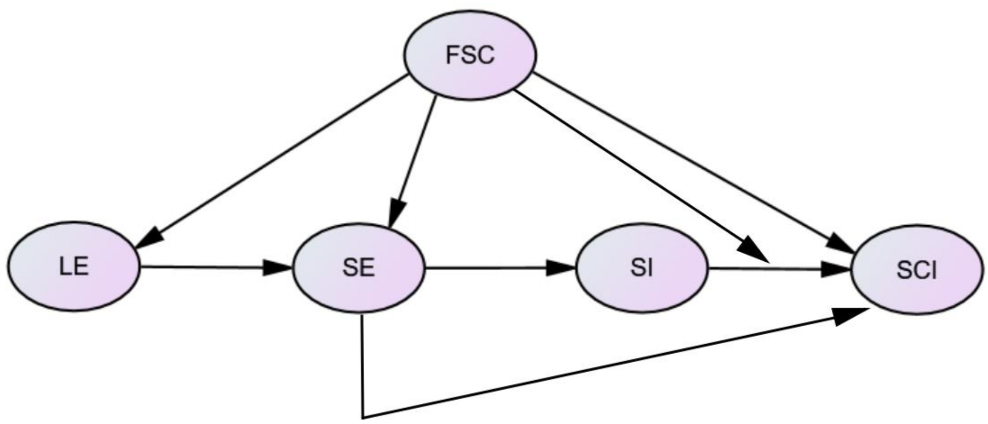

Figure 1.1 The hypothesised model I

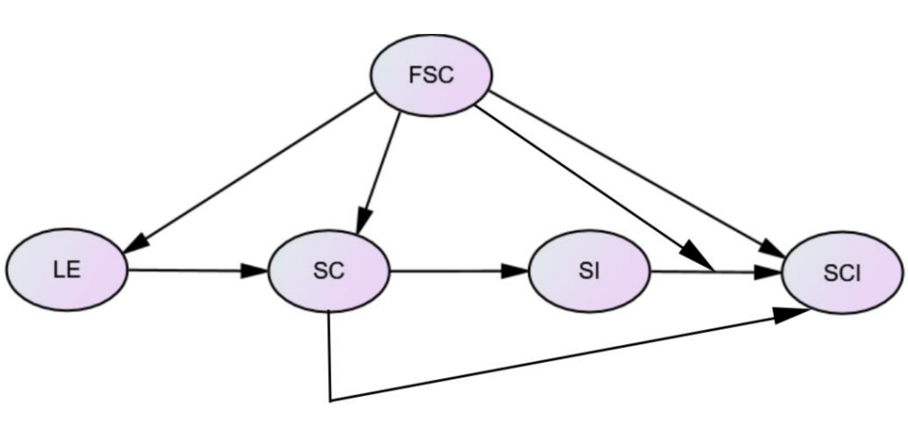

Figure 1.2 The hypothesised model II

Note: FSC: family science capital; LE: learning experiences; SE: self-efficacy; SC: self-concept; SI: science interest; SCI: science career intentions

The current study has employed a (quantitative-dominant) mixed methods research approach to the testing of the hypothetical models. Specifically, the research processes consist of two sequential steps:

(1) preparation of measurement instruments for the variables in the hypothesised models
(2) testing of the hypothesised models.

In step 1, confirmatory factor analysis has been employed to test whether the proposed measurement instruments could be applied to the participants in the current study. During this process, qualitative case studies have been employed to complement the statistical results of confirmatory factor analysis.

In step 2, the model fit of the hypothesised models and the hypothesised mediation and moderation effects in the two hypothetical models have been assessed. Specifically, model fit testing has been conducted through structural equation modelling analysis; the mediation effects have been investigated through bootstrap analysis, and the moderation effects have been investigated through hierarchical moderator regression analysis.

1.4 Research Results and Contributions

Through research steps 1 and 2, two modified models - model I* and model II* - have been tested to fit the data in the current study. The results indicate that Chinese high school students' development of science career intentions can be explained by these two models.

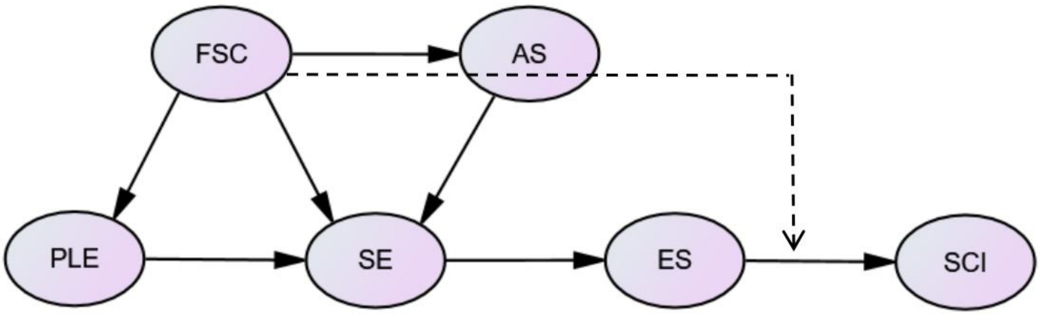

Figure 1.3 Model I*

Note: The dashed line represents moderation effects of FSC on the pathway from ES to SCI

FSC: family science capital; PLE: positive learning experiences; AS: affective state; SE: self-efficacy; ES: enjoyment of science; SCI: science career intentions

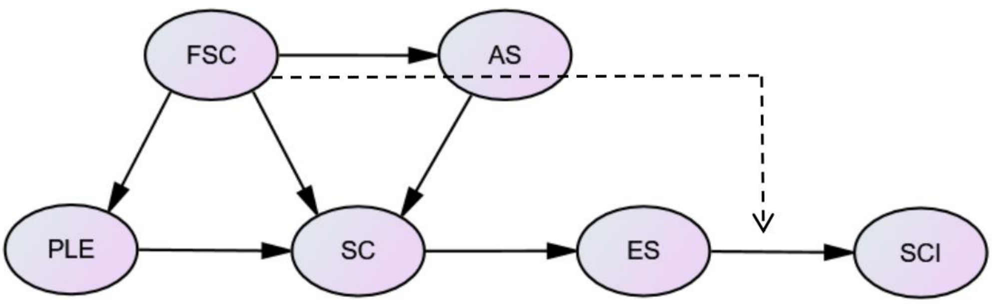

Figure 1.4 Model II*

Note: The dashed line represents moderation effects of FSC on the pathway from ES to SCI

FSC: family science capital; PLE: positive learning experiences; AS: affective state; SC: self-concept; ES: enjoyment of science; SCI: science career intentions

The current study makes both theoretical and applied contributions to future science career intentions studies. At the theoretical level, the current study complements both social cognitive career theory (SCCT) and science capital theory and provides empirical evidence of the applicability of SCCT and science capital theory in the Chinese context. Specifically, for SCCT, the current study provides empirical evidence that family science capital can be a distal contextual factor in SCCT. In addition, the current study proposes a new structure of the variable "learning experiences" in SCCT, and provides qualitative and quantitative evidence for this new structure. "Self-efficacy" is the pivotal variable in SCCT. The separability between self-efficacy and self-concept has been a disputable question in many studies. The current study supports the idea that self-efficacy is different from self-concept and provides evidence for the separability between self-efficacy and self-concept.

For science capital theory, the current study provides a series of paths that explain the mechanism of how students' family science capital contributes to their science career intentions. The current study shows that students' family science capital does not directly influence their science career intentions, but is first translated into students' personal agency in science, which further contributes to students' science career intentions. This effecting mechanism explains the findings from Archer et al. (2012) that some students who had high family science capital still did not aspire to science careers.

In addition, the current study provides suggestions for science education policies to enhance students' science career intentions and also has implications for future studies.

1.5 The Structure of the Current Thesis

This thesis has six chapters: introduction, literature review, methodology, data analysis and result, discussion, and conclusion.

In this introduction chapter, the overview of the current study has been introduced. This chapter firstly raises a widely discussed issue of students' lack of intentions in science careers and further introduces the research aim of the current study - investigation of Chinese high school students' development of science career intentions. Subsequently, this chapter introduces the research questions and briefly presents the research strategies and techniques to answer the research questions. Finally, the contributions of the present study are also summarised.

In the literature review chapter, previous vocational theories and empirical studies about students' science engagement and science career intentions are critically discussed. The critical discussions of previous relevant studies imply that an integrated analytic model including both sociological and psychological factors can comprehensively explain the mechanism of how students develop their science career intentions. To design this analytic model, this study draws on two theory lenses: social cognitive career theory and science capital theory. In the literature review chapter, both the social cognitive career theory and science capital theory are introduced with critical discussion. In addition, the current study was conducted in the Chinese context. Compared with western countries, which are the main contexts where most vocational and science education studies have been conducted, Chinese educational policies and cultural characteristics are saliently different. In the literature review chapter, the features of the Chinese context are presented, and based on those features, the implications for the current study are also presented.

In the methodology chapter, the design of the current study is firstly presented. In addition, the sampling process and the demographic features of participants are presented. Furthermore, the current study focuses on six variables in the hypothetical models. The instruments to measure those variables are presented in this chapter. Finally, given this study has employed many advanced data analysis approaches such as structural equation modelling, all of these analysis approaches are briefly introduced in the methodology chapter.

In the data analysis chapter, there are three subsequent sections. The first section is the data preparation, including multivariate normality testing, and data preparation for the cross-validation testing. The second section presents the testing of the applicability of the measurement instruments. The third section presents the investigations of the hypothetical structural models, including the model fitness testing, interpretations of parameters in the models, and testing of hypothesised mediation and moderation effects.

In the discussion chapter, the two data-converged models (model I* and model II*) are presented with critical discussions of the contributions of the previous studies and the implications for future studies. The strengths and limitations of the current study are also presented in this chapter.

In the end, in the concluding chapter, the current study is summarised, including the main results, alongside a critical discussion of research strategies, contributions, and implications.

Chapter 2 Literature Review

2.1 Introduction

The present study has investigated the formation mechanism of Chinese secondary students' science career intentions. Previous vocational studies have provided many perspectives for the current study to consider the formation mechanism of people's science career intentions. For example, Brown summarised the career-relevant studies for decades, and referring to his book- *career choice and development*, from the beginning of 20th century to the beginning of 21th century, there have been many studies concerning the formation mechanism of career intentions both in sociological and psychological perspectives (Brown, 2002). These studies have focused on sociological determinants such as gender, ethnicity, social resources, and psychological determinants such as personal attributes, interests, and values (Brown, 2002). Based on previous vocational studies, it seems that numerous factors may have effects on people's career intention development processes, and how these factors interact with each other to lead to people's intention and interest in a given career is also very complex.

Considering the complexity of people's forming process of career intentions, a theoretical model to explain this process is expected to contain many different dimensional factors, and this model also should explicitly depict the interactions between these factors. Social cognitive career theory (SCCT) is an integrated and comprehensive analytic framework to explain people's development of career intentions and choices (Lent et al., 1994). This theory has been widely used to explore the formation process of people's science career intentions (Fouad & Santana, 2017). From Lent, Brown, and Hackett set forth this theory in 1994 to date, numerous empirical studies have investigated its validity under many different cultural contexts, and this theory also expects to be refined and complemented from future studies (Brown & Lent, 2017).

Although SCCT is a good instrument for understanding the formation process of people's science-related intentions, additional research still needs to be conducted to refine this theory and test its validity among various samples under different contexts. Compared with SCCT relevant studies from Western countries, insufficient SCCT related studies have been conducted in the Chinese context (Sheu & Bordon, 2017). Hence, this study in China expands the applicability of SCCT in more contexts.

In addition, this study also refines and develops SCCT by involving a new factor-family science capital in SCCT. In recent years, science capital has drawn many researchers' attention in the science education field for its salient influence on students' science aspirations (e. g. Archer et al., 2013a). Combining family science capital with SCCT has implications for the theoretical supplement of both SCCT and science capital theory. Specifically, these contributions are discussed in the following sections.

Overall, this study aims at designing and testing models which may explain the formation process of Chinese secondary students' science career intentions. To justify the rationale and advantages of the hypothesised mechanism models, there are a few sections to discuss in this literature review. In the first part (from sections 2.2 to 2.4), many profound career intention theories, as well as plenty of empirical studies related to science career choice, are demonstrated. Through the comparison of these studies, the advantages of investigating students' science career intentions through structural equation modelling research strategy are shown. In the second part (section 2.5), the content of the theoretical model SCCT is firstly demonstrated. Subsequently, as Sheu & Bordon (2017) stated, SCCT is not flawless, and some parts of it are still disputable; hence, key criticisms of SCCT are also discussed in section 2.5. Additionally, family science capital which is another important theoretical lens for the current study is discussed in section 2.6. Since China has different educational and cultural features from western countries, in the literature review chapter, the features of the Chinese educational system and culture and Chinese students' attitudes to science are presented. Finally, based on previous discussions, two hypothesised models (Model I and Model II, shown in Figures 1.1 and 1.2) based on SCCT and science capital theory are proposed, and their rationale and applicability for the Chinese context are discussed.

2.2 An Overview of Theoretical Approaches to Career Intention Research

Many vocational development theories(e. g. social cognitive career theory) provide various angles to specifically explore the formation and development of science career intentions. Many science career intentions studies were designed based on the foundation of those vocational theories. Hence, before demonstrating the empirical findings of science career intentions studies, an overview of theoretical approaches to career intentions research is initially demonstrated. As Krumboltz (1994) says, a wonderful theory is like a well-drawn map through which reality can be represented. Through a theory lens, the reasons why students choose a career and the mechanism of how these reasons affect students' science-related career choices could be explicitly and clearly shown. Up to date, there have been many vocational studies from various perspectives investigating the theories related to career choice and development (Brown, 2002). The previous studies have indicated that the formation and development of people's career intentions might be complex processes that comprise a series of interactions between various factors (Brown, 2002).

One perspective to look at the formation and development of career intentions is from a sociological angle. Many sociologists have paid attention to people's socioeconomic inequity and social mobility (Johnson & Mortimer, 2002). Since occupation is strongly related to people's status (Ganzeboom, 2010), the factors influencing people's occupation choices have attracted many sociologists' attention. According to Johnson and Mortimer (2002), sociologically based occupation studies focused exclusively on the prestige dimensions of occupations for the past decades. For example, they tended to focus on academic or career motivation and goals, which were restrictively considered as pursuits for educational attainment and prestigious jobs. As Johnson and Mortimer (2002) stated, sociologists are more likely than psychologists to consider how the antecedents to status in social structure, such as race, ethnicity, gender, parental occupation, education, and income make effects on people's occupational choices.

Compared with sociologically oriented occupation studies, psychologically oriented occupation studies have focused more on the personality characteristics that can predispose people to seek a type of job. As Parsons (1909) stated, if people are more engaged in finding their jobs rather than being operated by the opportunities they encounter, they will be more satisfied with their occupational lives. According to Brown (2002), this simple rule guided the research on vocational psychology and inspired later studies to pay attention to the features of different careers and the people's traits that influence their career choices.

Guided by this rule, some vocational psychologists paid attention to the fit between personal characteristics and career features. For example, the trait-and-factor theory by Parson (1909) was a widely used theory describing the importance of convergence between people's traits and jobs. There have been many studies investigating what personal characteristics could influence people's occupational choices from then on. For example, Holland (1958, 1959) has categorised people into six personality types, corresponding to types of occupations (realistic, investigative, artistic, social, enterprising, and conventional). He claims that the match level between an individual's personality type and a job type could influence people's career interests, choices, and performance. These studies focused on the match between individual traits and job types but ignored the developmental nature of an individual's vocational psychology.

Compared with these "individual-job-match" theories, many researchers have focused on the developmental nature of people's vocational psychology. They argued that people's vocational intentions are the product of a series of interactions between various sociological and psychological factors, and these processes gradually shape people's vocational choices. For example, Ginzberg, Ginsburg, Axelrad, & Herma (1951) proposed that occupational preference is generated by a series of complex processes during which people may make a compromise between interests, capacities, values, and opportunities. Super (1953) enriched the ideas about the compromising processes during the psychological development of career intentions, and he argued that an individual's vocational development is a process of developing and implementing an individual's self-concept. He argued that if people can sufficiently implement their self-concept in a career, they are more likely to attain satisfaction from this career. According to him, people gradually produce their self-concept by compromising many factors, such as individuals' traits, opportunities to play different roles, and approval from other people. Gottfredson (1981) expanded the content of vocational development. She stated that people's acceptable alternative careers are firstly circumscribed to a small circle by factors such as sex role and social class. Their mature intentions for careers are polished by compromising their values and interests. These studies all incorporate a common idea that career choice development is a compromising process between different factors, but they have paid less attention to people's agency.

At the end of the 20th century, with the development of social cognitive theory by Bandura (1986), many vocational researchers paid attention to the vital role of personal agency in the formation and development process of career intentions. As Borgen (1991, p. 279) commented, "the cognitive revolution has quietly overtaken vocational psychology, leaving the field ripe for more explicit integration". Specifically, Bandura (1986) contended that people's behaviour choice is the product of complex interactions between personal determinants and environmental determinants. In terms of personal determinants, he especially paid attention to the crucial function of personal agency (self-direction) during the process of choosing behaviour. Based on Bandura's cognitive career theory, Lent, Brown, and Hackett (1994) set forth the social cognitive career theory (SCCT), which is an integrated and comprehensive theory incorporating personal characteristics (such as gender, race, and ethnicity), personal cognitive determinants (such as self-efficacy, and interest) and environmental determinants. Compared with the social cognitive theory, SCCT specifically focuses on people's career-related questions, such as career interest, career choice, career performance, and well-being from careers.

Social cognitive career theory (SCCT) has provided refreshing research perspectives for vocational studies. This theory contends that people are not victims who are just passively influenced by environmental factors or stable personal traits but have the self-direction ability to choose their preferred careers (Brown, 2002). It is certain that under some beyond-controlling environmental influences, people can be predominantly influenced by these environmental factors (Lent, Brown, & Hackett, 2000). Social cognitive career theory (SCCT) emphasises that how individuals subjectively perceive environmental factors has more effects on people's vocational development than how the environmental factors objectively are (Lent et al., 2000). In addition, SCCT argues that individuals' stable personal traits such as gender, race, and ethnicity are not direct predictors of people's career intentions. Personal cognitive factors such as self-efficacy and interest cross-cut the direct link between personal traits and career intentions. This theory explains why many people who experience many barriers and unsupported environmental factors still achieve great life and career success.

This section has briefly discussed the main content of many vocational theories. By critically discussing these vocational theories, two main advantages of SCCT have been preliminarily shown. Firstly, SCCT is an integrated and comprehensive analytic framework for career intentions studies, which considers both factors which were more likely to be focused on by sociology-oriented vocational studies (such as gender, race, and ethnicity) as well as psychological factors (such as self-efficacy and interest). Additionally, SCCT focuses on the important role of personal agency in people's development of career intentions. This theory asserts that individuals' career intentions are not passively generated by the influences of some stable personal traits and environmental factors. Instead of that, people have the self-direction ability to choose the careers they like.

Especially for studies that focus on science-related career intentions, SCCT has been widely employed as a theory lens (Fouad & Santana, 2017). The present study focuses on students' formation mechanism of science career intentions and has employed SCCT as one of the main theory lenses to investigate this question. To provide an overview of science career intention studies, the next section discusses empirical studies in recent years in the domain of science career intentions. Furthermore, based on critical discussions of these science career intentions studies, the reasons for integrating SCCT and science capital theories in the current study are further discussed.

2.3 The Overview of Empirical Studies about Science Career Intentions

Considering previous discussions, the mechanism of the formation and development of people's science career intentions is a complex process. To date, substantial studies have investigated the potential factors which can explain people's science career choosing behaviour (Tuij and van der Molen, 2016). Specifically, the determinants that were more likely to be focused on by sociologists such as gender, race, school structure, and family social-economic status have attracted many studies' attention. In addition, determinants that were more likely to be focused on by psychologists such as personalities, self-efficacy, and interests have also been explored in many empirical studies. However, only investigating whether a given factor can affect people's science career intentions or not is not enough. Since the formation processes of science career intentions are complex, which include the contribution of a variety of determinants, more and more science career intentions studies have integrated various factors into one model (e. g. Mau & Li, 2018). In this section, some widely discussed potential factors which may influence students' science career intentions are firstly demonstrated, and integrated models including various factors are subsequently demonstrated.

2.3.1 Potential Factors Influencing Science Career Intentions

Previous studies related to science career intentions have provided several potential factors influencing people's science career intentions. Gender and race, familial factors, school factors, and personal psychological factors are four widely discussed angles referring to these potential factors.

Gender and Race

It seems that there is a disparity in science career intentions between genders. At a general level, many studies have found that male students are more likely to choose science-related careers (e. g. Archer et al., 2013a; Mau & Li, 2018; Schreiner & Sjoberg, 2004). At a more specific level, males' and females' attitudes toward different scientific subjects are different. For example, Schreiner and Sjoberg (2004) found that girls were more likely to express more interest in biology but less interest in physics than boys. PISA 2015 project found that, on average, across OECD countries, more girls expected to work as health professionals than boys, and boys were more likely to intend to work as information and communications technology (ICT) professionals, scientists, and engineers than girls (OECD, 2016).

Many factors can mediate the links between gender and science aspirations. Self-efficacy is the focal factor in the SCCT model, and there has been much empirical evidence to support that self-efficacy can mediate the relation between gender and science aspirations. Tellhed, Bäckström & Björklund (2016) found that females' lower self-efficacy in science could significantly explain their lower intentions in science. The analysis results from Chi et al. (2017) were consistent with Tellhed, Bäckström & Björklund's (2016) idea that female students tended to perceive science as more complicated than their male counterparts. The results of project BIS also showed that male students were more likely to disagree with the statement that "I don't think I'm clever enough to understand science and technology" compared with their female counterparts (Opinion Panel, 2011). Hackett and Betz have investigated the effects of self-efficacy on women's lack of intentions in science careers and found that self-efficacy played an essential role in women's science career choices (Hackett & Betz, 1981; Betz & Hackett, 1981).

The results of project ASPIRES 2013 provided a new perspective to look at the gender disparity in science; the results showed that a girl who thought of herself as girly was more unlikely to aspire in science, and with students' grades going up, girls who thought themselves as girly were more likely to give up in choosing science courses（Archer et al., 2013a; Archer et al., 2013b). This study implied that female students' self-identified "girly" temperament might be negatively associated with their science aspirations. Based on the review of science career intentions studies for decades, Van Tuij and van der Molen (2016) proposed that one of the possible reasons for gender disparity in science careers is that studies and occupations in science are predominantly regarded as male-oriented. Although the gender stereotypes in vocational fields that some specific occupations are "male-dominant" or "female-dominant" have been declining over the last decades (Schoon, Martin, & Ross, 2007), gender stereotyping in work, especially in the science domain, has still existed (Miller, & Hayward, 2006). This stereotype may obstruct people eager for feminine lifestyles from science-related trajectories.

In addition, Archer and her colleagues (2014) further investigated the link between science attitudes and boys' self-identified masculinity temperament. They found that while the link between science attitudes and boys' masculinity was strong, social class could strongly moderate this link. Archer et al. (2014) implied that girls in the middle class with sufficient economic and social resources might have stronger intentions in science than the boys in the working class with insufficient economic and social resources.

The discussions of science intentions disparity between genders above indicate that the factor of gender may not directly influence students' science career intentions but indirectly influence students' science career intentions through the mediation of some other factors such as self-efficacy and self-identified gender temperament ("girly" or "masculine"). Hence, exploring these potential mediation factors may shed light on the gender disparity in science. The current study does not particularly focus on gender's influences on students' science career intentions. Instead, this study focuses on self-efficacy's influences on science career intentions.

Regarding race and ethnicity, it is interesting to notice that the phenomenon of high interest and achievement in science for Asian students, namely "Asian effects", has attracted many researchers' attention (Dewitt et al., 2010). For example, according to Kelly (1988), in the UK, Asian boys were better learners of school science than other secondary school students. The project ASPIRES (2013) also found that Asian students had high science aspirations in the UK compared to their white counterparts. Dewitt et al. (2010) found that although many Asian background students in the UK showed high science aspirations, only Indian and Chinese background students tended to translate this aspiration into achievement and participation in science. The three studies mentioned above all have compared Asian British students' science interests and performances with white students and found that more Asian British students had positive attitudes toward science and higher aspirations in science. By contrast, the PISA report 2015 showed that local Chinese students (who live and study in China)' interest in science careers was lower than the average level of all the OECD member countries in PISA 2015 (OECD, 2016). The controversial results between Chinese British and local Chinese students provide an interesting perspective to rethink "Asian effects".

Family

The influences of family on students' science engagement and career intentions have been well-documented (Maltese & Tai, 2010; Raved & Assaraf, 2011; Olszewski-Kubilius & Yasumot, 1995). Archer et al. (2012a) stated that students' engagement, aspirations, and attainment in science are associated with their familial effects. There can be various dimensional effects from family, such as economic, social, and cultural influences. For example, Maltese and Tai (2010) found that students were more likely to continue to choose a subject when they perceived that they can gain their parents' support. Sjaastad (2013) stated that parents could play role models who display the identity of science-related professionals and definers who help students identify their strengths and values during career choices. Aschbacher, Li, & Roth (2010) found that parents' biased perceptions of science could hinder those students who have initial interests in the science from potential science-related trajectories. The empirical study from DeWitt et al. (2013) provided statistical evidence to support that parental attitudes could predict students' science aspirations. These previous discussions indicate that family influences on people's science career intentions may incorporate various dimensional effects in economic, social, and cultural perspectives.

Social-economic status, a comprehensive family index reflecting the economic, social, and cultural assets of a family, has been widely linked with science education studies (OECD, 2016). Interesting to notice that the relations between a family's social-economic status and children's science intentions have been controversially discussed. Some studies have found that families' social-economic status could make significant effects on students' science aspirations (e.g. Thomson & De Bortoli, 2008, Uerz et al., 1999). For instance, Thomson and De Bortoli (2008) found that students who continued to choose science-related trajectories were more likely to have higher social-economic status. Van Tuij and van der Molen (2016) assumed that the stereotyped perception of science- "tough and difficult" may make students who are from disadvantaged backgrounds and cannot acquire sufficient support of science, feel less confident in choosing science-related trajectories. The project BIS, which is a survey study launched by the UK government aiming at investigating 14-16 years old students' attitudes to science, can support Van Tuij and Van der Molen's idea. BIS project found that students from poorer backgrounds were more likely to consider themselves not clever enough to handle science (Opinion Panel, 2011). However, the

Science Education Tracker project indicated different results. It is interesting in the Science Education Tracker project that British young people (14-18 years old) from "lower income backgrounds, as defined by free school meal eligibility and area deprivation, were just as likely to aspire to a science-related career as those from higher income backgrounds" (Hamlyn et al., 2017, in the cover page of Chapter 6).

As previous literature has shown, the direct relationship between people's social-economic status and their science career intentions is still disputable. Some studies have discussed the indirect relationship between people's social-economic status and their science career intentions (e. g. Van Tuij & van der Molen, 2016). Proximal family environment may be one of the mediators which may bridge the relation between social-economic status and science career intentions. Proximal family environmental factors are proximal with individuals and can be directly embed into their daily family life. Examples of proximal family environmental factors are parental expectations, values, beliefs, or family cultural atmosphere. Van Tuij and van der Molen (2016) argued that people's social-economic status could have direct effects on people's proximal family environments. Proximal family environmental factors can further affect people's science self-efficacy and career aspirations (e.g. Archer et al. 2015; Bandura et al. 2001; Gutman et al. 2012). The link between social-economic status and science career intentions may be mediated by proximal family environments.

As discussed before, family social-economic status is a comprehensive index that may reflect people's familial economic, social, and cultural resources. Family science capital is another family-related factor, which has been significantly linked with students' science career intentions. As Godec, King, and Archer (2017, p. 5) stated, "the concept of science capital is a way of encapsulating all the science-related knowledge, attitudes, experiences and social contacts that an individual may have." Specifically, it contains, about science, "what you know", "what you think", "what you do", and "whom you know". Archer and her colleague were interested in the reasons influencing students' science aspirations, and to answer this question, they launched the ASPIRES project. One of the most exciting findings is that students with high family science capital were more likely to have high science aspirations (Archer et al., 2013). The Science Education Tracker (SET) project generated an index named family science connection to represent people's family science capital, and the results showed that students with strong family science connections were more likely to be keen on science-related careers and to have science-related experiences than students with weak family science connections (Hamlyn et al., 2017). These two projects have provided empirical evidence to support the link between family science capital and science aspirations. However, Archer et al. (2012) have argued that family science capital is not a deterministic factor for people's science career intentions. Archer et al. (2012) also provided empirical support for this argument. They found that many students with sufficient family science capital did not have aspirations in science. The mechanism of how family science capital contributes to people's science career intentions is expected to be further explored.

Compared with social-economic status, which may generally reflect people's economic, social and cultural resources, people's family science capital incorporates economic, social, and cultural resources specifically related to science, especially the resources which may contribute to peoples' attainment, engagement, and participation in science (Archer et al., 2015). In the present study, family science capital is a focal variable in the hypothesised models to investigate the formation process of students' science career intentions. The discussion of science capital theory and the rationale to involve this variable in the hypothesised model in this study are specifically shown later in the literature review chapter.

School

School life plays an essential role in students' development. School is not only a place for students to learn new knowledge but also an essential social field where students socialise with others (friends and teachers). Much of the knowledge of school science may be forgotten by students. However, attitudinal outcomes from school science may have long-lasting effects. Schreiner & Sjoberg (2004) stated that whether students like school science or not may influence their future science aspirations. In addition, Reinhold, Holzberger, and Seidel (2018) presented that the learning experiences and interactions with people in school all have potential effects on students' science intentions. Based on students' answers to the interview, Mohd Shahali et al. (2019) found that students' decreasing interest in science was related to the quality of teaching of school science and their science learning experiences in school.

Many studies imply that school science curriculum setting is possibly to blame for students' lack of intentions in science. According to Osborne, Simon, and Collins (2003), traditional science classes provide insufficient opportunities for students to join activities relevant to real life and provide insufficient spaces for students to nurture their "scientific thinking". Osborne et al. (2003) stated that it is challenging to cultivate students educated by these science classes to know what actual scientists are like and to have positive attitudes toward school science. Students' negative attitudes toward school science can further reduce their engagement in science (Dewitt et al., 2013). However, Cleaves (2005) criticised this idea. He stated that students who show dissatisfaction with the school science curriculum are more likely to be those who have low self-efficacy in science. Therefore, it is hard to say whether it is dissatisfaction with the science curriculum or low confidence in science that influences their intentions in science.

As essential persons in students' school life, teachers are also considered to play an important role in shaping students' career intentions (Van Tuijl & van der Molen, 2016). Teachers can play role models and provide career guidance for students and inspire students' aspirations and stimulate students' interest in some specific fields (Krapp & Prenzel, 2011). Teaching strategies and teachers' attitudes to a subject also can influence students' attitudes toward this subject. For example, teachers' stereotypical notions may affect the opportunities, guidance, and suggestions they give to students based on students' gender or social status (Archer et al., 2012b). In addition, teachers' lack of confidence in STEM may restrict students' science learning pleasure and interest (Appleton & Kindt, 1999). The interview study by Maltese and Tai (2010) analysed the experiences of scientists and graduated students to find the influencing factors for their initial interest in science. They found that teachers' encouragement played a crucial role in sparkling participants' initial interests in science topics. For some participants, their science teachers' attributes also could trigger their interest in learning science (Maltese & Tai, 2010). Specifically, referring to participants' descriptions of their experiences, a science teacher who was full of passion and confidence in science was attractive to students, quoted by a participant "He's just a nutcase. You know kind of the mad scientist, and he was great" (Maltese & Tai, 2010, p. 682). Students' initial interest in science may begin from the interest in a superior science teacher.

Psychological factors

As discussed in section 2.2, many psychological factors have been linked with students' development of career intentions. Specifically, in science career intentions relevant studies, individuals' ability beliefs such as self-efficacy and self-concept are two factors that have been widely discussed. Self-efficacy and self-concept have been specifically discussed in the present study. Lent and Fouad (2011) focused on the reciprocal interplay of “self” and context in the process of vocational perception formation and development. They considered that “self” is a dynamic system that has power for career direction. In addition, “self” also mediates the effects of context in career development.

Hackett and Betz (1981) initially discussed the effects of science self-efficacy on women’s science career intentions, and since then, self-efficacy has been widely applied in investigating people’s science career intentions. Self-efficacy refers to “people’s judgments of their capabilities to organise and execute courses of action required to attain designated types of performances” (Bandura, 1986, p391). It attracts researchers’ attention because it can affect people’s science career intentions and also because it can make important mediation effects between many other factors and science career intentions. For example, in terms of gender, Chi et al. (2017) and Tellhed, Bäckström & Björklund (2016) both found that female students were more likely to evaluate themselves with low confidence and low capability in science than their male counterparts. Self-efficacy may have mediation effects on the relation between gender and science career intentions (Lent et al., 2000). In addition, self-efficacy may make mediation effects on the relation between family science capital and science career intentions. Archer et al. (2015) found that students who had high family science capital were more likely to have high science self-efficacy.

There is a similar concept to science self-efficacy: science self-concept. Science self-concept is defined as the self-evaluation of one's general ability in the science-related domain (Jansen, Ronny, & Ulrich, 2015). Compared with the definition of self-efficacy, which focuses on people's perceived capability for some specific tasks or activities, people's self-concept is a kind of more general self-evaluation in a domain. The discussions of the similarity and differences between self-efficacy and self-concept will be presented later in this chapter. Students' science self-concept may be related to their science achievement, academic choices, and science career intentions (e.g. Marsh & Martin, 2011; Nagengast & Marsh, 2012). Nagengast and Marsh (2012) found that academic self-concept could mediate the path from negative contextual effects to career aspirations.

People's ability and beliefs are likely to be hampered by their biased cognition. According to Dweck (2006), people may have two kinds of mindset: fixed or growth mindset. People with a fixed mindset are more likely to think that they are born with a specific amount of competencies in a specific domain, and these competencies are fixed and unchangeable. By contrast, people with a growth mindset tend to regard their ability level in a given domain as flexible and could be developed through effort. Hence, for students who have generated a fixed mindset, when they encounter science-related problems, they are more likely to identify themselves as "not talented in science" or "not the type of people for science". Van Tuijl & van der Molen (2016) suggested that people's perception of whether their ability is fixed or constructed can be influenced by interventions from parents, teachers, or media. Moreover, proactive interventions for young students, which help them generate the cognition that their ability can be incremental through efforts, may increase students' ability beliefs in science and further enhance their aspirations in science.

2.3.2 Integrated Models with Various Potential Factors

Although there have been productive results from studies on scientific career intentions, this diffuse literature only suggests to future researchers a series of potential relationships (Reinhold, Holzberger & Seidel, 2018). Van Tuijl and van der Molen (2016) showed their concern about the problem of the diffuseness and lack of systematic investigation of the factors in the present science career intentions relevant studies. Van Tuijl and van der Molen (2016) argued that most science career intention studies focused on one limited sphere of influence, such as factors in school or family influences, but in real life, our career choosing behaviour could be influenced by various factors, subjective or objective, and conscious or unconscious. Hence, several scholars in the field have suggested that an integrated model to summarise these potential career-influencing factors from numerous studies is expected (Brown, 2002). This integrated model could more comprehensively depict the story of how people develop their science career intentions. The work of these studies is discussed in the following few paragraphs.

For example, Mau and Li (2018) were inspired by previous literature. They clustered the potential factors into four categories:

> gender and race； familial/parental (e.g., socioeconomic status [SES], parental educational expectations, parental involvement ； school/academic (e.g., academic achievement, school engagement, school belonging, teacher influence)； personal/ psychological (e.g., math and science self-efficacy, identity, utility, interests) (Mau & Li, 2018, p. 248)

Their multivariate regression analysis concluded that not all the potential factors could significantly lead to students' science aspirations. Only race, gender, socioeconomic status, math interest, and science self-efficacy showed strong predictive effects on science career intentions of 9th-grade American students. Specifically, this study showed that male or white students with high socioeconomic status were especially interested in math. In addition, this study showed students with high self-efficacy in science were more likely to have science career intentions. This study provided implications for studies related to science career intentions that researchers could consider the potential factors influencing students' science career intentions through the four clusters proposed by Mau and Li's study. Although Mau and Li tried to explain students' science career intentions by an integrated model as comprehensively as possible, the statistical result showed that these significant, influential factors only accounted for approximately half of the variance in students' science career aspirations (Mau & Li, 2018). In addition, this study also suggested that the factors involved in this study did not fully explain students' science career intentions, and factor exploration studies are still required.

Similar to Mau and Li (2018), Huang (2017) investigated factors influencing Chinese students' science career intentions by an integrated model incorporating various potential factors. According to Huang, there are four clusters of factors:

- Students' background characteristics, including students' characteristic variables (e. g. gender, learning stage, and immigration situation), family characteristic variables (e. g. socioeconomic and cultural status, and career type of students' parents), and school characteristic variables (e. g. school scale, science-related resources, student-teacher ratio, and proportion of undergraduate science teachers in whole teachers).
- Science teachers' teaching strategies, including teachers' leading teaching strategies, debugging teaching strategies, inquiry teaching strategies, and student feedback-providing strategies.
- Personal/ psychological variables include students' participation in scientific activities, scientific motivation (love for science, interest in broad scientific topics, and instrumental motivation to science), and science-related beliefs (science epistemology and science self-efficacy)
- Students' scientific performance variables, including students' achievements in scientific literacy, students' ability to scientifically explain phenomena,

design and evaluate scientific exploration, and scientifically interpret data and evidence. (Huang, 2017)

The results showed that among all the potential factors, the relevance of fathers’ occupations to science, school type, student’s instrumental motivation with science, and students’ science performance could individually predict their science career intentions when other variables were controlled. Teaching strategies such as teacher-leading strategies and debugging strategies could have effects on students’ motivation and indirectly on students’ science career intentions.

The potential factors influencing students’ science career intentions from these two studies have overlapped contents. Both these two studies considered students’ characteristics such as gender, family characteristic variables such as social-economic status, students’ scientific performance variables such as academic achievement, teacher and school variables such as teacher influence, and psychological variables such as science self-efficacy as potential factors influencing students’ science career intentions. Compared with Mau and Li (2018), Huang (2017) involved more complex variables. For example, he involved more variables in the school characteristic dimension. In addition, Huang (2017) discussed the influences of various teaching strategies on students' science career intentions.

These two studies also have different results. Mau and Li (2018) found that only race, gender, socioeconomic status, math interest, and science self-efficacy significantly influenced American students' science career intentions, while Huang (2017) found that the relevance of fathers' occupations to science, school type, student's instrumental motivation with science and students' science performance were significant predictors for Chinese students' science career intentions. The different results between these two studies imply that under different contexts, factors that influence students' science career intentions may be different.

These factor-integrated models can explain people's science career intentions more comprehensively than simple-factor-focused studies, and the method of controlling factors in different levels of models may reveal the possible interacting relations between factors. However, the formation process of people's science career intentions is a very complex developing process during which many interactions between different variables may happen sequentially or concurrently (Brown, 2002). These factor-integrated models cannot describe this process successfully.

2.4 Reasons to Investigate Science Career Intentions through Integrated Structural Models

As mentioned above, the formation and development of human vocational perceptions is a very complex process (Brown, 2002). To explain this process, the factors that influence science career intentions need to be explored, and an analytical framework incorporating the interactions between these factors is also required. The models described above integrate factors and cluster them into sets, but they do not explain the processes and interactions that lead to differential science career choice outcomes. Martin et al. (2012, p. 2) claimed, "it is only through integration in one analytic framework that researchers gain insight into unique variance attributable to each factor and set." The suggestion of Martin emphasises the importance of investigating people's scientific career intentions by integrated structural models. The strengths of the integrated structural model compared with the factor-clustered model such as Huang (2017) are that it clearly shows the interplay relations between variables. The integrated structural model can show what factors influence students' science career intentions and also can explain the forming and developing process of students' science career intentions. The previous discussions about science career intentions studies provide two suggestions:

- An analytic structural framework is required to explicitly explain the forming and developing process of students' science career intentions.
- There are different perspectives on variables that can affect students' science career intentions; to comprehensively explain students' science career intentions, it is necessary to incorporate variables from various perspectives.

The social cognitive career theory (SCCT) is an integrated analytic framework to consider people's development of career intentions, which not only incorporates various variables from personal traits (e.g. gender and race), personal-psychological variables (e.g. self-efficacy, outcome expectancy, interest), environmental variables (e.g. contextual support and barriers) and so on but also shows the processes of how people construct their career intentions by the interplay of these variables (Lent et al., 1994). Because of these features, SCCT is the most widely applied theory in practice and research (Sampson et al., 2014). In addition, although SCCT incorporates various components, it specifically focuses on the pivotal role of personal agency (e.g. self-efficacy) in the formation process of vocational perception. It is worth mentioning that SCCT does not clearly demonstrate what contextual factors are and how these contextual factors influence people's career intentions and choices. Science capital theory (Archer et al., 2013; Archer et al., 2015) demonstrates the relationships between students' science capital with their science engagement and science career intentions. Science capital theory and SCCT theory could complement each other. Science capital theory focuses on contextual influences, meanwhile, SCCT focuses on personal cognitive factors.

In the present study, SCCT and science capital theory are drawn on as the theoretical lens to explore the formation process of Chinese high school students' science career intentions. The content and critical discussion of SCCT will be firstly presented in the next section. The introduction and critical discussion of science capital theory will be subsequently presented.

2.5 Social Cognitive Career Theory (SCCT)

2.5.1 Introduction to SCCT

Since Lent et al. (1994) established the social cognitive career theory on the foundation of the social cognitive theory from Bandura (1986), the social cognitive theory is briefly demonstrated in the present study. The social cognitive theory assumes triadic reciprocal causation between personal behaviour, personal attributes, and external environments, depicted in Figure 2.1. It denotes that personal and environmental determinants can influence a human's behaviour, and these two kinds of determinant factors also can interactively influence each other.

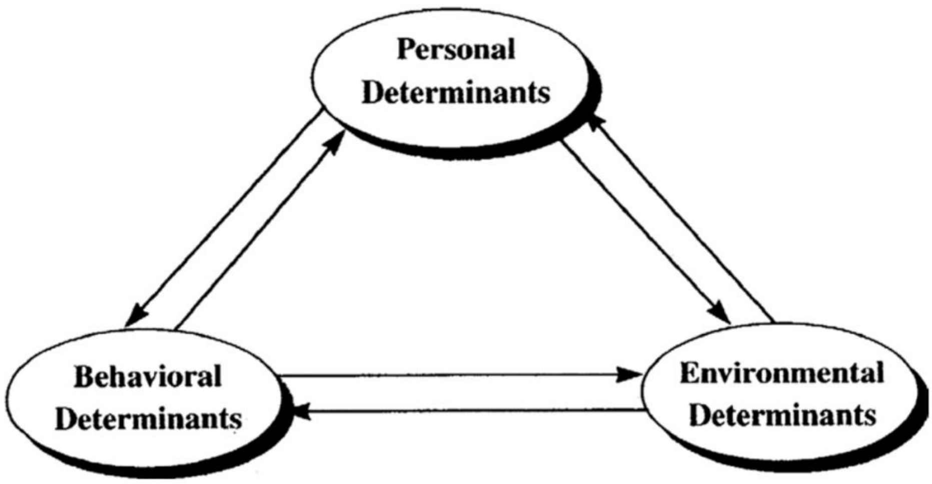

Figure 2.1. The schematization of Triadic Reciprocal Determination in the Causal Model of Social Cognitive Theory. From "On the Functional Properties of Perceived Self-Efficacy Revisited", by A, Bandura, 2012, Journal of Management, 33, p. 12.

Lent, Brown, and Hackett (1994) were inspired by social cognitive theory. Corresponding to the triadic causality system from Bandura (1986), they set forth a theory comprising personal cognitive determinants (such as self-efficacy and outcome expectation), environmental determinants, and overt career-relevant outcomes (such as career/academic interest, career-related choices, and task performance). Overview, the social cognitive career theory claims that career-relevant interests and choices are forged by the interplay of personal cognitive determinants and environmental determinants (Lent et al., 1994).

There are two points in SCCT worthy of mentioning (Lent et al., 1994):

- Since SCCT is derived from the social cognitive theory, corresponding to Bandura's theory, personal factors, environmental factors, and overt personal behaviour are bidirectional to each other.
- For particular individuals at different times, the causal weights of variables may be different (Lent et al., 1994). For example, for impoverished people, the effects of socioeconomic status may be more potent than others.

Generally, the social cognitive career theory comprises four kinds of the model depending on different career-relevant outcomes: interest model, choice model, performance model, and well-being model (Lent et al., 1994; Lent, Brown & Hackett, 2000; Lent & Brown, 2008). The interest model aims to explain people's development of academic and career interests. The choice model aims to explain people's career/academic choices development. Furthermore, similarly, the performance model and well-being model respectively aims to explain people's development to acquire good performance and well-being in some given activities. The research aim for this study is to explicate the development of Chinese secondary students' science-related intentions; therefore, this study focuses on the SCCT choice model (it will be called a choice model in this study). The SCCT choice model is demonstrated in Figure 2.2.

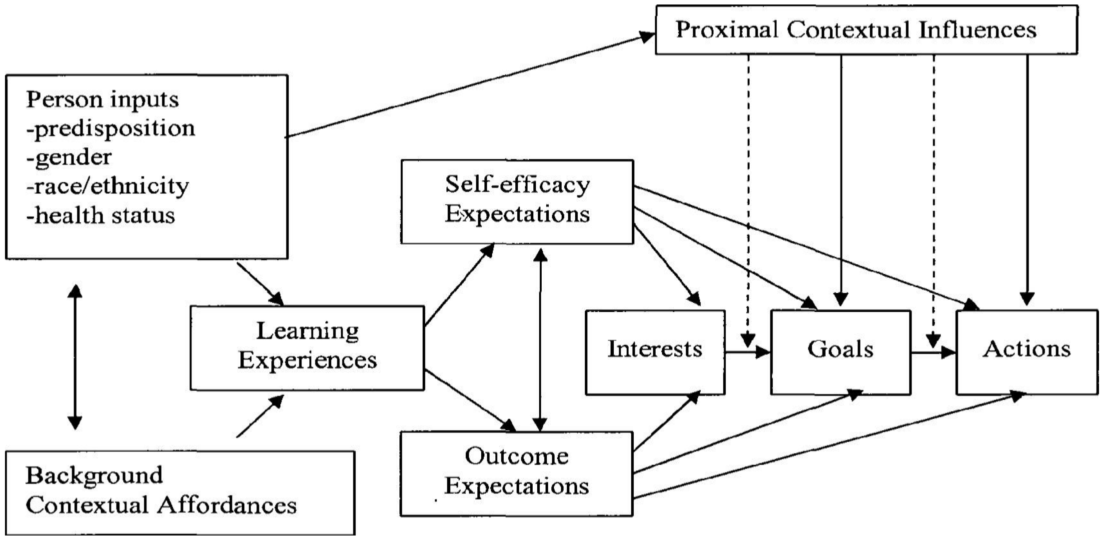

Figure 2.2 Model of social cognitive influences on career choice behaviour. From "Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance", by R. W. Lent, S. D. Brown, and G. Hackett, 1994, Journal of Vocational Behavior, 45, p. 93.

Note：The dotted paths indicate moderator effects on interest-goal and goal-action relations.

As Figure 2.2 shows, the SCCT choice model is a complex model which includes various variables. To date, numerous studies have investigated this model. However, according to Sheu and Bordon's review about SCCT related-studies in past decades, since the SCCT choice model is very complex, most SCCT relevant studies just focus on specific parts of the SCCT choice model (Sheu & Bordon, 2017). The specific contents of the SCCT model are discussed in the next section.

2.5.2 Key Variables in SCCT Choice Model

2.5.2.1 Self-efficacy

According to Lent et al. (1994), the social cognitive career theory was built based on the initial studies of self-efficacy's effects on career choices by Hackett and Betz (Hackett & Betz, 1981; Betz & Hackett, 1981). Self-efficacy has been one of the core variables investigated in SCCT-related studies. According to the review study on SCCT-related studies under international contexts for decades by Sheu and Bordon (2017), most SCCT-related empirical studies have found that self-efficacy could directly or indirectly predict people's career intentions. Self-efficacy is the variable that is focally investigated in this study. Self-efficacy refers to "people's judgments of their capabilities to organise and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). It is a kind of self-belief about one's capability to be competent in a given task. What should be noticed is that although self-efficacy is about people's perceived capability in a given field, the objective capability does not determine people's self-efficacy altogether (Betz & Hackett, 1981). Bandura (1994) argued that rather than the level of a person's objective ability, it is how they perceive their capability that has substantial effects on their self-efficacy.

Lent et al. (1994) presented that self-efficacy can predict people's choices of activities and influence their effort expenditure, persistence, and emotional reflection when they encounter obstacles. Bandura (1991) also stated that self-efficacy is one of the crucial determinants of people's choices, and high self-efficacy helps people generate persistence when they encounter an obstacle on the avenue to achieving their goal. This process happens especially when people set a long-term goal, such as a vocational goal. As Bandura (1991) stated, when people pursue a long-term goal, they will break it down into many proximal goals, and fulfilment of these small proximal goals contributes to their self-efficacy. With this reciprocal process going on, especially when it happens at the start of implementing their actions, a person may generate relatively stable high self-efficacy in a given field (Bandura, 1991). People with high self-efficacy are more likely to be persistent and actively mobilise their efforts to find problem-solving strategies when they encounter barriers later.

In SCCT, Lent and his colleagues (1994) proposed that the relations between self-efficacy with career goals are complicated. According to Lent et al. (1994), self-efficacy can play a direct predictor of people's goals. In addition, self-efficacy can have indirect effects on a career goal. The mechanisms of the indirect effects are shown as follows. Self-efficacy is considered in SCCT as a powerful predictor of people's interests, and interest can directly predict career goals (Lent et al., 1994).

Through the mediation effects of interest, self-efficacy also can have indirect effects on career goals (shown as self-efficacy-interest-career goals). Bandura (1986) contended that mature people tend to show interest in the task in which they can feel efficacious and expect positive outcomes. His idea also supports that people's self-efficacy can predict interest. It is noteworthy that it is not the people's ability but the perceived ability that may determine their interest in a given task (Bandura, 1991).

According to Lent et al. (1994), self-efficacy can predict people's career goals. However, the direct relation between self-efficacy and career goals has been disputed in many empirical studies in the Chinese context. For example, Jiang and Zhang (2012) have investigated Chinese vocational school students' development of science career intentions based on the SCCT choice model. This study indicated that self-efficacy could not directly predict students' science career intentions significantly, but self-efficacy had indirect effects on science career intentions by the mediation of interest in science. Similarly, Song and Chon (2012) investigated the relationship between Chinese students' general self-efficacy and career intentions. They found that general self-efficacy could not directly predict students' career intentions, but general self-efficacy could indirectly predict career intentions with the mediation of vocational interest. These empirical studies under the Chinese context provide implication that it is worthy of conducting further studies under the Chinese context to investigate the direct predicting effects of self-efficacy on career intentions.

In addition to affecting career goals, self-efficacy as a kind of personal cognitive factor links some contextual factors with people's interests and career goals (Lent et al., 1994). Depending on different kinds of contextual factors, the relations between self-efficacy and contextual factors are also different. The interplay relations between self-efficacy, contextual factors, interests, and career goals are discussed later in the contextual factor section, in which contextual factors are specifically classified.

2.5.2.2 Outcome expectations

"Outcome expectations" is another important person-cognitive variable in SCCT. Bandura (1977) stated that compared with self-efficacy which is described as personal perceived beliefs about whether people can complete a task, outcome expectations reflect people's estimated outcomes if they do the task. In this sense, outcome expectations are temporally later than self-efficacy during the process of undertaking a behaviour (shown in Figure 2.3). Specifically, outcome expectations show individuals' anticipated outcomes for undertaking given tasks, and if an individual holds severe doubts about whether he/she is capable of undertaking the task, outcome expectations are in vain in influencing the person's behaviour (Bandura, 1977).

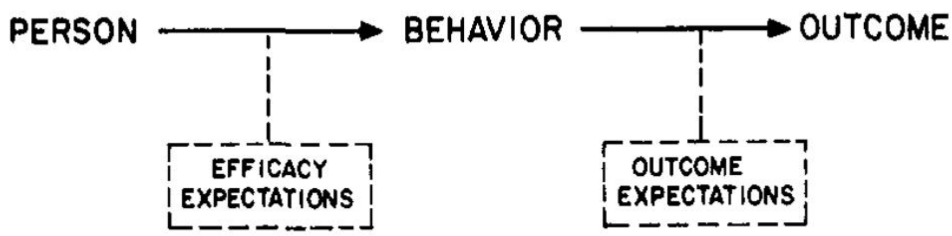

Figure 2.3. Diagrammatic representation of the difference between efficacy expectations and outcome expectations. From “Self-efficacy: Toward a Unifying Theory of Behavioral Change” by A, Bandura, 1997, Journal of Psychological Review, 84, p. 193.

Bandura (1986) summarised three different dimensions of outcome expectations:

- physical outcomes (e.g., financial attainment, lifestyles, and settings)
- social outcomes (e.g., parents’ or teachers’ approval, friends’ or peers’ approval, societal status)
- self-outcomes (e.g., sense of achievement, intrinsic motivation)

In SCCT, Lent and his colleagues also conceptualised outcome expectations, referring to Bandura’s classifications (Lent et al., 1994). However, Fouad and Guillen (2006) have critically reviewed the measurement approaches to outcome expectations and found that outcome expectations in most SCCT studies were not operationalised by measurement approaches which consist of three dimensions of outcome expectations based on theoretical classification by Bandura (1986). Shoffner, Newsome, Barrio, and Wachter Morris (2015) also criticised that the mainstream measurements of outcome expectations were not congruent with the theoretical definition from Bandura (1986). For example, many outcome expectation measurements just operationalised the outcomes (specifically physical outcomes) for success in some domains, and these measurement approaches just focused on a limited dimension of outcome expectations (Lent & Brown, 2006). In addition, Lent and Brown (2006) proposed that outcome expectations can be positive and negative. Although most SCCT-related studies have focused on positive outcome expectations, it is still meaningful to consider the role of negative outcome expectations such as difficulty, loneliness, and so on in SCCT (Lent & Brown, 2006).

A critical hypothesis of SCCT is that self-efficacy can, to some extent, predict outcome expectations, so people with high self-efficacy are more likely to have positive outcome expectations in a given domain (Lent et al., 1994). The longitudinal study from Lent et al. (2008) found that self-efficacy was the temporal precursor for outcome expectations. This study has been conducted for five months. Lent and his colleague set two important time points: Time 1(the beginning time) and Time 2 (5 months later than Time 1), and they tested American university students' self-efficacy, outcome expectation, and some other variables in SCCT, respectively in Time 1 and Time 2. Then they designed a few models, including the model of self-efficacy as antecedence, the model of self-efficacy as a consequence, and the bidirectional model (including the paths of the previous two models). Results indicated that only Time1 self-efficacy could significantly predict Time 2 outcome expectation, and the reversed path was not accepted. Statistically, the temporal precedence of self-efficacy before outcome expectation was supported by this study.

The SCCT choice model also hypothesised that self-efficacy and outcome expectations could predict people's interests and career intentions (Lent et al., 1994). According to Bandura (1986, p. 231), people act on "their judgments of what they can do" and "their beliefs about the likely effects of various actions". Bandura (1986) also stated that compared with self-efficacy, outcome expectations serve as less influencing determinants for behaviours. Lent et al. (1994) supported this idea when they demonstrated the SCCT Choice model. Lent et al. (1994) further explained this idea that it is not surprising for a person to give up doing a behaviour if he/ she does not feel capable of doing it, even though he/she has a very positive outcome expectation for the behaviour, whereas people with solid self-efficacy can sustain efforts even if they do not hold positive expectations for the outcome.

In addition, Lent et al. (1994) assumed that self-efficacy and outcome expectations could have different effects on motivation and behaviour for different activities. For some particular activities where the quality of the performance could strongly predict some particular outcomes, self-efficacy can play a predominant role in predicting behaviours. While for other activities where performance quality is only loosely tied with outcomes, outcome expectations can independently influence motivation and behaviour. Lent et al. (1994) regarded the latter scenario as more related to the career development field since the vagaries in academic and career fields do not promise perfect linkage from performance quality to outcomes.

The relations between outcome expectations, interest, and goals are disputable among many relevant studies. Some empirical studies have found that outcome expectations only could predict students' interests but were not significantly predictive of career goals. For example, Jiang and Zhang (2012) found that Chinese vocational school students' outcome expectations of engineering majors predicted their interest in an engineering major but did not predict their intentions of studying in an engineering major. Some empirical studies even found that outcome expectations neither predicted interest nor goals. For example, Lent et al. (2003) conducted an empirical study to test the prediction model based on SCCT on some graduated students who had selected engineering design courses in university. This study showed that engineering self-efficacy could predict engineering outcome expectations, but engineering outcome expectations could not further significantly predict technical interests and educational goals. In addition, the longitudinal study from Lent et al. (2008) also found that outcome expectations neither played as temporal precursors for academic interest nor career goals. Based on the previous discussion of empirical evidence of the predictive effects of outcome expectation on interest and goals, these two hypothesised paths require more discussions from future studies.

2.5.2.3 Learning experiences

As shown in Figure 2.2, the role of learning experiences in the SCCT choice model is experiential sources of self-efficacy and outcome expectation and can intervene in the relationship between personal input and contextual factors with these two personal-cognitive factors. What should be mentioned is that Lent and his colleague did not give learning experiences a theoretical definition in the SCCT choice model. They involved the variable “learning experiences” in the SCCT choice model as the sources for self-efficacy and outcome expectation, based on the theory foundation from Bandura (1977, 1986).

According to Bandura’s (1977) self-efficacy theory, self-efficacy is a kind of dynamic self-belief regarding some given domains. According to Bandura (1977), there are four informative sources for self-efficacy: mastery experiences, verbal persuasion, vicarious learning, and affective state. Mastery experiences refer to people’s self-perceived achievement experiences in a given domain. Verbal persuasion refers to experiences of being encouraged by other people that they are capable of doing some activities. Vicarious learning refers to experiences of observing others doing some activities. Affective state refers to experiences in which people gain psychologically affective arousal (such as anxiety) when they encounter some tasks. People gradually generate their self-efficacy by facing the experiences that provide these four sources, interpreting these experiences, and internalising them into perceived ability in a given task (Bandura, 1977; Bandura, 1994). Since building one's self-efficacy is a gradual learning process for a person, these four sources are also called learning experiences.

In addition, Bandura (1986) posited that people's self-efficacy informs their outcome expectations. Based on the theory foundation from Bandura (Sheu et al., 2018), Lent et al. (1994) proposed in the SCCT choice model that outcome expectation may be derived from the same sources of self-efficacy. Hence, the variable learning experiences in SCCT are conceptualised as experiential sources for self-efficacy and outcome expectation, which consist of four sub-factors: mastery experiences, verbal persuasion, vicarious learning, and affective states. Specifically, the mechanisms of how these four sources contribute to self-efficacy are further discussed below.

Mastery experiences contribute to building people's confidence, while unsuccessful experiences undermine confidence. The spoiling effects of failures on self-efficacy are more potent in the situation if self-efficacy has not firmly been built (Bandura, 1994). Successful experiences of beating arduous tasks may enhance people's self-efficacy more than experiences of completing effortless tasks (Bandura, 1977). Through putting effort into solving the problems, getting mastery experience, and enhancing self-efficacy, people may gradually generate their instruments to solve problems strategically and psychologically, enhancing their confidence to cope with even more challenging situations.

Being persuaded by others that "I am capable of doing a given task" is another way people build their self-efficacy. Encouragement about people's capability boosts them to put in more effort, develop their skills and sustain the task, especially when they are self-doubting and dwell on their deficiencies (Bandura, 1994). An actively mobilised individual is more likely to succeed than one who harbours self-doubt. Furthermore, the successful experiences could further contribute to their self-efficacy.

It is noteworthy that according to Bandura (1994), the constructing effects of positive encouragements on capability are weaker than the undermining effects of negative comments on one's capability. The results of negative persuasion may lead to avoidance behaviour and less persistence when people encounter challenging situations. What is worse, avoidance behaviour can trigger a vicious circle in that people may avoid facing the challenging situation, then miss the opportunities to develop their skills, and experience failure; in the end, the failure experiences may exacerbate the lack of self-efficacy.

Vicarious learning is a way that people build their self-efficacy: people can strengthen their self-efficacy by seeing and interpreting others' behaviour (Bandura, 1994). Specifically, seeing one who is similar to the individual, completing a task by sustained efforts may help the individual build the belief that he/she also can attain a similar task by putting effort. Hence, the first important point of vicarious learning is the similarity between the observing person and the reference person. If there is a salient disparity of ability between the observing person and the reference person, the successful or failed experiences of the reference person may have minor effects on the observing person. The meaning of vicarious learning provides a comparable standard with which people can evaluate their competence for a task, and by observing others, people can also learn what skills and strategies are needed for completing the task (Bandura, 1994).

Affective states such as anxiety or stress can reduce people's self-efficacy (Bandura, 1994). People can evaluate their capability through their emotional reflections. People with affective states interpreted as negative are less likely to consider themselves confident than those who hold positively-interpreted emotions. In addition, the negative affective state may lead to avoidance behaviour, further exacerbating people's lack of self-efficacy (Bandura, 1977). When people avoid undertaking the task, they may have fewer opportunities to develop their skills and strategies to complete this task. The result is that people may miss opportunities to get an outstanding performance on the task and, in the end, have static insufficient self-efficacy in this task.

Although learning experiences play an essential role in SCCT, which links contextual factors with personal-cognitive factors, according to Schaub and Tokar (2005), insufficient vocational development studies have focused on it, and there was a lack of empirical evidence about its role in SCCT.

2.5.2.4 Interest

Academic/career interest in SCCT refers to individuals' likes or dislikes for a given academic subject or career. Interest is postulated as a direct predictor of career goals in the choice model (Lent et al., 1994). However, in the science-related domain, the relation between interest in science with science career intentions has been disputed, and this relation is further discussed in the next section.

As mentioned before, in SCCT, self-efficacy and outcome expectations are postulated as predictors of people's interests. Bandura (1986) posited that mature people tend to show interest in the task in which they can feel efficacious and expect positive outcomes. However, many empirical studies have not supported the predictive effects of self-efficacy and outcome expectation on interest. As mentioned in the outcome expectation section, the relations between outcome expectation and interest have been disputed (Lent et al., 2003; Lent et al., 2008). In the study by Lent et al. (2003), participants' (American university students) outcome expectations for engineering majors could not significantly predict their interest in engineering. In the longitudinal study of Lent et al. (2008), outcome expectations for engineering majors were not the precedent predictor for interest in engineering (this study was also conducted on American university students). However, under a similar research context, Lent et al. (2001) found that participants' (American university students) mathematics outcome expectations could significantly predict their interest in math. Lent et al. (2008) and Lent et al. (2003) both focused on the topic of engineering, by contrast with that, Lent et al. (2001) focused on the topic of math. It seems that the different results between these studies may be due to different focused topics in studies under similar contexts. In addition, Jiang and Zhang (2012) drew on Lent et al. (2003)'s study and conducted a similar SCCT-based study in China. The result indicated that outcome expectations for engineering majors could significantly predict students' interest in an engineering major, which was different from Lent et al. (2003). Based on the previous discussions, the relations between outcome expectation with interest may be different under different contexts and may be variant dependent on different tasks.

According to empirical exploration from many studies, the interactions between self-efficacy and interest are complex. Some studies investigate the bi-directionality between self-efficacy and interest (e.g. Lent, Tracey, Brown, Soresi, & Nota, 2006; Tracey, 2002; Nauta, Kahn, Angell, and Cantarelli, 2002). For example, Nauta et al. (2002) conducted a longitudinal study, and the results showed that students' self-efficacy could predict their future interests and vice versa. This reciprocal process is like a beneficial cycle. Self-efficacy leads to initial positive engagement and interest in tasks or activities, and the individual's positive engagement enhances the possibility of good performance in this task. Subsequently, good performance can trigger people's intrinsic interest and enhance their self-efficacy.

In contrast, the longitudinal study from Lent et al. (2008) did not show bidirectionality between self-efficacy and interest. Lent and his colleagues did not ignore this inconsistent result and suggested that the reciprocal relation between self-efficacy and interest does happen, but when people's self-efficacy is not static. Moreover, after self-efficacy is formed firmly, the relation between self-efficacy and interest is more likely to be unidirectional.

2.5.2.5 Goal

Drawing on the idea from social cognitive theory, the goal can play an important role in the self-regulation of behaviour (Bandura, 1986). Humans not only can correspond to environmental determinants and reinforcement from personal experiences but also can perform their agency to regulate their life by setting goals (Bandura, 1986). People can mobilise their efforts and sustain them for a long time, even without external positive reinforcement, to achieve their goals (Lent et al., 1994). Self-efficacy, outcome expectations, interest, and goals are all personal cognitive variables in SCCT, which enable people to exercise their agency during their career development process. As mentioned before, SCCT is derived from Bandura's triadic causality model; besides cognitive-person variables, SCCT also focuses on the effects of environmental variables.

2.5.2.6 Contextual factors

In the perspective of SCCT, it is not the objective features of the environment but how people subjectively perceive them that influence people's behaviour (Lent, Brown, &

Hackett, 2000). According to Lent et al. (2000), people certainly can be influenced beneficially or detrimentally by events out of their control. However, how they interpret these environmental factors through mobilising their potential personal agency also influences their career choice development. Hence, contextual factors are regarded as affecting career choices through the mediation of personal cognitive variables. For conceptual convenience, based on how the contextual factors have effects in the SCCT choice model, Lent et al. (2000) categorised contextual factors into distal and proximal contextual factors. Distal and proximal contextual factors are distinguished by the different temporal periods in which their influences occur. The contextual factors whose influencing period occurs distally with career choice are named distal contextual factors, and the factors that affect proximally with career choice are named proximal contextual factors.

As shown in figure 2.2, distal contextual factors (termed background contextual affordances in figure 2.2) make remote, indirect influences on career intentions through many steps. Firstly, distal contextual factors can directly influence people's learning experiences. Then with the mediating effects of learning experiences, distal contextual factors can help generate people's cognitive factors, including self-efficacy, outcome expectation, and interest, and finally, people's personal cognitive factors can be translated into their career intentions. Lent and his colleagues (2000) state that people's career role models can be perceived as distal contextual factors during their school years. Students may not enhance their interests in a career just by meeting a career role model, but this experience may contribute to their positive learning experiences in this specific career, which may further contribute to their self-efficacy and interest.

In contrast with distal contextual factors, proximal contextual factors such as some career/academic tightly relevant supports and barriers (termed as contextual proximal influences in figure 2.2) can either directly predict career goals or moderate the path from interest to goal. Lent et al. (2000, p.38) state that an example of a proximal contextual factor is “the adequacy of one’s informal career contacts or exposure to discriminatory hiring practices”. Compared with just being exposed to career role models (distal contextual factor), people are more likely to be familiar with the job and then intend/quit to choose it since they adequately have informal career contacts (proximal contextual factor). In addition, people with an interest in a specific career may not intend to choose this career, given their exposure to discriminatory hiring practices.

Although Lent and his colleagues demonstrated the theoretical mechanisms of these two kinds of contextual factors in the SCCT choice model, they did not define the characteristics of distal and proximal contextual factors, respectively. Consequently, it is hard to identify whether the contextual factor is distal or proximal literally. The practical approach to identifying whether a contextual factor is distal or proximal is by investigating its role in the SCCT choice model. The contextual factor directly influencing learning experiences is the distal contextual factor, and the contextual factor influencing career intentions and moderating the relation between interest with career intentions is the proximal contextual factor.

As the review of SCCT-based studies from Sheu & Bordon (2017) showed, empirical studies aimed at expanding and deepening the understanding of contextual factors in SCCT are expected priorities for future research. Differentiated from the conceptualizing way of contextual factors in SCCT, it is interesting to mention that many empirical studies found that the mechanisms of how contextual factors make effects were not the same paths corresponding with the SCCT choice model (shown in figure 2.2) but were more consistent with Bandura's triadic model, namely the environmental determinants could directly make effects on person-cognitive variables (Bandura, 1986). For example, the empirical study from Turner, Steward, and Lapan (2004) found that parental support for pursuing maths and science careers and the structure of the family (two parents or a single-parent family) could directly predict people's math self-efficacy. Lent et al. (2003) conducted empirical studies on graduated students who had selected engineering courses, and the results showed that students perceived environmental supports and barriers that were relevant to the pursuit of an engineering major only had direct effects on engineering self-efficacy rather than engineering outcome expectation, engineering interest or educational goals.

2.6. Criticisms of SCCT

2.6.1 Discussion of Distinction between Self-Efficacy and Self-Concept

Self-efficacy is a vital variable in SCCT. In the psychological sphere, similar to self-efficacy, self-concept is an alternative formulation to indicate the evaluation of the "self" (Lent, Brown, & Gore, 1997). The comparison between self-efficacy and self-concept has attracted many researchers' attention. The products of these comparison studies can be summarised into two dimensions: conceptual level and operational level. At the conceptual level, researchers discussed the theoretical distinction between these two concepts. However, whether these two concepts are theoretically distinguished is still disputable. At the operational level, researchers found that the specificity level of measurement instruments could influence the difference between these two kinds of self-perceived competencies. Some studies even found that when self-efficacy was measured at a domain-specific level, the separation boundary between self-efficacy and self-concept was blurry (e.g. Skaalvik & Skaalvik, 2004).

SCCT specifically depicts a comprehensive picture of self-efficacy's antecedence and predictive outcomes. These relations associated with self-efficacy in SCCT can identify self-efficacy; namely, self-efficacy is the product of four kinds of learning experiences and predicts people's interests. Hence, comparing the roles of self-efficacy and self-concept in SCCT may provide empirical evidence for the separability discussion between self-efficacy and self-concept.

In this section, the conceptual differences between self-efficacy and self-concept are discussed first. In addition, the operationalisations of self-efficacy and self-concept in empirical studies and how the specificity levels of operational instruments influence the differences between self-efficacy and self-concept are discussed. Furthermore, comparisons of the relations between self-efficacy and self-concept with career intentions are discussed.

2.6.1.1 Conceptual differences between self-efficacy and self-concept

Many studies have discussed the theoretical similarity and difference between these two “self”-related concepts. Bong et al. (2012) gave the definition of self-concept: “Self-concept refers to an individual’s perceptions of the self that are formed through experiences and evaluative feedback received from significant others” (p. 336). In this sense, self-concept is a broad concept that incorporates descriptive characteristics of self and evaluative feelings about that perceived “self” (Vondracek & Porfeli, 2011). Supper (1990) even contended that self-efficacy and self-concept are two interchangeable variables, and self-efficacy could be subsumed into self-concept as a trait-like sub-component.

By contrast, Bandura did not agree that self-efficacy and self-concept are two interchangeable concepts. According to Bandura, from the perspective of social cognitive theory, “the efficacy belief system is not a global trait but a differentiated set of self-beliefs linked to distinct realms of functioning” (Bandura, 2005, p. 1).

Bandura (1986) emphasised that self-efficacy is people's belief in their ability to accomplish specific tasks or performance in given domains. However, self-concept does not focus on people's perceived ability to accomplish a given task but represents people's more general self-perception and self-evaluative feelings (Zimmerman, 1995). The representation of people with self-efficacy and self-concept can indicate the difference. For example, people with strong science self-efficacy could say, "I can solve this type of science problem." By contrast, people with strong science self-concept could say, "I am a good student in school science.".

It is noteworthy that compared with self-efficacy, theoretically, self-concept has the nature of comparison (Möller & Marsh, 2013). For example, when a student says, "I am a good student in school science", the evaluative feeling of "good student" is not just derived from the objective achievement before, but it is also generated from the evaluation of the comparison with other references, such as other students. To summarise previous studies, researchers have proposed three comparison processes in the development of self-concept: social comparisons (Seaton, Marsh, & Craven, 2009), temporal comparisons (Möller, 2005), and dimensional comparisons (Marsh et al., 2015). Social comparisons indicate that people may generate their self-concept by comparing their performances with others in the same domain (Seaton et al., 2009). Temporal comparisons indicate that people may generate their self-concept by comparing their performances in a domain at present with their previous performances in the same domain (Möller, 2005). Dimensional comparisons indicate that people may generate their self-concept by comparing their performances in one domain with performances in other domains (Marsh et al., 2015). There has been empirical evidence to support the nature of the comparison of self-concept. For example, many researchers have found that the average school academic achievement is negatively associated with individuals' academic self-concept (e. g. Marsh et al., 2008; Nagengast & Marsh, 2012).). This phenomenon indicates that students are more likely to gain a high academic self-concept if their compared references are relatively low achieving. Marsh et al. (2008) called this phenomenon the big-fish-little-pond effect.

2.6.1.2 Empirical evidence for the differences between self-efficacy and self-concept

In empirical studies, the operationalisations of self-efficacy are more variate than self-concept. How self-efficacy is operationalised may significantly influence the results of empirical studies that investigate differences between self-efficacy and self-concept. To discuss the empirical evidence for the differences, this section firstly discussed the operationalisations of science self-concept and science self-efficacy. Empirical studies to compare the differences between self-efficacy and self-concept are further presented.

The operationalisations of science self-concept are not disputable (Jansen, Scherer & Schroeders, 2015). Science self-concept generally assesses whether people are good at science (Jansen, Scherer & Schroeders, 2015). However, the operationalisations of science self-efficacy can be different. Bandura (1986, p. 391) defined self-efficacy as "people's judgments of their capabilities to organise and execute courses of action required to attain designated types of performances". Bandura only defined self-efficacy as a belief about the capability to be competent in some actions. However, he did not expound on what targeted actions could be. Hence, there were various conceptualising and measuring ways for self-efficacy in different situations. Specifically, Lent and Brown (2006) stated that self-efficacy can be conceptualised and measured at different levels of specificity. Science self-efficacy can be scientific self-efficacy, chemistry self-efficacy, and chemistry experiment self-efficacy, from the most global level to the most specific level (Lent & Brown, 2006). In practice, there have been two kinds of operationalisation of science self-efficacy. One body of studies has measured science self-efficacy at a domain-specific level, such as Lent and his colleagues (2000, 2001, 2003), which measured science self-efficacy by testing people's beliefs in more general tasks or goals, such as having high marks in the examination. An example of this type of question is "rate their confidence in their ability to successfully perform majors required for success in electric power engineering majors" (Jiang & Zhang, 2012. P. 61). Other studies have measured science self-efficacy at task-specific levels, such as PISA 2006 and 2015 project and TIMSS 2011 project, which referred to more specific tasks related to science (OECD, 2008, 2016; TIMSS, 2011). An example of this type of question is "recognise the science question that underlies a newspaper report on a health issue." (OECD, 2016, P. 284).

There have been controversial ideas about what kind of measurement of self-efficacy is better. For example, Pajares (1996) asserted that

> domain-specific assessments, such as asking students to report their confidence to learn mathematics or writing […] are inferior to task-specific judgments because the sub-domains differ markedly in the skills required. (p. 547)

However, Lent and Brown (2006, p. 20) criticised the task-specific measurement that "there is the risk of studying phenomena that may be theoretically interesting but lack clear relevance to practical vocational applications." According to Lent and Brown (2006), the majority of empirical studies about SCCT have measured self-efficacy in a domain-specific way.

In addition to the theoretical definition difference between self-efficacy and self-concept, many empirical studies have noticed that the degree of specificity of how self-efficacy is assessed influences the empirical result of the difference between self-efficacy and self-concept. Based on the conceptual definition, self-concept refers to self-evaluation in a domain that is very similar to domain-specific self-efficacy. Skaalvik and Skaalvik (2004) argued that when self-efficacy is operationalised by domains, the difference between domain-specific self-efficacy and self-concept is very blurry. By contrast, task-specific self-efficacy is significantly distinguished from self-concept (Bong & Skaalvik, 2003).

There has been empirical evidence for the relations between self-concept and domain-specific and task-specific self-efficacy. For example, Bong et al. (2012) investigated the relations between math self-concept and math self-efficacy. They found that statistically, the correlation coefficients between math self-concept and math self-efficacy measured in a domain-specific way were 0.96 and 0.91, respectively, in samples of elementary and secondary school students. An example of the self-efficacy measurement question is "I'm confident I can do an excellent job on the assignments and tests in this course" (p. 340). Statistically, the correlation coefficients between math self-concept and domain-specific math self-efficacy were over 0.8, and this result implies that these two measurement constructs have co-linearity (Cohen et al., 2003). At the statistical level, these two concepts cannot be significantly distinguished.

By contrast, many empirical studies have found that task-specific self-efficacy was statistically distinguished from self-concept. For example, Ferla, Valcke, and Cai (2009) investigated the statistical difference between math task-specific self-efficacy and math self-concept and found that these two concepts merely had moderate correlation relationships with each other. Jansen, Scherer & Schroeders (2015) found that for German high school students, task-specific science self-efficacy could be statistically separable from science self-concept through the test of confirmatory factor analysis. These results imply that task-specific self-efficacy and self-concept are empirically distinguished.

2.6.1.3 Comparisons of the relations between self-efficacy and self-concept with career intentions

In terms of self-efficacy and self-concept, there are still two disputable points. Firstly, the conceptual and operational separability between self-efficacy and self-concept are still disputable. This point has been discussed before in this section. Secondly, the relations between self-concept and self-efficacy with career intentions are disputable.

Self-perceived academic competencies, including self-efficacy and self-concept, are essential in career choice studies. For example, Betz and Hackett's (1981) encouraged people to increase their self-efficacy to enhance their personal agency for career choices. Super and his colleagues (1963, 1990) contended that people have the motivation to implement their self-concept through careers. Many studies have provided empirical evidence for the relations between self-efficacy and self-concept with career intentions, as discussed in the earlier section 2.3.1.

However, many empirical studies indicated that the predictive effects of these two concepts on career intentions are different. As discussed before in this section, in the same domain, the specificity level of the operationalisation may influence the statistical separability between self-efficacy and self-concept. Hence, it is important to consider the specificity level of the operationalisation when discussing the difference between these two concepts' predictive effects on career intentions. Considering the disputable separability between self-concept and domain-specific self-efficacy, the present study focuses on the comparison between task-specific self-efficacy and self-concept.

Specifically, many studies found that self-concept had stronger predictive effects on career intentions than task-specific self-efficacy. For example, Jansen, Scherer, and Schroeders (2015) found that statistically, German secondary school students' science self-concept had a stronger predictive effect on their science-related career intentions than task-specific science self-efficacy. Jansen, Scherer, and Schroeders (2015) stated that compared with task-specific science self-efficacy, science self-concept could represent a more stable and more general self-perceived ability in the scientific domain, and this self-perceived ability contributes to students' science career intentions more. Parker et al. (2014) conducted a longitudinal study to investigate the respective relations of task-specific math self-efficacy and math self-concept with STEM career intentions. This study showed that only math self-concept predicted whether students would choose STEM careers. These empirical studies support that the predictive effects of these two concepts on career intentions are different.

The present study investigates the formation process of Chinese secondary school students' science career intentions. Self-efficacy and self-concept are two important factors that may play a crucial role in the formation and development of science career intentions. However, the differences between these two factors are still disputable. Hence, the present study designed two hypothesised models that respectively involved (task-specific) science self-efficacy and science self-concept. By comparing the roles of (task-specific) science self-efficacy and science self-concept in the corresponding models, this study could provide empirical evidence for the distinction between (task-specific) science self-efficacy and science self-concept.

2.6.2 Critical Discussion of Interest

2.6.2.1 Discussion about the linkage between science interest and science career intentions

The predicting effect of interest in science on career intentions is one of the focal hypotheses for SCCT. It is noteworthy that many studies have shown that, generally, students show interest and a positive attitude toward science (e. g. Osborne et al., 2003; DeWitt et al., 2013). However, Archer et al. (2012a) stated that for most students, this general interest and positive attitudes to science seem challenging to translate into their aspirations in science. For example, the ASPIRES project is a five-year study in the UK that investigated how 10 to 14-year-old students developed their science-related aspirations (Archer et al., 2013a). Specifically, in the ASPIRES project, most participants from year 6 to year 9 had positive attitudes toward general science; for example, they might think of science as fun, exciting, important, and interesting and showed expectations for future science learning. However, most of these participants did not show expectations of having science-related jobs. This phenomenon is called the doing-being divide: students enjoy science but do not expect to work in science (Archer et al., 2010). The striking discrepancy between students' positive attitudes to science (including attitudes to science in and out of school, and impressions of scientists) and the lack of aspirations for science has been still unexplained (DeWitt et al., 2013).

The doing-being divide seems inconsistent with the proposition that science interest can positively predict science career goals, which is one of the significant hypotheses from SCCT. One possible explanation of the doing-being divide is that under the scenario of ASPIRES project, these students' response of interest in science might be a kind of unstable and superficial interest that lacked deep commitment. Current theories of the development of interest emphasise that situational interest must be supported and sustained to develop as a more stable disposition (Hidi and Renninger, 2006; Krapp, 2002). Archer et al. (2012) also argued that without the support of a set of cultural, financial, and social resources from family and reinforcement of interest from daily science-related activities, students may find it difficult to translate their interest in science into aspirations in science.

In addition, Reinhold, Holzberger, and Seidel (2018) also have paid attention to the striking discrepancy between interest or positive attitudes to science and aspirations in science. They have drawn on the "Rubicon Model of Action Phases"

(Heckhausen & Gollwitzer, 1987) to explain this phenomenon. They contended that the step to cross the "Rubicon river" from wishing (students are interested in science) to planning (students intend to choose science-related routes) is never an easy task. During this challenging step, students may evaluate the desirability and the feasibility of many opportunities. Especially for the students of secondary school ages, Archer et al. (2010) stated that these students may rule out not only "undesirable" but also "unthinkable" career routes. Moreover, science-related jobs, especially being scientists for many students, are very brainy, not reachable, and not relevant, namely, unthinkable (Scantlebury, Tal, & Rahm, 2007). The characteristics of science in students' perception may make students struggle to cross the gap from "enjoying doing science" to "aspiring in science".

The broader study of ASPIRES project by DeWitt et al. (2013) found that through analysing with multi-level modelling analysis, statistically, there were many factors accounting for the variance of science aspirations to some extent. Specifically, students' attitudes to school science, parental attitudes to science, and students' self-concept in science were most closely related to science aspirations, some other factors such as gender, ethnicity, and cultural capital were also associated with students' science aspirations. In this study, although the factor "attitudes to school science" was associated with students' science aspirations, it should be noticed that apart from students' attitudes to school science, many other factors were also potential influencing factors. Considering there are various potential factors influencing students' aspirations in science, this study implies that students' interest or positive attitudes to science might just be the necessary but insufficient condition for students' science aspirations, which means that if other conditions are not met, the effect of only interest is very limited.

2.6.2.2 Measurement approaches to interest in science in SCCT

The measurement approach to interest in science may influence the role of interest in science in the SCCT model since students' interest in general science is not always aligned with their interest in science in some specific domain. Krapp and Prenzel (2011) stated that interest in science can be conceptualised at different levels of specificity. On a more generalised level, science interest could comprise the whole body of content related to the science people can be aware of (Krapp & Prenzel, 2011). On a more concrete level, interest in science is limited to specific school subjects, science-related activities, and topics, or science-related disciplines and research fields (Krapp & Prenzel, 2011). Moreover, interests at different levels of specificity may not always be aligned with each other. For example, Lindahl (2007) stated that students' attitudes to their school science may be quite different from their attitudes to science. Schreiner and Sjoberg (2004) stated that students' falling interest in specific science domains was not equal to their falling interest in general science. Similarly, Osborne et al. (2003) also found that students tended to show interest in general science, but in contrast, students were not likely to show interest in school science learning.

According to Lent and Brown (2006), in SCCT studies, researchers tended to focus on assessing interests in tasks conducted before the entry of careers at a relatively concrete level, such as interests in a single activity domain or a set of conceptually linked tasks. As the example from Lent and Brown (2006) showed:

> A researcher may wish to examine the specific types of activity interests (e.g., solving computer software problems, playing video games) that motivate the choice of computer programming courses in high school or computer science majors in college. (P. 28)

The science interest measurements used in empirical studies of SCCT also have supported Lent and Brown's (2006) statement. For instance, a maths/science interest measurement which has been widely used in SCCT studies by Lent and Brown (2001), assessed participants' interest by asking the degree of their interest in learning eight topics and doing seven activities in science and maths. Another example of science interest measurement is from Lent et al. (2003), who measured technical interest by asking the degree of participants' interest in doing seven engineering-related activities; this technical interest measurement is also applied widely (e. g. Lent, 2005; Lent et al., 2008). According to Lent and Brown (2006), in the majority of SCCT studies, interest in science was measured at a concrete specificity level (e. g. science in some specific domain).

In addition, Ajzen and Fishbein's "theory of reasoned action" (1980) argued that people's attitudes towards some "object" (e. g. interest in science topics) are distinctive from people's attitudes to the actions that are performed on the "object" (e. g. interest in doing school science). Ajzen and Fishbein (1980) also argued that people's attitudes to the actions that are performed on the "object" are more predictive of behaviour intentions than people's attitudes towards some "object".

Based on the previous discussion, science interests that are measured differently may have different relations with science career goals. Considering Ajzen and Fishbein's (1980) argument of the distinction between people's attitudes toward some "object" (e. g. interest in science topics) and people's attitudes to the actions that are performed on the "object" (e. g. interest in doing science), the present study involved two kinds of measurement approaches to interest in science. One measurement instrument of scientific interest is the index of broad interest in science topics (INTBRSCI) (OECD, 2016), which assesses students' interest in some science-related topics that they may learn and hear about in and out of school. In addition, another measurement is the index of enjoyment of science (JOYSCIE) (OECD, 2016), which assesses students' enjoyment of doing some specific behaviour in science. These two measurement approaches were compared by comparing each of their predicting effects on science career intentions in the present study.

2.6.3 Critical Discussion of the Structure of Learning Experiences

The structure of the variable "learning experiences" in SCCT has been a disputed topic. Theoretically, in Bandura's self-efficacy theory, four kinds of learning experiences (mastery experiences, vicarious learning, verbal persuasion, and affective statement) were initially considered the antecedent predictors for self-efficacy (Bandura, 1977). Later, Lent et al. (1994) included "learning experiences" as a variable in the SCCT model and hypothesised that the variable "learning experiences" directly predicts self-efficacy and outcome expectations. To recognise the concept, in the following discussion, "learning experiences" refers to the variable in SCCT, and four different types of learning experiences (mastery experiences, vicarious learning, verbal persuasion, and affective statement) are called sub-factors of the learning experiences variable. Lent et al. (1994) merely postulated the role of "learning experiences" in the SCCT model, but they did not theoretically explain this concept (learning experiences) clearly. According to Bandura (1986), learning experiences are constituted of four-sub factors, however, Lent and his colleagues did not provide sufficient demonstrations of the hierarchical structure of "learning experiences". This section discusses the potential hierarchical structures of learning experiences.

2.6.3.1 The relations between four sub-factors of the learning experiences with self-efficacy

To discuss the structure of "learning experiences", it is necessary to consider it through a theoretical lens. As Lent et al. (1994) stated, "learning experiences" is hypothesised as the source of self-efficacy and outcome expectation in the SCCT choice model. The theoretical foundation of this hypothesis is based on Bandura's theoretical discussion of sources for self-efficacy, namely that people generate their self-efficacy by interpreting the four kinds of learning experiences (Sheu et al., 2018). As posited by Bandura (1997), all of the four kinds of learning experiences are potential sources of self-efficacy; however, in practice, there has been much empirical evidence indicating that in different domains, the sources to nourish students' self-efficacy may be different.

For example, to investigate the relations of the four sub-factors of the learning experience with maths self-efficacy (including sub-scales of everyday math tasks self-efficacy, math courses self-efficacy, and professional math problem self-efficacy), Matsui, Matsui, and Ohnishi (1990) conducted quantitative research on Japanese undergraduate students. Specifically, by employing hierarchical regression analysis, they controlled the effects of the other three kinds of learning experiences on math self-efficacy and were able to find whether a specific factor could provide a unique contribution to math self-efficacy. This study indicated that except for verbal persuasion, all the other three sub-factors of learning experiences could, to some extent, account for the unique variance in maths self-efficacy. Matsui, Matsui, and Ohnishi (1990) 's study suggested that verbal persuasion could not be the direct source of math self-efficacy for their participants, which is not consistent with Bandura (1997) 's proposition about the sources of self-efficacy.

By contrast, Lent, Lopez, and Bieschke (1991) conducted similar research on American undergraduate students. However, they found that among the four sub-factors, only "mastery experiences" alone could explain the unique variance in math self-efficacy (which is specifically measured by the math college course self-efficacy scale). Lent, Lopez, and Bieschke's (1991) findings indicated that among all the four kinds of learning experiences, only mastery experiences could directly predict math self-efficacy for their participants. The differences between Lent, Lopez, and Bieschke (1991) and Matsui, Matsui, and Ohnishi (1990) imply that under different contexts and in different domains, students' self-efficacy may be derived from different sources.

To investigate the differences between the sources of self-efficacy in different domains, Usher and Pajares (2009) specified maths self-efficacy precisely into mathematics grade self-efficacy (MGSE), mathematics skills self-efficacy (MSSE), and mathematics courses self-efficacy (MCSE). They found that all the sub-factors except verbal persuasion predicted MGSE; mastery experience and vicarious learning predicted MSSE; mastery experience and verbal persuasion predicted MCSE.

In addition, in the science domain, Britner and Pajares (2006) found that among four kinds of learning experiences, only mastery experiences alone significantly predicted science self-efficacy.

The disputable results from the empirical studies provide implications for future studies that generally, potential sources for self-efficacy are likely to be mastery experiences, vicarious learning, verbal persuasion, and affective state.

However, it is noteworthy that in different specific domains, the sources for self-efficacy may be variate.

2.6.3.2 Empirical studies of the hierarchical structures of learning experiences

Through the technique of structural equation modelling, more potential structures of "learning experiences" have been supported by empirical studies. For example, Lent, Lopez, Brown, and Gore (1996) hypothesised four types of structure of "learning experiences" in math. Specifically, they investigated a 4-factor learning experiences model including factors- mastery learning experiences, vicarious learning, verbal persuasion, and affective state. Then, they contended that mastery experiences and verbal persuasion have a theoretical link and that people who have many mastery experiences tend to be encouraged in their ability. Hence, considering the high correlation between mastery experiences and verbal persuasion, they hypothesised a 3-factor learning experiences model in which mastery performances and verbal persuasion constitute one integrated factor and affective state and vicarious learning respectively represents one factor. In addition, they presented that vicarious learning is not a format of direct learning, whereas the other three kinds of learning experiences are all direct personal experiences. Hence, they also hypothesised a 2-factor model in which one factor is constituted of three personal direct learning experiences (mastery experiences, verbal persuasion, and affective state) and the other is the indirect learning experience (vicarious learning). Finally, they discussed two dimensions of vicarious learning, in which one dimension is peer and friends' modelling, and the other dimension is adult (e. g. teachers and parents' verbal persuasion) modelling. Hence, they hypothesised a five-factor learning experience model with factors - of mastery learning experiences, vicarious learning, affective state, peer modelling, and adult modelling. This study conducted on both high school students and college students. The results of the model fit testing showed that all four kinds of models were acceptable for high school students and college students. However, by comparing these models, statistically, the four-factor learning experiences model was the most suitable for college students, while the five-factor learning experiences model was the most suitable for high school students. These results indicated that compared with college students, the influence of peer models and adult models were more different for high school students. The structure exploration study from Lent et al. (1996) implied that "learning experiences" might have many potential acceptable structures. Furthermore, for students of different ages, the suitable structure to depict their "learning experiences" might differ. The limitation of this study is that the quantitative study only could provide statistical evidence for the possible suitable "learning experiences" models. However, for example, the substantive reasons why the five-factor "learning experiences" was the most suitable model for high school participants have not been shown by this study.

However, a meta-analysis study from Sheu et al. (2018) found inconsistent results with Lent et al. (1996), which showed that only the 2-factor learning experience (in science, technology, engineering, and mathematics domains) model could converge the data. Furthermore, Sheu et al. (2018) found that four kinds of learning experiences were significantly correlated with each other. Sheu et al. (2018) summarised 141 independent samples to find the most appropriate structure to represent “learning experiences”. Furthermore, moderator analysis indicated that the two-factor model of “learning experiences” was also suitable for different gender, race/ethnicity, and age groups (high school students and younger people and college students and older people).

In addition, Sheu et al. (2018) found that the effects of the affective state in the “learning experiences” model were different between different gender groups and differences between race/ethnicity majority and minority groups. Specifically, this study suggested that the affective state affected self-efficacy for females more than that for males. Furthermore, the affective state was a stronger indicator for race/ethnicity majority than minority groups (race/ethnicity majority: white American sample, race/ethnicity minority: all the possible different racial minority groups in America), which implied that some race/ethnicity minority people were less likely to have these unpleasant affective states when they learned STEM. However, the limitation of this study was that it did not disaggregate the specific race/ethnicity groups to reveal whether the variance of affective state has indeed existed within the group.

Tokar et al. (2012) have investigated the structure of “learning experiences” and found that “learning experiences” in six different Holland domains, including realistic, investigative, artistic, social, enterprising, and conventional (Holland, 1958, 1959), could be differentiated with each other. Furthermore, under each Holland domain, the four-factor “learning experiences” structure was supported in this study.

What should be noticed is that these seven studies mentioned before, including Matsui et al. (1990), Lent et al. (1991), Usher and Pajares (2009), Britner and Pajares (2006), Lent et al. (1996), Sheu et al. (2018) and Tokar et al. (2012) all found that these four kinds of learning experiences are significantly bi-correlated with each other. The significant correlations between these four kinds of learning experiences provide a prerequisite for designing the measurement instrument of the latent variable “learning experiences”. Only if the four kinds of learning experiences are correlated with each other, the measurement scale of “learning experiences” consisting of these four sub-factors have high inner consistency.

The empirical studies mentioned before imply that under different contexts, for different groups of participants and in different domains, the possible sources for self-efficacy may be different; namely, the sub-factors of “learning experiences” may be different. Furthermore, these studies also imply that depending on the possible relations between the four sub-factors of “learning experiences”, the potential hierarchical structures of “learning experiences” may differ. Hence, there are two-dimensional discussions about “learning experiences” in this study. Firstly, this study focuses on whether all four kinds of learning experiences can contribute to self-efficacy. Secondly, this study focuses on the relations between these four kinds of learning experiences. Since the four-factor model of “learning experiences”, which consists of four kinds of learning experiences, is the basic and the simplest structure of “learning experiences” and also has been widely supported by empirical studies, this study initially hypothesised that the four-factor model of “learning experiences” was suitable for the participants in the present study.

Although there have been many quantitative empirical studies investigating the structure of “learning experiences”, and based on the results of these studies, the possible structures of “learning experiences” had statistical evidence, these statistically supported structures have not been qualitatively explained. For example, as Lent et al. (1996) showed the five-factor “learning experiences” model was statistically most suitable for high school students, but the possible reasons to explain this statistical result were unknown based on Lent et al. (1996) ’s study. Hence, in the present study, not only a quantitative investigation on the structure of learning experiences but also a follow-up qualitative study to explain the possible reasons for the structure of “learning experiences” were conducted. Specifically, the structure of “learning experiences” was particularly investigated quantitatively (by confirmatory factor analysis) and qualitatively (by interview), and the details of the method will be illustrated in the methodology chapter.

2.7 Family Science Capital and SCCT

2.7.1 Introduction of Family Science Capital

Family science capital has been found to have a significant linkage with students' science career intentions (e. g. Archer et al., 2013a). Investigations about this concept have already drawn researchers' attention for decades. Bourdieu (1977, 1984, 1986) gave an explicit explanation and classification of capital. He theorised capital as a kind of resource in society that was legitimate, exchangeable, and valuable, which could generate and provide social advantages to people who owned them in a given field. Bourdieu (1986) contended that there were four key forms of capital: social (e.g. social networks and relations), cultural (e.g. qualifications, dispositions, and cultural goods), economic (e.g. money and financial resources), and symbolic (which is a kind of abstract capital, refers to people's prestige, honour or celebrity) and these four types of capital were not isolated but functioned interactively to determine one's position in a specific field.

Bourdieu's notion of capital has inspired numerous studies to investigate its link with education outcomes. It has been shown that middle-class families tend to use their privileged resources to positively affect their children's education attainment (Perna & Titus, 2005; Sandefur et al., 2006). Such family assistance might include providing additional benefits and advantages, such as going to high-level schools and providing out-of-curricular enrichment activities (Vincent & Ball, 2007). Through interactions between family capital and family habitus, a family's values, expectations, attitudes, and behaviour might affect their children's educational achievement (Dika & Singh, 2002).

Inspired by Bourdieu's theory, the ASPIRES project took their new concept of "science capital" into consideration to investigate the factors influencing middle school students' science intentions. Archer and her colleagues have given the conceptual definition of science capital.

> Science capital refers to science-related qualifications, understanding, knowledge (about science and 'how it works), interest, and social contacts (e. g. knowing someone who works in a science-related job). （Archer et al., 2013a, p.13)

Specifically, science capital contains pertaining to science, what you know, what you think, what you do, and whom you know. Notably, science capital is not a specific type of capital but a conceptual device to aggregate various economic, social, and cultural capitals related to science (Archer et al., 2014).

ASPIRES project specifically focused on science capital aggregated from family, measured by the family's relation and attitude towards science. In this project, students with different levels of family science capital have been classified into high, medium, and low family science capital groups. Archer et al. (2013a) found that students with medium or high family science capital were more likely to have science career aspirations. Furthermore, this phenomenon was more salient for higher-grade students (year nine students) than lower-grade students (year six students).

2.7.2 The Relation between Family Science Capital and Science Career Intentions

Archer et al. (2012) explained how family science capital facilitated the enhancement of individuals' science aspirations with the interaction with family habitus. In this context, habitus is an important but complex concept. Archer and her colleagues (2012) described the concept of family habitus as not only incorporating attitudes and feelings (such as attitudes to liking/disliking science) but also incorporating values and daily practices. They contended that the interplay between family science capital and family habitus can be embodied in these three ways: 1> people with high family science capital are more likely to be familiar with science since they are surrounded by a high "science atmosphere". 2> people with high family science capital are more likely to undertake more science-related practices and have more science-related support when they encounter problems during these practices. 3> finally, by becoming familiar with science in their daily lives and acquiring a sense of achievement by practising, they may tend to regard science-related jobs as desirable and reachable.

In addition, Archer et al. (2012) argued that students in families equipped with insufficient science capital are more likely to regard science jobs as "unthinkable", even if they have positive attitudes towards science. Archer et al. (2012) stated that students with a lack of family science capital find it difficult to translate their nascent interest in science into science aspirations. This statement is supported by Hidi and Renninger's (2006) four-phase interest model. Hidi and Renninger (2006) have classified people's interests into four phases during which interest is developed from a triggered situational interest to a mature well-developed individual interest. Through continuous practice, people's initial interest can be sustained (Azevedo, 2010). However, without the behaviour to sustain, students' nascent interest in science may have the risk of diminishing. Archer et al. (2012) thought that science is less likely to be woven into the family's daily life for a family with low science capital. Although children in these families may have interest and positive attitudes to science, the family does not provide good soil to sustain and develop students' nascent interest in science into a mature interest in science. Therefore, these students' interest in science is more likely to be superficial and fragile and it is difficult to translate their interest into science aspirations. In this sense, a lack of family science capital is regarded as a kind of barrier which blocks the process of the interest in science to aspirations in science (Archer et al., 2012). Cleaves (2005) has proposed that the lack of awareness about science occupation and underestimation of his/her science abilities are two possible reasons why students do not choose science-related careers. An environment with high family science capital can facilitate students to undertake more practical experiences related to science, and these experiences are more likely to mitigate students' underestimated self-evaluation about science. Furthermore, families in which members have science occupations may provide occupational education about science to their children. In this sense, families with high science capital may be able to mitigate two possible factors which block students from aspiring to science. Hence, family science capital is an important and promising concept to involve in studies about students' development of science career intentions.

As discussed above, the interplay of family science capital and family habitus can influence children's science aspirations. However, these processes were described qualitatively. Although family science capital may influence students' science career intentions, Archer et al. (2012) also pointed out that the predictive effect of family science capital on science career intentions is not deterministic. For example, they found that some students had high family science capital but did not prefer to choose science-related jobs. Hence, the specific mechanism between family science capital and science career intentions should be further investigated.

2.7.3 Family Science Capital as Inequality Capital

Archer et al. (2012, 2015) stated that family science capital is more likely to be a privileged resource for middle-class and upper-middle-class families. For instance, opportunities to undertake extensive enrichment science activities require additional social and economic resources, restricting disadvantaged families from providing those opportunities for their children (Archer & Francis, 2006). The inequality nature of family science capital indicates that the science capital and family habitus that facilitates students' science aspirations are not reachable for all the students.

It is noteworthy that science capital does not just indicate a specific type of capital but includes a series of economic, social, and cultural capital related to science. Not only the socioeconomic inequality in the society but also this cultural inequality can profoundly affect the rearing way for children (Lareau, 2007). For example, disadvantaged families may expect their children to choose a "safe career road", which indicates somewhere they know others have been to and have been successful (Archer & Francis, 2006). However, the lack of knowledge about potential scientific careers and the relevant support they should provide for their children may restrict these parents' expectations and guidance for their children's career choices (Smart & Rahman, 2009).

Family science capital is a kind of privileged resource for some advantaged families (Archer et al., 2012). It relates to various economic, social, and cultural resources, which are hardly reachable for many families. In this sense, even though we know it is essential for a family lacking science capital, it seems very difficult to conduct some specific intervention to enhance their family's science capital. Although Godec et al. (2017) came up with the science capital teaching approach that students' science capital is expected to build during school science learning, there are some potential difficulties in practically applying this approach in some underdeveloped regions. Considering this approach requires many teacher-student interactions, this approach may not be appropriate for places with limited teaching resources but numerous students. Investigating the deep mechanism of how family science capital contributes to people's science aspiration building may provide the implication for further intervention studies to compensate for students' lack of family science capital.

2.7.4 Linkage between Family Science Capital and SCCT

It is hypothesised that family science capital can play a similar role as contextual factors in SCCT. As discussed in section 2.3.2.6 (contextual factors), there are two kinds of contextual factors in the SCCT choice model: distal contextual factors and proximal contextual factors. Distal contextual factors indirectly influence career choices through learning experiences and person-cognitive factors such as self-efficacy. In addition, proximal contextual factors can directly influence people's career intentions and moderate the relation between people's interests to their career intentions (Lent et al., 2000). However, Lent and his colleagues only identified the roles of contextual factors in SCCT and did not clearly distinguish the conceptual difference between distal contextual factors and proximal contextual factors. Hence, it is hard to directly recognise whether family science capital can play as distal contextual factors or proximal contextual factors in SCCT by the conceptual definitions of contextual factors. This study explores whether family science capital can play as distal contextual factors or proximal contextual factors in the SCCT choice model.

Although there has been insufficient empirical evidence to support the role of family science capital in SCCT, the previous quantitative and qualitative investigations on family science capital have provided the foundation for the hypothesised role of family science capital in SCCT. Referring to the qualitative investigation of the processes of how family science capital contributes to people's science aspirations by Archer et al. (2012), it implies that people with family science capital are more likely to have more science-related learning experiences (e.g. high science learning atmosphere at home, and enrichment of science-related activities after class). The relation between family science capital and science-related learning experiences is congruent with the role of distal contextual factors in SCCT that distal contextual factors have effects on people's learning experiences, and learning experiences can further contribute to people's personal cognitive factors, which eventually influence people's career intentions.

Many studies have found that not all students' interest in science can transfer to their intentions in science careers (e. g. DeWitt et al., 2013, Archer et al., 2013). Archer et al. (2012) argued that for students whose family science capital is woven into their daily family life, their interest in science is more likely to translate into science career intentions. By contrast, students whose family lacks science capital, although they have positive attitudes toward science, may still regard science careers as "unthinkable". This statement implies that family science capital may moderate the path from the interest in science to science career intentions, which is also consistent with a path of contextual factors in SCCT that proximal contextual factors can moderate the path from interest to career intentions.

In addition, the quantitative study from Archer et al. (2015) found that statistically, students' family science capital was significantly regressed with their science self-efficacy. This result indicated that students with high family science capital were more likely to have high science self-efficacy. Jones et al. (2020) found that the family's interest and value in science, considered elements of family science capital, were related to science self-efficacy. These results imply that elements of family science capital seem to be related to self-efficacy. Theoretically, this assumption is consistent with the proposition from the social cognitive theory that contextual factors can directly affect self-efficacy (Bandura, 1986). The empirical study from Lent et al. (2003) also supports this proposition:

Based on the discussion of the linkage between family science capital and SCCT, there are four postulates about the roles of family science capital in SCCT.

Postulate1> Family science capital would directly affect learning experiences.

Postulate 2> Family science capital would directly affect science career intentions.

Postulate 3> Family science capital would moderate the path between interest in science and science career intentions.

Postulate 4> Family science capital would directly affect self-efficacy.

Archer and her colleagues have discussed how family science capital affected science aspirations mainly based on qualitative research strategies (e. g. Archer et al., 2012). In the present study, through incorporating family science capital into SCCT, the mechanism of how family science capital contributes to students' science career intention is quantitatively investigated.

This investigation has implications for both family science capital theory as well as SCCT. For family science capital, through involvement in the SCCT choice model, this study provides a series of sequential paths which clearly explain the possible mechanism of how family science capital influences people's science career intentions. This finding may contribute to family science capital intervention studies in the future. For the SCCT choice model, the involvement of family science capital expands the content of specific contextual factors which may influence people's career intentions. According to Sheu et al. (2017), the review of SCCT-related studies for decades indicated there had been insufficient studies focusing on investigating the specific content of contextual factors. Hence, involving family science capital in the SCCT choice model has theoretical and applied significance.

2.8 Study Design in the Chinese Context

Up to now, Western counties have accounted for the majority of science career intentions related studies. A large body of vocational psychology theories was generally initiated in these Western countries, and the ensuing empirical studies to investigate the applicability of this theory were also conducted in these countries. For example, the SCCT theory, which is used in this study, was set forth and firstly supported by empirical evidence in the US. In addition, family science capital was initially linked with students' science career intentions in the ASPIRES project in the UK (Archer et al., 2013a). From then on, the UK was also the main context to investigate the theoretical foundation and applied implication of science capital (Du and Wong, 2019). China is the targeted context for this study, and there were insufficient studies either to test the applicability of SCCT or to investigate the effects of family science capital in the Chinese context. Hence, the investigation into the Chinese context may contribute to expanding the applicability of these theories. To understand more about the Chinese context, the features of China are firstly discussed in this chapter. Subsequently, Chinese students' attitudes towards science careers and their comparisons with other counties are discussed. Finally, based on the features of the Chinese context discussed before, the implications for the present study's design are discussed.

2.8.1 Features of the Chinese Context

2.8.1.1 Features of the educational system: academic outcome-oriented

In the Chinese educational system, the importance of academic achievement is never underestimated. Students with high academic attainment have more freedom for academic trajectory choices (Du and Wong, 2019). For example, the high school entrance examination decides what type of high school students can go to (such as academic vs vocational) and what level of high school they can attend. Students' grades in the College Entrance Examination decide what university they can select and, to some extent, also influence the majors they can choose in university since, in China, the admission requirement grades for the popular majors tend to be higher (Du and Wong, 2019). Given the vital importance of the college entrance examination, whether they can do well in a subject tend to be a crucial factor influencing the selection of the optional subjects (physics, chemistry, biology, history, politics, and geography) in high school. Compared with secondary students in the UK, Du and Wong (2019) found that science academic achievement for Chinese secondary students had much stronger links to science aspirations. The academic outcome-oriented educational system may, to some extent, explain this phenomenon.

It is worthwhile to particularly discuss the importance of the college entrance examination, which is called Gaokao in China. According to Qiang Li, a famous sociologist in China, education has always been a crucial screen for social-economic status, especially in Chinese society (Li, 2015). Since Gaokao was restored and effectuated in 1977, it has been the main approach to social mobility, and many trajectories to the middle class are in conjunction with Gaokao in China (Li, 2015). For example, many professional certificates (such as a certificate of lawyer and a professional accountant) require the qualification of a higher education diploma.

Under the social status selection system of Gaokao, school education and family education have also been influenced to be academic outcome-oriented, and under the culture of Confucian values, the influence of family and school may be elevated. This cultural feature of China is discussed explicitly in the next paragraph.

2.8.1.2 Features of culture

Under the profound influence of Confucian values, there are two crucial cultural features for Chinese students: 1. Respect for teachers is highly emphasised under Confucian values; hence Chinese students are less likely to have the confidence or initiative to question or challenge their teachers (Chan, 1999). 2. Obedience and family obligation are strongly emphasised under Confucian values; hence family expectation may highly influence students' educational and vocational development (Chao & Sue, 1996).

Specifically, in terms of the relationship between students and teachers, traditional Confucian learning emphasised that students should show extreme respect for teachers, and teachers are regarded as sophisticated mentors while students are novices and learners (Du & Wong, 2019). Hence, Chinese students tend to be passive knowledge receivers, and school teachers focus on enhancing students' ability to excel in exams instead of cultivating their confidence and critical thinking ability (Marlina, 2009).

Du and Wong (2019, p. 350) stated that the influence of parental expectation on students' education and career development may be elevated by cultural values such as "filial piety, loyalty to family, and obedience to parents". One possible effect is that Chinese students may feel higher parental pressure than their Euro-American peers (Leong & Serafica, 1995). Leung et al. (2011) found that parental expectation was related to students' career-decision difficulties in Chinese university students. This finding implies that under the cultural values that emphasise family obedience, students' career choice is significantly influenced by family expectations in China.

2.8.2 Chinese Students' Attitudes Towards Science Careers

PISA (Programme for International Students Assessment) 2015 and 2018 are two an international surveys that both investigated 15-year-old students' attitudes to science careers from the OECD member counties (Organization for Economic Cooperation and Development) and some other counties such as China. Compared with PISA2018 which only showed students' science career expectations, PISA2015 specifically indicated comprehensive pictures of students' attitudes to science including students' enjoyment of doing science, interest in science-related practices, instrumental motivations of doing science, interest in science-related topics. What should be mentioned is that the PISA project just recruited participants in China from four provinces: Beijing, Shanghai, Jiangsu, and Guangdong (B-S-J-G). There were few large-scale surveys investigating Chinese students' attitudes towards science careers.

Especially surveys including international comparisons between China and other counties were very rare. Hence, PISA 2015 and 2018 have provided important information to preliminarily review Chinese students' science career intentions.

Specifically, PISA 2015 and 2018 have investigated students' expected jobs when they are 30 years old with the format of an open-ended questionnaire. The job names answered by students have been coded by the international standard classification of occupations, 2008 edition- ISCO-08 (Ganzeboom, 2010). PISA 2015 and 2018 identified science careers as those that require "the study of science beyond compulsory education, typically in formal tertiary education" (OECD, 2016, p. 111). According to PISA 2015 and 2018, science-related jobs consist of four types: science and engineering professionals, health professionals, ICT professionals, and science technicians and associate professionals. This definition of a science career in PISA was very necessary, considering the boundary of science-related careers was not clear.

15-year-old students' career intentions in four provinces in China are shown in table 2.1 (OECD, 2016, 2019). PISA2015 showed that Chinese (B-S-J-G) students expected to work in science were less than 20%. PISA2018 showed that 25% Chinese (B-S-J-G) students expected to work in science, which was higher than that in 2015. On average, students were much more likely to expect to work in non-science careers. It is noteworthy that a significant number of students were still ambiguous or reluctant to express their career expectations.

Table 2.1 Students' career intentions in B-S-J-G

Students' career intentions	**Percentages**	
	PISA2015	**PISA2018**
Science and engineering professionals	6.7%	10%
Health professionals	7.5%	11%
ICT professionals	2.1%	4%
Science technicians and associate professionals	0.4%	0
Non-science professionals	51.7%	unknown
Ambiguous answers	31.5%	unknown

Compared with other countries, Chinese (B-S-J-G) students' science career intentions were relatively low. To demonstrate it clearly, I selected the data from the United States, Canada, United Kingdom, Germany, Singapore, Japan, Korea, China (B-S-J-G), and the average of OECD member counties. The comparisons of students' science career expectations among these counties are shown in figure 2.4 (PISA2015) and figure 2.5 (PISA2018). PISA2015 shows that Chinese students in four provinces had almost the lowest science career expectations among these counties, and their science career expectations were significantly lower than the average level of all the OECD member countries. Although in PISA2018 more Chinese students presented that they had science career expectations, their science career expectations were still significantly lower than the average level of all the OECD member countries.

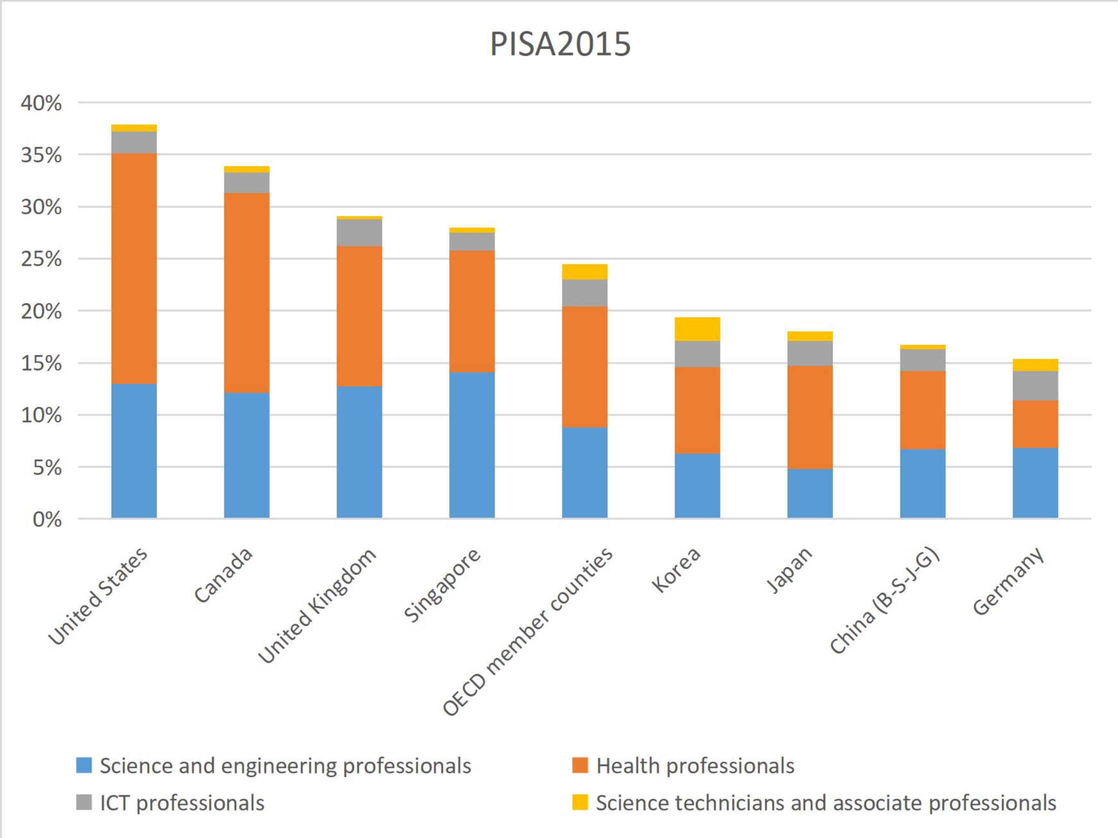

Figure 2.4 Percentage of students who expect to work in science-related occupations when they are 30 from PISA2015

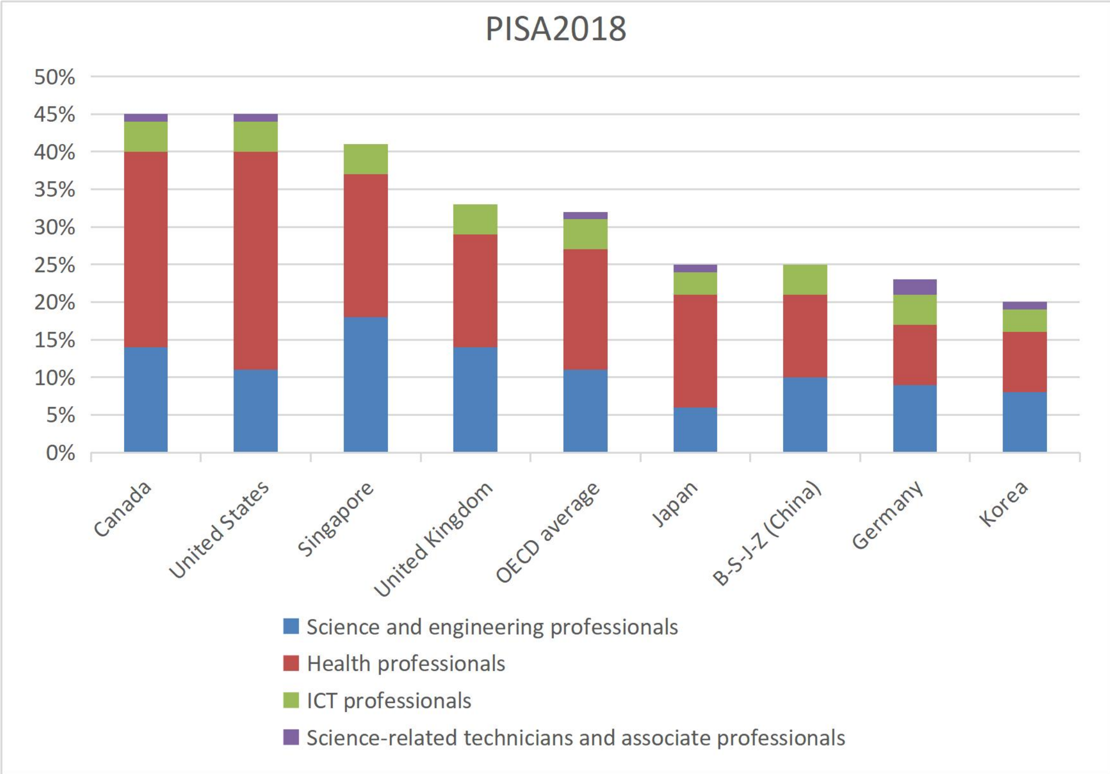

Figure 2.5 Percentage of students who expect to work in science-related occupations when they are 30 from PISA2018

PISA2015 also indicated that in contrast with the relatively low science career expectations from Chinese (B-S-J-G) students, their interest and enjoyment in science, such as enjoyment of science, and interest in broad science topics, were higher than the average level of OECD member counties (OECD, 2016). On average, 78% of Chinese (B-S-J-G) students strongly agreed or agreed that they enjoyed doing science-related tasks, and 71% of Chinese (B-S-J-G) students strongly agreed or agreed that they were interested in some broad science topics such as "biosphere", "motion and forces", or "the Universe and its history".

The gap between Chinese (B-S-J-G) students' interest in science and their intentions to have science-related careers is not unique in China. For example, Archer and her colleagues termed this phenomenon the "doing-being divide": students who have positive attitudes toward science but still lack intentions in science careers (Archer et al., 2010). Project ASPIRES colleagues indicated that British students (10-14 years old) had a doing-being divide in science (Archer et al., 2013a). Schreiner and Sjoberg (2004) also stated that people have paradoxical attitudes towards science. Specifically, the lack of recruitment in science careers has attracted many countries or organisations' attention, such as the US and the EU, but most people generally have positive attitudes towards science (Schreiner & Sjoberg, 2004).

In addition, it is noteworthy that about 87% of Chinese (B-S-J-G) students expressed that learning school science was useful for their future academic and career development (OECD, 2016). It implies that although the majority of Chinese (B-S-J-G) students did not want to choose a science-related job, they also thought the knowledge and skills learned from school science may help them get a job, solve problems at work, and even enhance their career prospects.

PISA 2015 and 2018 have provided important information about Chinese students' attitudes towards science and science careers. Chinese 15-year-old students' science career intentions were lower than the average level of OECD member countries, but their interest in science was higher than the average level of OECD member countries. Interestingly, Archer et al. (2013a) found that Chinese British students had higher science aspirations than white students. However, PISA 2015 found that Chinese local students' expectations of science careers were significantly lower than that in many Western countries, such as the UK, the US, and Canada. Considering local Chinese students' low science career intentions, Chinese British students' high aspirations in science may not be due to the "cultural fetish" of science in China.

What should be mentioned is that PISA project just collected data in four provinces in China, and these four provinces are the most developed regions in China. Hence, PISA project may not reflect the whole picture of students' attitudes towards science and science careers in China. Since, as discussed before, students' attitudes towards science and science career may be influenced by their social-economic status, the data from the underdeveloped places in China may be different from the data shown in PISA project from the four advanced provinces. In the present study, data is collected in Hebei province, whose per capita GDP of Hebei from 2019 to 2021 was lower than the national average level (https://ceidata.cei.cn/jsps/Default?f=1). The data from Heibei may complement the data from the four advanced provinces from PISA project.

2.8.3 The Implication for the Study Design under the Chinese Context

Although there have been a few studies using SCCT to explain Chinese students' formation process of science career intentions, the validity and generality of the results of these studies still need more discussion. For example, Jiang and Zhang (2012) conducted an empirical study that supported SCCT and could explain participants' development of science career intentions. However, the participants in that study were all majoring in electric power engineering at a Chinese middle vocational school, which implies that those students might have a stronger commitment to science careers than normal high school students. Under the Chinese context, students in middle vocational school face different challenges from normal high school students during their school years. Middle vocational schools focus on cultivating in students some particular techniques, and in contrast with normal high schools cultivate students to acquire specialized knowledge and focus on the preparation for Gaokao. The sample in Jiang and Zhang's (2012) study is not representative of Chinese students. The present study focuses on the participants from high schools (including rural and urban schools, high academic level schools, and normal academic level schools) in Hebei province. This sample is relatively representative of Chinese high school students.

Considering the emphasis on academic outcomes for Chinese students, students' perceived academic ability is crucial for their career choices. In the SCCT framework, self-efficacy and outcome expectations are two person-cognitive variables influencing people's academic interests and career intentions. Both Bandura (1986) and Lent et al. (1994) have proposed that self-efficacy has stronger predicting effects than outcome expectations. Especially for some particular activities where the quality of the performance could strongly predict some particular outcomes, self-efficacy can play a predominant role in predicting behaviour (Lent et al., 1994). Under the Chinese selection system of Gaokao, students' academic performance, to a large extent, decides their college choice and can influence students' major choosing freedom. It implies that self-efficacy plays a predominant role in predicting career choices for Chinese high school students compared with outcome expectations. In the present study, considering self-efficacy's stronger predicting effects on career choices than outcome expectations, the hypothesised model to explain the development of Chinese students' science career intentions includes the variable "self-efficacy" but does not include "outcome expectations".

2.9 Overview of the Present Study

Overall research aim:

The Overall investigatory aim is to understand more deeply the formation processes of Chinese high school students' science career intentions aged 16-18.

Research questions:

RQ1: In what ways do family science capital, learning experiences, self-efficacy/self-concept, interest act individually as potential factors influencing Chinese high school students' science career intentions?

RQ2: How do these potential factors interact with each other in influencing Chinese high school students' science career intentions?

RQ2a: How do statistical models of high school students' science career intentions developed in Western socio-economic contexts require adjustment for a Chinese context?

To answer the research questions, the developed models designed based on SCCT and science capital theory are hypothesised and shown in figure 2.6 (the hypothesised model I) and figure 2.7 (the hypothesised model II). The only difference between the hypothesised model I and hypothesised model II is that hypothesised model II replaces the variable self-efficacy in hypothesised model I into the variable self-concept.

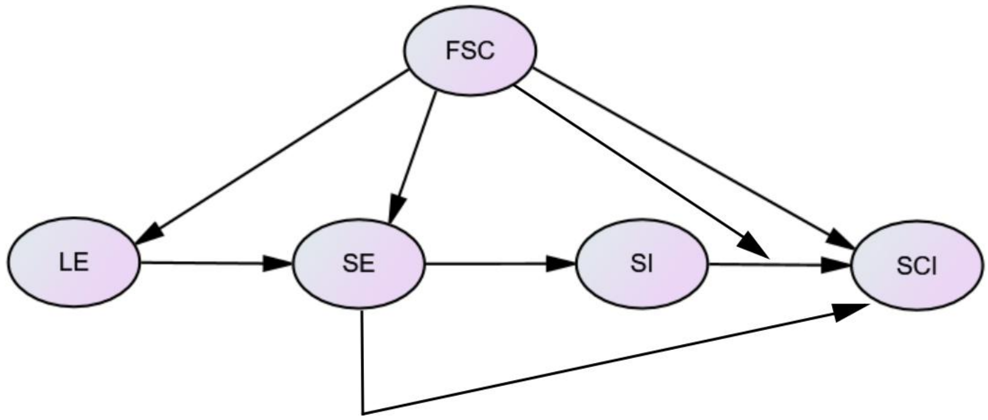

Figure 2.6 The hypothesised model I

Note: FSC: family science capital; LE: learning experiences; SE: self-efficacy; SI: science interest; SCI: science career intentions

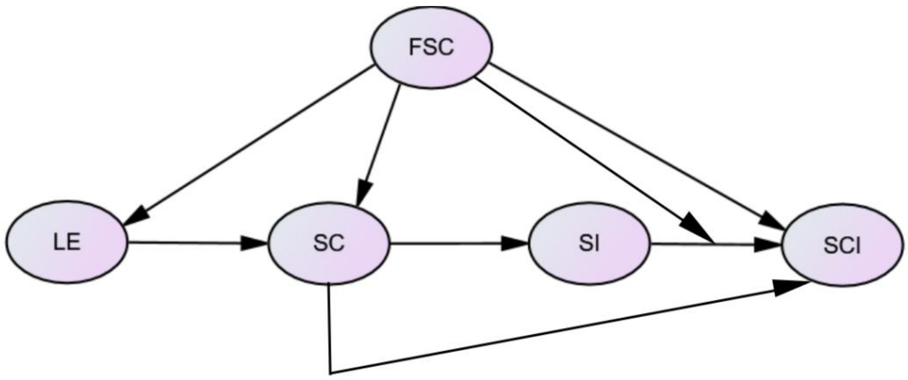

Figure 2.7 The hypothesised model II

Note: FSC: family science capital; LE: learning experiences; SC self-concept; SI: science interest; SCI: science career intentions

This study investigates whether the formation process of Chinese high school students' science career intentions can be explained by the developed models designed based on SCCT and science capital theory. These developed models refine SCCT by clarifying some controversial and disputable variables of SCCT, which include interest in science, science self-efficacy, and learning experiences and adding a new variable - family science capital - into it. Hence, to build the hypothesised model which explains students' career intentions, there are a few sub-questions to consider.

As discussed before, this study focuses on three disputable variables of SCCT. Firstly, the assessment of interest could be different in specificity level from general to concrete. In the majority of SCCT related studies, interest in science was measured in concrete ways (e. g. interest in science in some specific domains) (Lent et al., 2006). As discussed before, interests measured in different kinds of ways are not always consistent with each other. Hence, choosing the proper measuring way of interest is important for SCCT related studies. This study discusses two measurement approaches to interest in science: interest in broad science topics and enjoyment of science. The type of scientific interest which predicts more science career intentions is involved in the hypothesised causal structural model that is designed to explain students' development of science career intentions.

Secondly, the different roles of science self-efficacy and self-concept in students' formation process of science career intentions are discussed in this study. Many studies have focused on distinguishing between self-efficacy and self-concept at a conceptual and operational level. At the conceptual level, some researchers contended that self-concept refers to a kind of more general self-perceived competence than self-efficacy, but other researchers think self-efficacy can be subsumed into self-concept. Theoretically, there is no commonly accepted idea about whether these two concepts are interchangeable. At the operational level, one common idea from these studies is that the specificity level of measurement approaches to self-efficacy could influence the distinction between self-efficacy and self-concept. Specifically, self-efficacy measured at a task-specific level is more likely to be statistically distinguished from self-concept. By contrast, the distinction between domain-specific self-efficacy and self-concept is blurry (Jansen, Scherer & Schroeders, 2015). In addition, many studies have also found that the relations between task-specific self-efficacy and self-concept with career intentions are different. The present study investigates the separability between science self-efficacy and self-concept and compares their respective roles in the formation process of students' science career intentions. As mentioned before, the specificity level of operationalisation of self-efficacy may significantly influence the distinction between these concepts. Hence, the operationalisation of self-efficacy must be particularly paid attention to. In the present study, self-efficacy was measured at a task-specific level.

The third discussion about the original SCCT is that the hierarchical structure of the variable "learning experiences", which is an important variable of SCCT, is not clear. Generally, mastery experiences, vicarious learning, verbal persuasion, and affective state are four sub-factors of the learning experiences (Bandura, 1986). However, as discussed before, the previous studies investigating the hierarchical structures of these four sub-factors indicated disputable and controversial results. In the present study, apart from involving quantitative investigation, which provides statistical evidence for the structure of the learning experiences, qualitative interviews also are involved as a complement to the results from the quantitative part.

In addition to discussing three variables of the original SCCT, this study also involves a new variable: family science capital in the refined SCCT model.

As discussed in the family science capital chapter, there are four postulates about the role of family science capital in SCCT.

Postulate 1> Family science capital would directly affect learning experiences.

Postulate 2> Family science capital would directly affect science career intentions.

Postulate 3> Family science capital would moderate the path between scientific interest and science career intentions.

Postulate 4> Family science capital would directly affect self-efficacy/self-concept.

Based on these four postulations, family science capital is introduced to the hypothesised models.

Chapter 3 Methodology

3.1 Introduction

This study aims at depicting the formation process of Chinese high school students' science career intentions. As discussed in the literature review, an integrated structural model including both environmental and personal factors may relatively more comprehensively explain the development of students' science career intentions than the potential predictors investigation of science career intentions. In a structural model, not only the variables influence science career intentions can be demonstrated, but the interactions between these predictive variables of science career intentions also can be clearly shown. Hence, this study proposed two hypothetical statistical models which could help to explain Chinese secondary school students' science career intentions: hypothesised model I and hypothesised model II (which are shown in Figures 2.6 and 2.7). The study then investigated whether these two models would explain Chinese secondary school students' science career intentions, through both quantitative and qualitative research strategies.

Overall, in the methodology chapter, the design of this study is first demonstrated. Then, participants and sampling in this study are introduced. Subsequently, the measurement approaches to assessing variables in the hypothesised models are introduced. In this study, both quantitative and qualitative methods have been employed for data analysis. Given that the qualitative study was designed based on the quantitative results, the qualitative study design will be precisely demonstrated later in the data analysis chapter. In this chapter, quantitative data analysis methods and qualitative approaches employed in this study are demonstrated.

3.2 Study Design

Overall, there were two subsequent steps of testing the hypothesised models:

- preparation of measurement instruments for the variables in the hypothesised models
- testing of the hypothesised models.

3.2.1 Step 1: Preparation of measurement instruments of the variables in the hypothesised models.

All the variables in the hypothesised models were measured by corresponding sections of the composite questionnaire that was given to participants. Since the measurement instruments for the variables were not been applied in the Chinese context before, all of them have been tested for their applicability to the participants in the present study. These applicability testings are part of the preparation of the instruments discussed here. Once applicability was established, the specific measurement instrument would be used to represent the corresponding variable in the hypothesised models. The statistical analysis method employed to test the applicability of the questionnaires was the confirmatory factor analysis (CFA). Apart from conducting confirmatory factor analysis to test whether the measurement constructs applied to the participants in this study, namely the model fit of all the measurement constructs, three additional sub-steps were needed in the preparation of instruments for measuring variables in the model. These were:

- separability testing between self-efficacy and self-concept as measured by the proposed instruments for these variables
- choosing an appropriate measurement approach to assessing science interest from the two possible alternatives
- investigation to establish a suitable structure for the instrument measuring the learning experiences of Chinese participants. (The structure of the instrument may represent the underlying structure of the latent variable "learning experiences").

Separability testing between self-efficacy and self-concept as measured by the proposed instruments.

The only difference between hypothesised model I and hypothesised model II was in the way they represent the two variables ‘self-efficacy’ and ‘self-concept’. As discussed in the literature review chapter, this study investigated the different roles of self-efficacy and self-concept in the hypothesised model I and model II to compare the difference between self-efficacy and self-concept. Before involving self-efficacy and self-concept in these two hypothesised models, it was necessary to conduct preliminary testing of the statistical separability between these two variables. The present study explored the separability of self-efficacy and self-concept by comparing the model fit of two models (for clarity, to distinguish them from the two overall hypothesised models in this study, they were termed model A and model B). Model A was a one-factor model (in which self-efficacy and self-concept were not distinguishable), so model A brought together all the items from the self-efficacy measurement instrument with all the items from the self-concept measurement instrument. Model B was a two-factor model, which treated self-efficacy and self-concept as two distinguishable factors (so the survey response for each of these two factors was not merged together in the model). Confirmatory factor analysis was employed to test the fits of model A and model B to the data. Suppose model A was tested and rejected, but model B was tested and found to fit the data: this implied that statistically, the two variables, self-efficacy, and self-concept could be separable (Jansen, Scherer & Schroeders, 2015).

Comparison between two measurement approaches to "science interest"

Furthermore, two kinds of measurement approaches to assessing "science interest" were compared in the present study. They were "interest in broad science topics" and "enjoyment of doing science". In order to identify which version of science interest had stronger effects on science career intentions, a hypothesised model was designed in which interest in broad science topics and enjoyment of doing science operated as independent variables, and "science career intentions" was the dependent variable. Among these two kinds of scientific interest, the one which could statistically account for more variance of science career intention would be chosen to represent the variable "science interest" in the final hypothesised model.

Investigation of the structure of the variable "learning experiences"

The structure of the variable "learning experiences" was investigated at the quantitative level by conducting confirmatory factor analysis on a hypothesised learning experiences model. It was a second-order model of learning experiences, in other words, it modeled "learning experiences" as being derived from four sub-factors. These four sub-factors were mastery experiences, vicarious learning, verbal persuasion, and affective state. If the hypothesised model was rejected, it would imply that contrary to the hypothesis, it was not the case that each of the four sub-factors was consistent with the latent variable "learning experiences". Furthermore, a qualitative study would be needed to find possible reasons for the internal inconsistency of learning experiences. Hence, to complement the quantitative result. the follow-up qualitative case studies were designed and conducted employing the semi-structured interviews method. Since the qualitative study was designed based on the quantitative results of the structural investigation of "learning experiences", the details of the design of the qualitative study will be shown in the data analysis section of the learning experiences questionnaire in the next chapter.

3.2.2 Step 2: Testings of the overall hypothesised models

If hypothesised models could match the data from this study, it indicated that the hypothesised models could depict a possible formation process of Chinese high school students' science career intentions. Given that the hypothesised models were complex, incorporating direct path effects, mediation effects, and also a moderation effect, the investigation and examination of the hypothesised models not only included the testing of overall model fit but also included specific testing of direct path effects, mediation effects, and also moderation effects in the hypothesised models.

Notably, one common moderation effect both in the hypothesised model I and II was discussed: family science capital (FSC) would have moderation effects on the path from science interest to science career intentions (SCI).

In the present study, testing a complex structural model with various effects, including moderation effects and path effects, by the structural equation modelling method had technical difficulty and complexity. Many studies have separately examined the overall model fit of the structural model without moderation effects and individually tested whether the moderated paths extracted from the whole model were accepted or not (e. g. Dahling, Melloy & Thompson, 2013). In this study, I individually discussed the moderation effect by considering a hypothesised moderator model (shown in Figure 3.1)

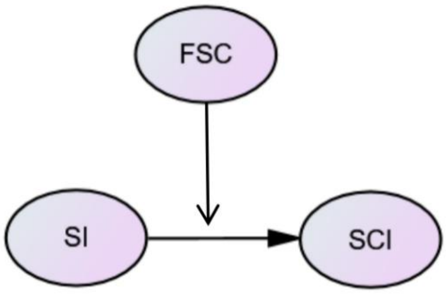

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Figure 3.1 The hypothesised moderator model

Note: FSC: family science capital; SI: science interest; SCI: science career intentions

In addition, the original hypothesised model I and II were turned into hypothesised model III and IV without the moderation effect (shown in Figure 3.2 and 3.3).

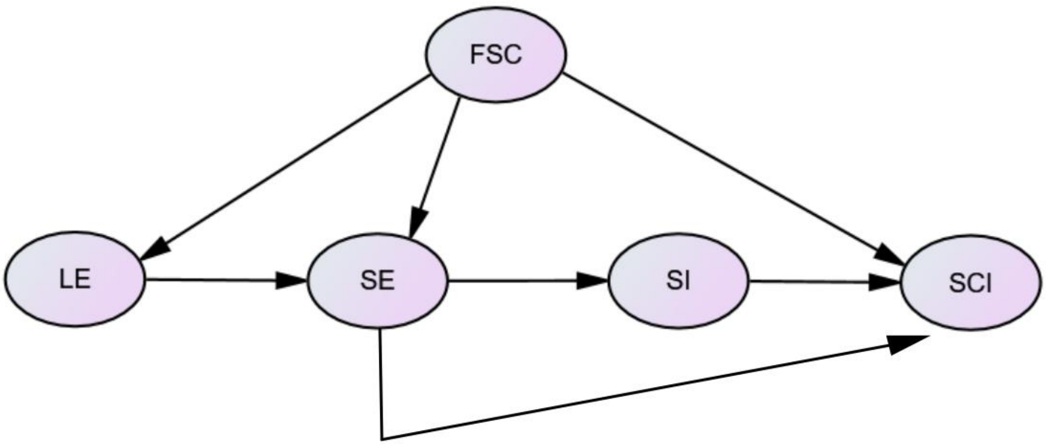


Figure 3.2 the hypothesised model III

Note: FSC: family science capital; LE: learning experiences; SE: self-efficacy; SI: science interest; SCI: science career intentions

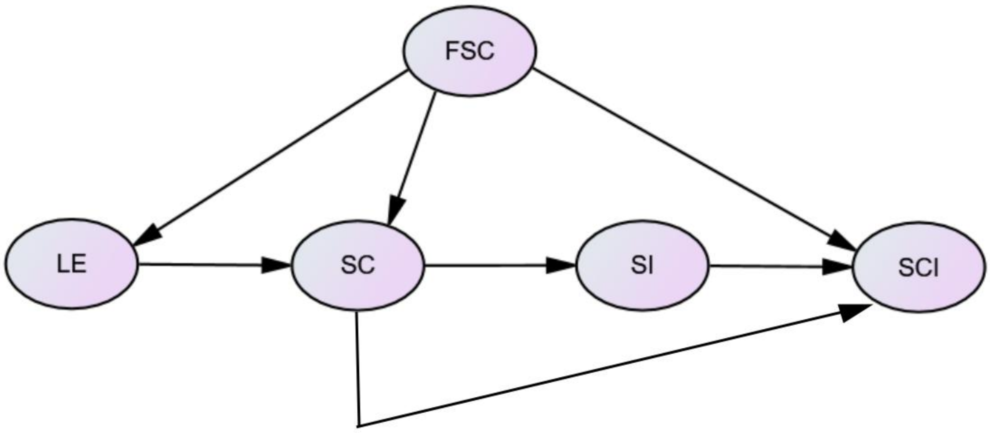


Figure 3.3 the hypothesised model IV

Note: FSC: family science capital; LE: learning experiences; SC self-concept; SI: science interest; SCI: science career intentions

Each arrow line directly links two variables in Figures 3.1 and 3.2 and represents a possible predictive relationship between two variables, and we term these arrow lines 'direct paths'. Discussions on these paths' statistical significance and effect sizes provide more information about the predictive relations between the variables in the hypothesised models. Hence, in addition to the investigation of model fits of models III and IV, the present study also interpreted the paths in these models.

In addition, four hypothesised mediation effects in the hypothesised models III and IV were discussed in the present study:

In the hypothesised model III:

- Family science capital (FSC) would have indirect effects on self-efficacy (SE) through the mediation of learning experiences (LE);
- Self-efficacy (SE) would have indirect effects on science career intentions (SCI) through the mediation effect of science interests (SI);
- Family science capital (FSC) would have indirect effects on science career intentions (SCI) through the mediation of learning experiences (LE), self-efficacy (SE), and science interests (SI);
- Learning experiences (LE) would have indirect effects on science career intentions (SCI) through the mediation effects of self-efficacy (SE) and science interests (SI).

In hypothesised model IV:

- Family science capital (FSC) would make indirect effects on self-concept (SC) through the mediation of learning experiences (LE);
- Self-concept (SC) would have indirect effects on science career intentions (SCI) through the mediation effect of science interests (SI);
- Family science capital (FSC) would have indirect effects on science career intentions (SCI) through the mediation of learning experiences (LE), self-concept (SC), and science interests (SI);

- Learning experiences (LE) would have indirect effects on science career intentions (SCI) through the mediation effects of self-concept (SC) and science interests (SI).

To summarise, the investigation and examination of the hypothesised models contained three specific methods:

1. Structural equation modelling (SEM) was employed to test the model fit of the hypothesised models III and IV without the moderator effect of FSC on the pathway between SI and SCI. Subsequently, the statistical significance and path effects of all the direct paths in this model were discussed.

2. Bootstrap analysis was employed for potential mediation effects in the hypothesised models III and IV.

3. Hierarchical moderator regression analysis was employed to test the hypothesis that family science capital would make moderation effects on the path from science interest to science career intentions.

These three methods will be specifically illustrated later in this chapter.

Summary

Guest (2013) has stated that it is a regular format for mixed-method studies that the design of the qualitative study is dependent on the results of the quantitative study (or vice versa). In this study, the quantitative part, which investigated whether the hypothesised models I and II would explain students' science career intentions, was dominant. The qualitative part employed a semi-structured interview to explain the possible reasons for the quantitative results of the "learning experiences" structure. It played a supplemental role in the whole study.

3.3 Participants

3.3.1 Description of Sampling Context

This study investigated high school students (16-18 years old) who were likely to have a relatively stable and mature science career aspiration. Many previous studies (e. g. Lindahl, 2007; The Royal Society, 2006) have stated that students' attitudes toward science are fairly fixed after 14 years old. Van Griethuijsen et al. (2015) have stated that by the age of 14, students almost have decided whether to choose science, and their opinion about science can be stable for the rest of life. According to Gottfredson's (1981) statement about people's development of self-images and occupational aspirations, the developments of young people's occupational aspirations go into a new stage after 14 years old. Whereas before 14 years old, students can refuse the career choices that are not acceptable to them, after 14 years old, students begin to identify which acceptable career choices are preferable and accessible for them. That implies that, after 14 years old, students start to have relatively stable and mature science-related career aspirations.

In addition, high school is a stage to choose whether to link their life trajectories with science. The high school students who choose to go for jobs after high school will face the decision of job choosing. Those who will further study in a higher-level institution will face finding their preferred majors. Hence, the high school stage is significant for students' science-related career choices. Investigating this group of students may provide implications for future career consultant studies.

The targeted high school students were from Hebei province in China. In China, different provinces have different educational policies. Moreover, these policies may influence students' science choices. For example, in some other provinces, when students choose the courses to enter the college entrance examination (also the courses they major to learn in their high schools), they only can choose either all three art courses (history, politics and geography) or all three science courses (physics, chemistry and biology). However, in Hebei province, after the education reformation in 2018, the courses that students can choose are based on the "1+2 model". "1" means that students must choose one course from physics and history. "2" means that students can randomly choose two courses from chemistry, biology, politics and geography. Students' choices are freer and also more diverse now. In addition, their course choices in high school are directly linked with their major choices in university since many university majors require the relevant knowledge background in high school. Compared with students adhering to either science or art education policy in the past, more students' choices recently contain science courses. Therefore, it enhances the probability of linking their trajectory with science. A less binary system allows me to examine more nuanced choices and trajectories. Since the education reformation in 2018 in Hebei province, students who go to high school in and after 2018 will face the new course-choosing policy. Hence, my participants were students who, under the guidance of the new education policy, were in the first and second years of high school.

3.3.2 The Sampling Procedure

This study selected a sample covering different demographic groups: urban and rural. Urban and rural school students might obtain different social culture resources about science. Participants who studied in urban schools were more likely to have more opportunities to experience prosperous city life, possibly providing more cultural capital (Archer et al., 2012) about science than their peers living in rural places. Social culture resources about science might impact students' science-related learning experiences, and science-related "learning experiences" was an important investigated variable in this study. Hence, involving students with different social and cultural resources about science from urban and rural schools was necessary.

In this study, students' data were collected through convenience sampling. I am from Hebei province and was able to connect with some high school teachers in Hebei province at the beginning of the research using personal connections. With their help and advertising, I was able to contact more school headteachers and convince them to join my study. Through this “snowball rolling” strategy, I successfully invited numerous schools to join my study. Collecting data through a convenience sampling strategy implies that the sample may not perfectly reflect high school students’ responses in a way that is generalizable across all of Hebei province. To enhance the representativeness of the sample, I collected data from schools in both rural and urban locations. The targeted schools are also diverse in their academic levels, including the “province key high school” and “normal high school” - the admission score of the high school entrance examination to “province key high school” is much higher than that of “normal high school”. These measures ensure that (in terms of these potentially important variables) the sample does not exclude key sub-groups of Hebei province’s high school population from representation in the study, although it may not capture their relative frequencies accurately. The influences of potential sampling bias on the results of this study are further discussed in the limitations section of the discussion chapter.

This study recruited students from four urban schools and four rural schools. There were 465 participants in urban schools and 695 participants in rural schools for this study. All participants completed the questionnaire online. The data were gathered in the second semester of an academic year. All participants had already decided which courses to learn in high school, and these subjects were also the examination subjects for the college entrance examination. Participants were recruited with the help of school headteachers in these eight high schools. The headteachers described the content of this study to the students. Then the interested students would be sent the link to the questionnaire, and after they completed the consent form, they would complete the questionnaire online.

3.3.3 Participants' Demographic Background

Demographic questions include students' gender, grades, schools and selected subjects in high schools, parents' education attainment information, and their jobs. Parents' education level and occupation status can reflect students' social and economic status (OECD, 2016).

1161 high school students participated in this study. Among all the students, there were 491 (42.25%) male students, 669 (57.57%) female students and 1 (0.17%) others (who neither identified himself/herself as male nor female) participating in this study. 465 students were from urban schools, and 696 were from rural schools.

The parents' educational level data show that most participants' parents have not attained university education (as Figures 3.3 and 3.4 show). Only about one-third of fathers or mothers went to high school (as Figures 3.5 and 3.6 show). Compared with the parents' educational level in Hebei province, parents' educational level in four places – Beijing, Shanghai, Jiangsu and Guangdong (B-S-J-G), which were regarded as the most developed cities in China was much higher: in B-S-J-G, the percentages of parents' highest education level were respectively 56% (secondary school or lower), 21% (high school education) and 23% (higher education) (Du &

Wong, 2019). The PISA project regarded parental education level as one of the important indexes to represent students' social-economic status (OECD, 2016). This comparison implies that the developed places in China, B-S-J-G, where PISA projects collected data, may not represent China's whole context.

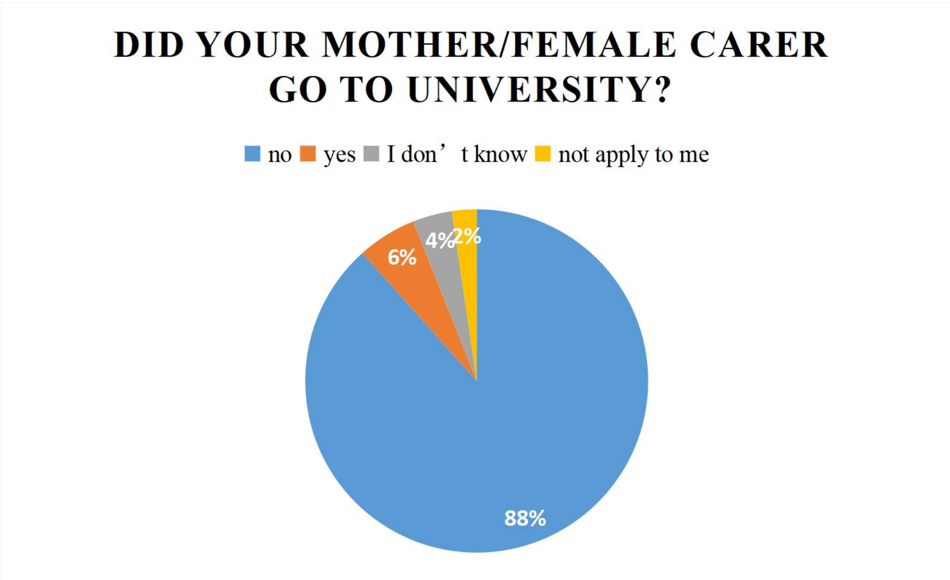


Figure 3.3 The percentage of students' mother/female carers who have been to university

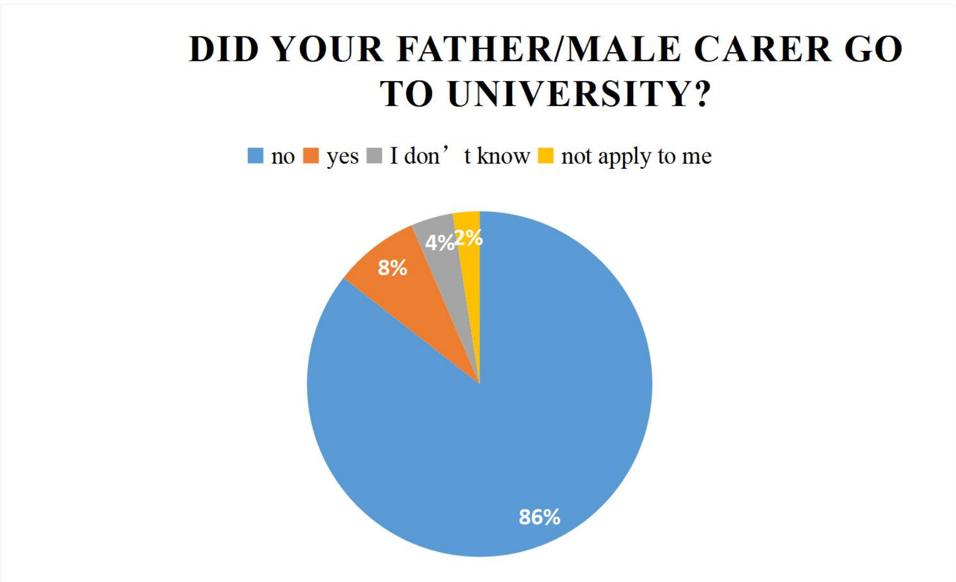


Figure 3.4 The percentage of students' father/male carers who have been to university

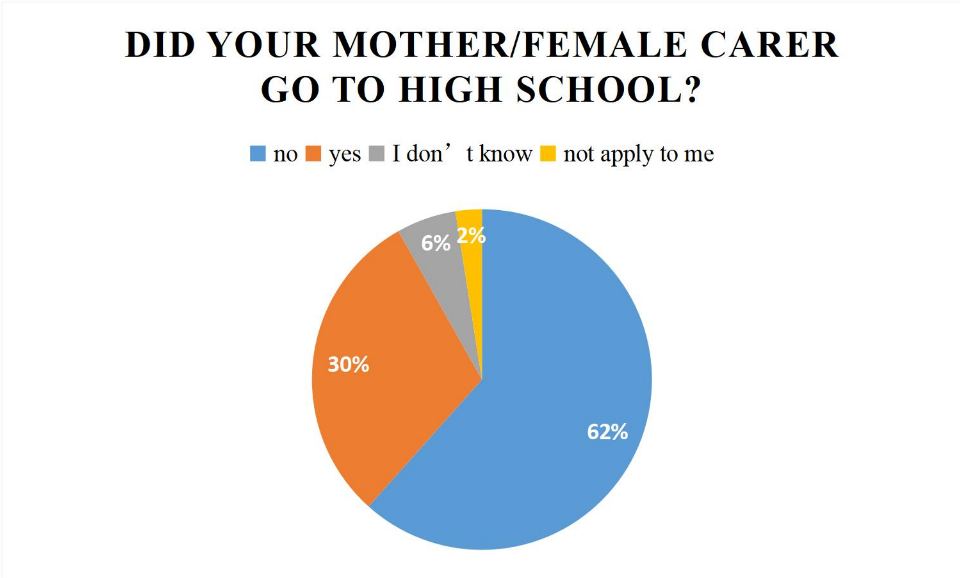


Figure 3.5 The percentage of students' mother/female carers who have been to high school

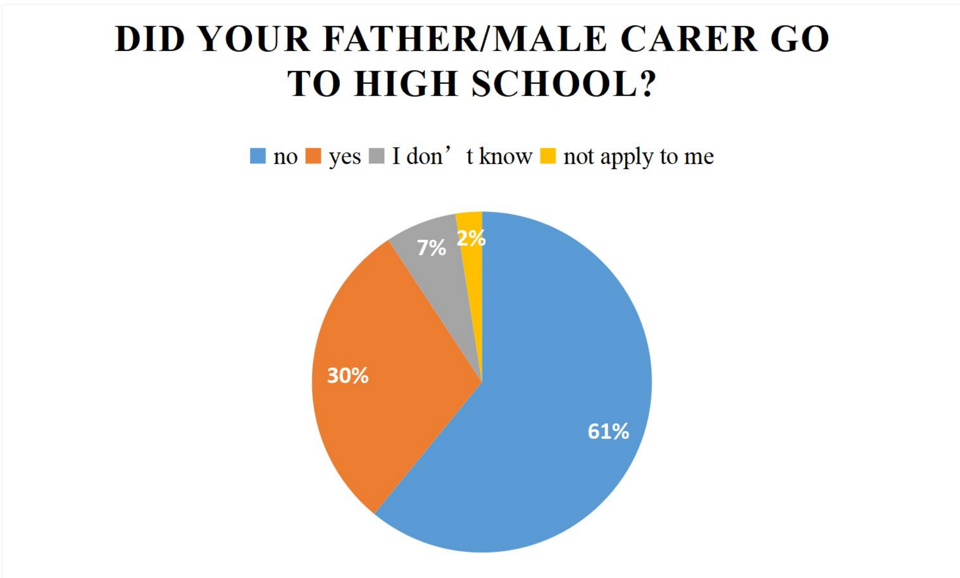


Figure 3.6 The percentage of students' father/male carers who have been to high school

3.3.4 Discussion about the Gender Disparity of the Data

The data showed that there were 491 (42.25%) male students, 669 (57.57%) female students and 1 (0.17%) others participating in this study. I have not found specific data on female and male rates of high school attendance in Hebei province. However, many other surveys could support that the number of female high school students was larger than their counterparts. The education sector of the Zhejiang province government (2013) has published the female and male student rates from all the universities in Zhejiang province: female students accounted for 55%, and male students accounted for 45%. The number of female and male university students may imply the same disparity in high school. They also analysed the reasons for this phenomenon, speculating that men were expected to earn money early according to Chinese conventions. Especially in some economically disadvantaged families, men were urgently expected to be “bread winners”. If the male students were not good at their school work, their families might prefer them to learn a skill or trade instead of continuing to study in school. The data in the present study are also consistent with this analysis from Zhejiang government: in urban schools, there were 218 male students (47%) and 239 female students (53%). By contrast, there were only 273 male students (38.72%) in rural schools and 430 female students (60.99%).

3.4 Pilot Study

Since the measurement instruments in the present study were translated from their original English versions, a pilot study to test the applicability of the measurement instruments for Chinese high school students was necessary. Two high school teachers and 10 high school students took part in the pilot study. Students were asked to complete the questionnaire and their times to finish the questionnaire were counted. After they finished the questionnaire, a short interview was conducted to gain their feedback on the questionnaire, asking questions such as “Did you feel fatigued by completing this long questionnaire?” and “Did you have any confusion when answering the questions?” Teachers were asked to carefully scrutinise all the questions and give feedback on any questions that may not be appropriate for high school students.

All students could finish the questionnaire in 30 minutes and they all stated that they had enough patience to finish the whole questionnaire. Based on students’ and teachers’ feedback, there were a few modifications to the original questionnaire. Firstly, the instruction sentence was revised. The original instruction sentence was

‘Please read the following questions, and think about to what extent you agree with them. Answers will be from 1 “strongly disagree” to 7 “strongly agree”.’

Participants from the pilot study stated that the explanation of answers in the instruction is ambiguous. They suggested to explain each point with words. Hence, the revised instruction was

‘Please read the following questions, and think about to what extent you agree with them. Answers will be from 1 “strongly disagree” to 7 “strongly

agree". 1: strongly disagree; 2: disagree; 3: a little bit disagree; 4: neutral; 5: a little bit agree; 6: agree; 7: strongly agree.'

Second, based on participants' feedback, there was one demographic question deleted from the questionnaire. In the original version, a question on "How many books are there in your home?" was included as one of the indicators of family socioeconomic background. This question was included in PISA2015 and ASPIRES project as one of the indicators of family socioeconomic background. However, both of the piloting teachers stated that the majority of high school students have many textbooks and exercise books. They did not know whether the textbooks and exercise books would count in this question. In addition, three students thought that the answers to this question ("none", "very few", "one shelf filled with books", "one bookcase filled with books", and "more than one bookcase filled with books") were not clear to follow. Because of this confusion, in the actual study, the question about books was deleted; however, questions referring to parental educational levels and occupations were included instead, to indicate the family's socioeconomic background.

Furthermore, participants also provided feedback on two other questions that confused them. As a result, question 17 of the "learning experience sub-questionnaire" was modified from "I have felt dread while using science in a job" to "I would feel dread about using science in my future job". The reason for this change is that participants in this study were high school students, who did not have a job yet. The original question "Apart from your doctor, do you know anyone with a medical or science-related job that you could talk to about health, medicine, or other scientific issues outside of school?" in the "family science capital sub-questionnaire" was also modified. Given the cultural difference, participants thought that the expression "your doctor" did not apply to them. They did not own personal doctors. They suggested to modified this expression into "Apart from doctors in hospital, …".

The pilot study preliminarily tested the applicability of the measurement instruments employed in the present study. The next section specifically presents those measurement instruments.

3.5 Instruments

In this study, structural equation modelling (SEM) was employed to test the model fit of the hypothesised models. To further analyse the numerical data from the questionnaires, there are two points we need to consider:

Since SEM only deals with continuous latent variables, it is more convenient to collect data from continuous questionnaires than categorical questionnaires. If in some special situations, data only can be collected from categorical questionnaires, there are further statistical modifications to transfer categorical questionnaires into continuous questionnaires, but this model needs a huge sample size (Kline, 2011). Given the requirement of SEM, the questionnaires used in this study should be continuous.

In practice, there were many SEM studies where the variables were indicated by the Likert scale instead of scales with continuous total scores (e.g., Harris, 1995). According to Kline (2011), a variable with a Likert scale can be regarded as continuous when the indicators of the scale are widely discrete. Based on previous methodology studies of SEM, the range of the Likert scale may influence further data analysis. The wider the Likert scale, the better it will be in the data analysis step (Yusoff & Mohd Janor, 2014). However, the disadvantage of the over-divided Likert scale is that this scale may make students feel confused. For example, if the scale is a 100-points Likert scale, the difference between 99 and 100 may be hard to distinguish. Hence, in the present study, I used the 7-point Likert scale, which is more precise than the 5-points scale and also it is easy to implement practically. Answers are from 1 “strongly disagree” to 7 “strongly agree”. (1: strongly disagree; 2: disagree; 3: a little bit disagree; 4 neutral; 5: a little bit agree; 6: agree; 7: strongly agree.) Specifically, the measurements of the variables in the hypothesised models will be illustrated in the following paragraphs.

3.5.1 Learning Experiences

The measurement approach to “Learning experiences” drew on the Learning Experience Questionnaire (LEQ) (Schaub, 2004).

> The Learning Experience Questionnaire (LEQ) was used to measure participant’s RIASEC (Realistic, Investigative, Artistic, Social, Enterprising, and

Conventional) framework learning through performance accomplishments, vicarious learning, verbal persuasion, and physiological arousal (Tenenbaum et al., 2013, P. 279).

RIASEC domains are derived from Holland's classifications of vocation and all careers can be categorised into these six domains (Holland, Fritzsche, & Powell, 1994; Holland, 1997). Performance accomplishments, vicarious learning, verbal persuasion, and physiological arousal are four sources of self-efficacy from Bandura's self-efficacy theory (Bandura, 1997). Specifically, the original LEQ consists of 24 sub-scales (six Holland RIASEC domains, each domain having four types of learning experiences), and there are a total of 120 items (5 items per subscale).

As discussed in the literature review, the other three sub-factors of learning experiences positively contribute to self-efficacy except for the negative affective state, such as anxiety (shown in section 2.5.2.3). In LEQ, affective state sub-scales comprise questions to assess students' anxiety towards different science-related activities, therefore affective state sub-scales in LEQ are negatively related to self-efficacy. Consistent with the LEQ scoring key (Schaub, 2004), affective state sub-scale scores were reversed (the reversed score is equal to 8 minus the score of the affective state) in the present study. So, the affective state sub-scale can be consistent with the role: the higher score of the learning experiences, the more positive the learning experiences contribute to self-efficacy.

Tokar et al. (2012) tested the structure of LEQ by empirical research and found that each of the sub-scales in LEQ had convergent validity and could be discriminated from each other statistically. Although the internal consistency estimates for the LEQ RIASEC summary scales have been reported to be acceptable (ranging from .70 to .90) by some studies (e. g. Schaub & Tokar, 2005; Tokar et al., 2007; and Williams & Subich, 2006), the structure investigation of LEQ from Tokar et al. (2012) indicated that LEQ had a hierarchical structure. Tokar et al. (2012) found that learning experiences could be statistically distinguishable between Holland's (1997) RIASEC domains. Given that this study only focused on the science-related domain, learning experiences related to science (which correspond to the investigative domain of RIASEC) were extracted from the whole LEQ and employed as the measurement approach to assessing learning experiences in the present study.

The science-related section of the LEQ comprises 20 questions, of which I have made modifications to some of the questions. The first modification was that the subject "math" has changed into "science". Since I focused on science in the present study, it could be confusing to leave the subject "math" in this questionnaire. Science courses referred to the school subject biology, chemistry, and physics in the present study. In addition, based on the feedback of the pilot study, question 17 has also been modified from "I have felt dread while using science in a job" to "I would feel dread about using science in my future job". The reason for this change is that participants in this study were high school students, who might not have a job yet. The original

LEQ is a 6-point Likert Scale, and in this study, to make all the questionnaires consistent, it has been changed into a 7-point Likert scale.

It is noteworthy that students' science achievement, which (conceptualised as mastery experiences) makes a major contribution to science self-efficacy, was measured by a self-reported questionnaire in the present study. Independent data on students' academic attainment, such as grades in school examinations, would provide a more objective evaluation of students' science achievement than self-reported judgements. However, in practice, many schools were reluctant to share such grade data beyond the school. Hence, students' grades were not accessible in the present study.

3.5.2 Science Self-Efficacy

Science self-efficacy was measured by a questionnaire modified by the science self-efficacy questionnaire used in the PISA2006 project (OECD, 2008) and the PISA2015 project (OECD, 2016). The original science self-efficacy questionnaire is an eight-item questionnaire assessing students' perceived capability in performing eight science-related tasks. For example, the original question is "recognise some science questions that underlie a newspaper report on a health issue", and answers are 1 "I couldn't do this", 2 "I would struggle to do this on my own", 3 "I could do this with a bit of effort" and 4 "I could do this easily". At the specificity level, this science self-efficacy questionnaire is task-specific, which meets the requirement of exploring the role of task-specific self-efficacy in the SCCT framework in this study (Jansen, Scherer, Schroeders, 2015).

In the PISA2006 project, the score of Cronbach's Alpha for science self-efficacy was 0.83 for OECD countries and 0.80 for OECD partner countries/ economies, which implied that this questionnaire had acceptable internal consistency. In addition, Nagengast and Marsh (2014) provided empirical evidence for the validity of this instrument. Since China was included in the PISA2015 project, this questionnaire has been already employed in the Chinese context (OECD, 2016). However, only B-S-J-G provinces have been involved in PISA2015, so it is possible that the PISA instruments were only valid in these advantaged provinces.

What should be noticed is that the original questions of science self-efficacy in PISA are categorical questions with four categories. For example, to transfer them into Likert typed questions, I changed the question from "recognise some science questions that underlies a newspaper report on a health issue" into "I can recognise some science questions that underlie a newspaper report on a health issue". With this change, I modified the original questionnaire into a 7-points Likert scale with answers from 1 "strongly disagree" to 7 "strongly agree," and the higher scores represented the higher science self-efficacy participants had. These changes are congruent with Bandura's (2006) guidance on constructing a self-efficacy scale that assesses whether people can do things or not instead of will do things in some given areas.

3.5.3 Science Self-Concept

Science self-concept was measured by a questionnaire modified by the science self-concept questionnaire used in the PISA2006 project (OECD, 2008). The original science self-concept questionnaire is a six-item questionnaire assessing students' general self-evaluation about their performance in school science. An example is "I can usually give good answers to test questions on school science topics" and "I can learn school science topics quickly". In the PISA2006 project, the score of Cronbach's Alpha for science self-concept was 0.92 for OECD countries and 0.89 for OECD partner countries/ economies, which indicated that this questionnaire had very high internal consistency for these samples. The original science self-concept questionnaire is a 4-point Likert scale, and it has been changed into a 7-point Likert scale in this study.

3.5.4 Interest

3.5.4.1 Interest in broad science topics

The "interest in broad science topics" questionnaire has been designed and employed originally in the PISA2015 project (OECD, 2016). The "interest in broad science topics" questionnaire is a 5-item questionnaire assessing students' extent of interest in five science topics. The topics are broad science topics such as "biosphere (e.g. ecosystem services, sustainability)" or "motion and forces (e.g. velocity, friction, magnetic and gravitational forces)" (OECD, 2016, p. 284). The original "interest in broad science topics" questionnaire is a 5-point Likert scale with the categories "not interested", "hardly interested ", "interested", "highly interested", and "I don't know what this is" (OECD, 2016, p. 284). This questionnaire has been changed into a 7-point Likert scale in this study.

3.5.4.2 Enjoyment of science

The "enjoyment of science" questionnaire has been employed in the PISA2006 project (OECD, 2008) and the PISA2015 project (OECD, 2016). This questionnaire comprises five items, assessing participants' level of enjoyment in broad science. An example is "I generally have fun when I am learning broad science topics" or "I am happy doing broad science problems" (OECD, 2008, p. 337). The original 'enjoyment of science' questionnaire is a 4-point Likert scale (OECD, 2008), and in this study, it has been changed into a 7-point Likert scale. The PISA2006 project showed the Cronbach's Alpha of the enjoyment of science questionnaire was 0.88 for OECD countries and 0.91 for OECD Partner countries /economies, which indicated this questionnaire had high inner consistency for these samples.

3.5.5 Science Career Intentions

"Science career intentions" was measured by a questionnaire modified from the Math/Science Intentions and Goals Scale (MSIGS; Fouad & Smith, 1996). MSIGS was initially designed for middle school students to assess their intentions to pursue and persist in math/science-related school activities and future careers. The original MSIGS is a 5-point Likert scale, ranging from 1 (strongly agree) to 5 (strongly disagree). An example of an item is "I plan to take more math classes in college than will be required of me," and "I intend to enter a career that will use science." MSIGS was reported to have acceptable inner reliability, as Fouad and Smith (1996) and Navarro, Flores, and Worthington (2007) reported that Cronbach's Alpha of MSIGS was 0.81.

In the present study, only four items related to science in MSIGS have been employed as the measurement approach to assessing students' science career intentions. The other three items that this study did not include were all about math-related intentions. To be consistent with other items in the present study's questionnaire, this questionnaire also has been changed into a 7-point Likert scale.

3.5.6 Family Science Capital

Family science capital was measured by a questionnaire modified from the index of family science connections from the Science Education Tracker (2017) project (Hamlyn et al., 2017). Hamlyn et al. (2017) drew on the results from the ASPIRES study (Archer et al., 2013a) that students' science career intentions were associated with the levels of science capital in their families. According to the conceptual definition of science capital, it refers to science-related networks and resources that people can utilise (Archer et al., 2015). Specifically, family science capital contains science-related skills, qualifications, and attitudes from family, opportunities to talk about science in daily life, and knowing professionals in science-related domains (Archer et al., 2016). Guided by the conceptual definition of family science capital, researchers in the Science Education Tracker project designed the Family Science Connection index to assess participants' levels of family science capital (Hamlyn et al., 2017).

There are three items in the Family Science Connection index:

> 1. Apart from your doctor, do you know anyone with a medical or science-related job that you could talk to about health, medicine, or other scientific issues outside of school?
> Don't know (score 0); No (score 0); One or two people (score 1); Three or four people (score 2); At least five people (score 2)
>
> 2. Would you say your parents are interested in science?
> Don't know (score 0); Neither parent interested (score 0); Yes-mother (score 1); Yes-father (score 1); Yes-both (score 2)
>
> 3. Does anyone in your family work as a scientist or in a job using science or medicine?
> Don't know (score 0); No-one (score 0); Siblings, Other family members in household, Other family members outside household, not mother or father (score 1); Mother or Father (score 2) (Hamlyn et al., 2017, p. 7)

According to Hamlyn et al. (2017), in the Science Education Tracker project, students were recoded into three levels of family science connection groups with score 0-2 indicating low family science connection, score 3-4 indicating medium family science connection, and score 5-6 indicating high family science connection. However, in this study, the questionnaires were modified into 7-point Likert scales to facilitate structural equation modelling analysis. Hence, the Family Science Connection index has been modified into a 7-point Likert scale. An example of a modified item is “Apart from doctors in hospital, I still know some people with medical or science-related jobs that I could talk to about health, medicine or other scientific issues outside of school” with answers from 1 “strongly disagree” to 7 “strongly agree”.

3.6 Quantitative Data Analysis Methods

3.6.1 Structural Equation Modelling Analysis (SEM)

The overall aim of the quantitative part of this study was to create structural models, including students' learning experiences, science self-efficacy or science self-concept, interest in science (interest in broad science topics or enjoyment of science), family science capital and science career intentions. By creating structural models, we could gain an in-depth understanding of why Chinese secondary students decided whether or not to choose a science-related career. To achieve this research aim, I conducted the structural equation modelling (SEM) approach in the present study. I used Amos

24 as the computer analysis tool for SEM in the present study. Specifically, the approach to structural equation modelling (SEM) in this study involved these two stages:

- Confirmatory factor analysis (CFA), employed to test and modify the measurement instruments.
- Structural regression (SR) modelling, used to investigate the hypothesised structural models.

This section briefly introduces confirmatory factor analysis (CFA), structural regression (SR) model, which together constitute the model fit test of SEM. The advantage of SEM for model investigation research is also discussed in the following paragraphs.

3.6.1.1 The Confirmatory Factor Analysis (CFA)

Firstly, the tests of the measurement tools were the preliminary operation; the tests guaranteed that measurable questions in a valid way can represent the investigated factors in the structural model. The method used to test the measurement tools was confirmatory factor analysis (CFA). According to Byrne (2016, p. 97), “confirmatory factor analysis of a measuring instrument is most appropriately applied to measures that have been fully developed, and their factor structures validated.”

To demonstrate the mechanism of CFA, the measurement model of "enjoyment of science" is set as an example here. A schematic diagram of the measurement tool for "enjoyment of science" is shown below (Fig. 3.6). The whole figure represents a measurement model for the enjoyment of science, among which the oval shape represents the investigated factor (also named the latent variable) which cannot be directly observed, the rectangles (the observed variables) represent the actual measurable questions. The circles (named the error terms) represent the part of the variances of the corresponding observed variables which cannot be explained by the latent variable (Byrne, 2016). In Amos, there is a default setting that all the unstandardised residual path coefficients and the unstandardised loading for the direct effect on any one of the indicators are fixed to equal the constant 1.0 (shown in Figure 3.7). According to Kline (2011), this set is for model identification, and most computer programs do this set by default. What should be noticed is that in the data analysis chapter, to make the figures clear, all the default constant "1" are not shown in the figures of the hypothesised models. However, these constant "1" has been set in the computer analysing processes.

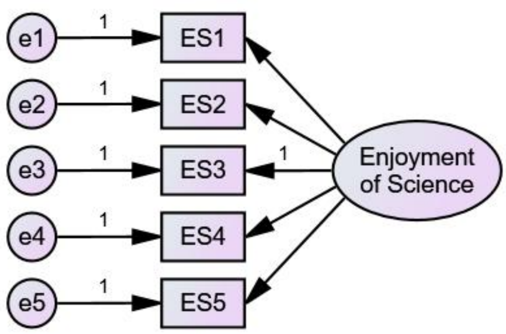


Figure 3.7 The measurement tool for enjoyment of science

Overall, a measurement model tests whether a series of observed variables can represent a latent variable. The computer tool generates a series of model fit indices that evaluate the discrepancy between the real sample covariance with the measurement model implied covariance. If the real sample covariance is close enough to the measurement model's implied covariance, then this measurement model is not rejected.

3.6.1.2 Structural regression (SR) modelling

The hypothesised model III and IV in the present study are all structural regression models. Compared with traditional factor analysis (widely used to create measurement models) and path analysis (widely used to create structural models), analysis of structural regression models synthesises both components of measurement and path models. The ability to simultaneously test hypotheses about measurement and structural relations within a single model makes this method outstanding and distinctive (Kline, 2011).

An attractive advantage of synthesising both measurement models and path models in one model is that it allows the researchers to locate the error specification of the model. For instance, SR avoids situations where strong covariances between observed variables that relate to different latent variables remain undetected. To illustrate it clearly, Figure 3.8 is shown below. In a traditional path analysis model, factor A is represented by the mean of answers responding to questions in questionnaire A and the same for factor B. However, even though the inner reliability and factorial validity respectively of questionnaire A and B are good, it is hard to detect whether the questions under factor A are exclusive only for A. If any of the questions in factor A are strongly correlated with any of the questions in factor B, that would suggest a lack of discriminant validity between these two factors (Kline, 2011). A lack of discriminant validity may influence the model fit, which apparently could not be detected clearly in a path model. By contrast, in the structural regression (SR) model, it is operable to detect this potential model fit “spoiler” by directly observing the correlated relations between questions.

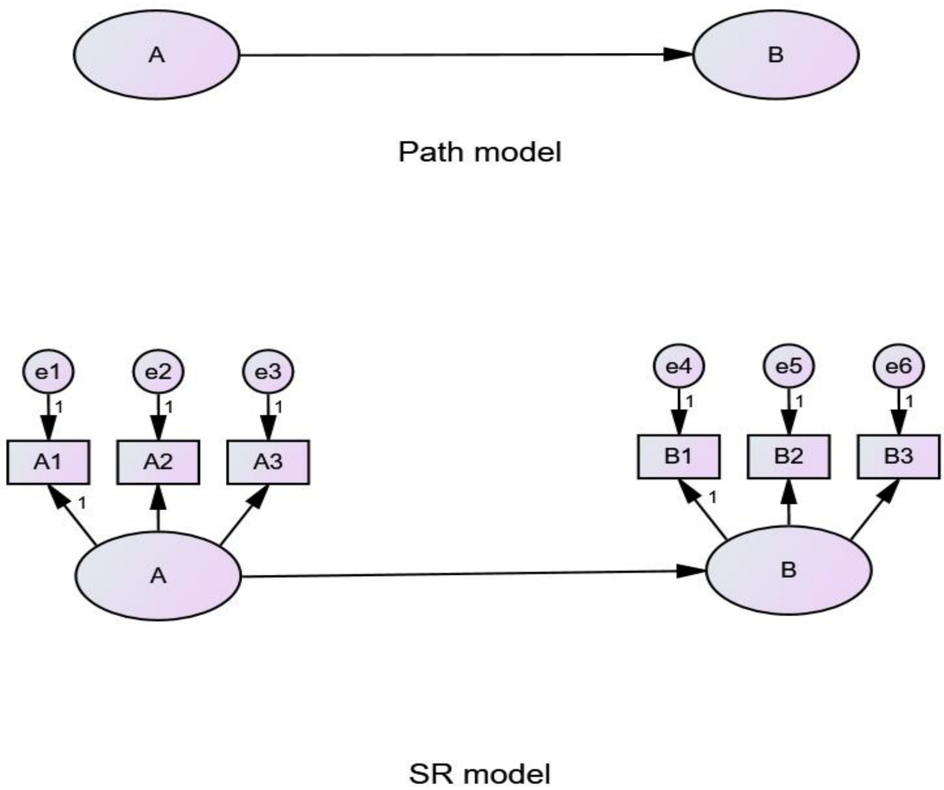
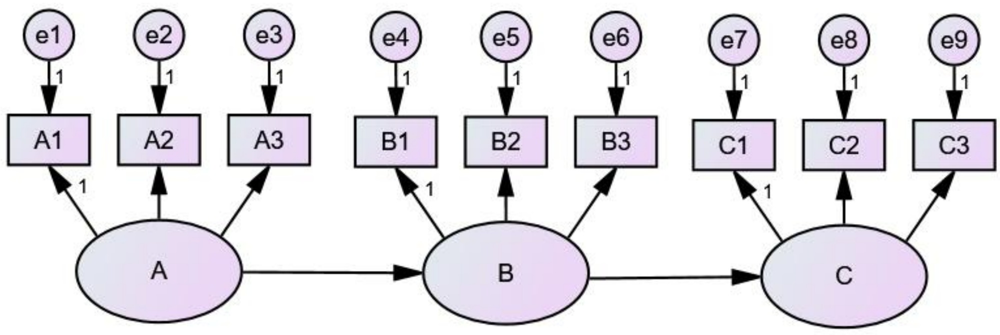


Figure 3.8 Path model and SR model

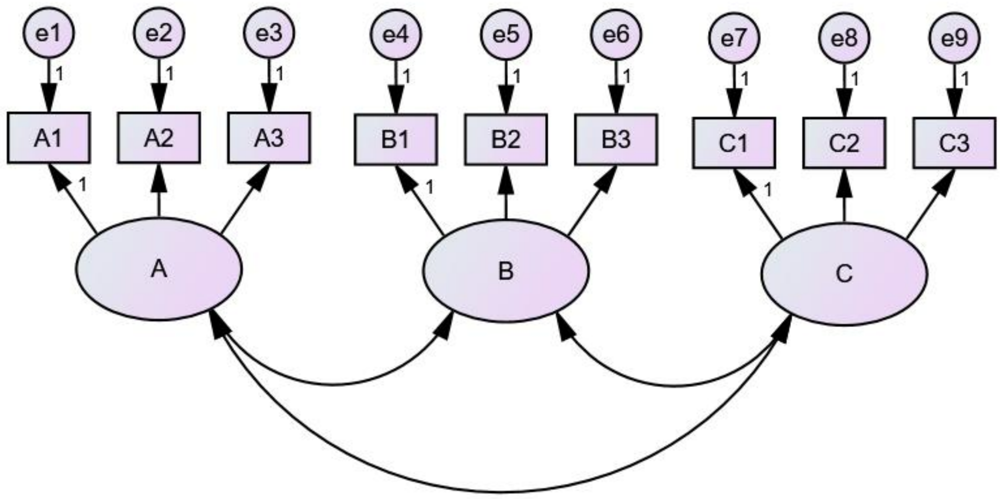
3.6.1.3 The Anderson and Gerbing two-step method

In this study, Anderson and Gerbing two-step method was used to test the hypothesised structural regression models. This method has been a widely used method to test SR models, designed by Anderson and Gerbing (1988). The Anderson and Gerbing two-step method provides clear operational steps that help researchers identify the specific "bad part" of the measurement components and, subsequently, the structural components. In step one, the SR model is re-specified into a measurement model, and CFA is used to test and modify this measurement model. In step two, the modified measurement model is re-transformed into a new SR model, which aims at testing the hypothesised effects between variables.

In the first step of the Anderson and Gerbing two-step method, the SR model is re-specified into a measurement model, and this measurement model is tested and modified by CFA. Specifically, this measurement model contains all the factors of the SR model but deletes the paths between factors that represent the direct effects in the SR model and, at the same time, adds all possible non-directional paths between any two factors. Figure 3.9 illustrates this transformation.



SR model



measurement model

Figure 3. 9 SR model and measurement model

After implementing this transformation, the SR model is re-specified into an integrated measurement model with the same factors as the SR model. Furthermore, the CFA test of this measurement model provides suggestions for modifications of measurement components and finally aims at finding an adequate measurement model.

Partial measurement model tests, with only one latent variable, test and modify the measurement model for each latent variable individually. Compared with partial measurement model tests, integrated measurement model tests containing all the factors in the SR model are necessary because whole model tests can identify the problem of collinearity between factors (Hair, Babin & Krey, 2017). Given the adequate measurement model attained in the first step, the second step is operated by re-transforming the modified measurement model back into a new SR model. In this second step, the paths between factors are changed back to the paths in the original SR model created by theoretical hypotheses. The results of model fit testings of this modified SR model provide suggestions of whether the theoretical hypotheses-based model should be rejected or not.

3.6.1.4 Model fit testings

Model fit testings aim to evaluate the discrepancy between the real sample covariance matrix with the hypothetical model's implied covariance matrix. This model is not rejected, if the real data covariance matrix is close enough to the hypothetical model's implied covariance matrix.

Three primary indices which have been widely used to assess model fit were employed in the present study: the comparative fit index (CFI), the standardised root mean squared residual (SRMR), and the root mean squared error of approximation (RMSEA) (Lent et al., 2018). The model fit may be considered adequate when CFI values are ≥0.90 (Hoyle & Panter, 1995) and preferably, ≥0.95 (Hu & Bentler, 1999); SRMR values are ≤0.08 (Hu & Bentler, 1999); and RMSEA values are ≤0.08

(Browne & Cudeck, 1992) or, more stringently, ≤0.06 (Hu & Bentler, 1999). It is considered that a model can offer a representation of the relations of variables if it meets one or more of these criteria (Lent et al., 2018; Kenny, 2011).

However, the Chi-squared testing, which functions powerfully in model fit testings, has many limitations when used in structural equation modelling (SEM), and it was not used as the model fit testing for the present study (Fornell & Larcker, 1981). Kline (2011) summarised why the Chi-squared testing could be affected in SEM. Firstly, multivariate non-normality can affect the Chi-squared value (Kline, 2011). According to Hayduk et al. (2007), under different patterns and severities of multivariate non-normality, it is possible that the Chi-squared value can increase so that the model fit seems worse than it really is or the Chi-squared value can decrease so that the model fit seems better than it really is. However, Byrne (2016) stated that most data in SEM studies cannot meet the requirement of multivariate normality in practice. Hence, the result of the Chi-squared testing for SEM may be disturbed. Secondly, a big sample size can affect the Chi-squared value (Kline, 2011). Kline (2011) stated that in samples as small as 200-300 cases, it is possible that even though the discrepancy between the real sample covariance matrix and the model-predicted covariance matrix is very small, the Chi-squared testing still shows that the null hypothesis is rejected. Unfortunately, SEM studies whose sample sizes are generally bigger than 200 are big sample studies, which seem not to be harmonious with the Chi-square testing.

3.6.2 Mediation Analysis by the Bootstrapping Method

In the hypothesised structural models in the present study, there were not only direct relations between two variables (independent variable- outcome variable) but also indirect relations through mediators. In sequential casual relationships, a mediator variable acts as a connecting factor between the other two variables (Baron & Kenny, 1986). In the present study, four mediation hypotheses in the hypothesised model III and four mediation hypotheses in the hypothesised model IV would be tested.

Mediation testings were conducted using the bootstrap method. The bootstrap method is a computer-intensive method that re-samples the collected data to generate a reference distribution, and this reference distribution is then used for significance testing (Mooney & Duval, 1993). According to Bollen and Stine (1992) and MacKinnon, Lockwood, and Williams (2004), the bootstrap method provides a promising and accurate way for mediation estimation. In this study, Amos 24 software has been employed to conduct the bootstrap analysis. Specifically, to test the statistical significance of mediation effects, drawing on the mediation analysis process by Garriott, Flores, and Martens (2013), 10,000 random samples were generated with 95% bias-corrected confidence intervals by the Amos program. Confidence intervals of the bootstrap results not including zero indicated a significant mediation effect (Mallinckrodt, Abraham, Wei, & Russell, 2006).

3.6.3 Hierarchical Moderator Regression Analysis

A moderator is a "variable that affects the direction and/or strength of the relationship between an independent or predictor variable and a dependent or criterion variable" (Baron & Kenny, 1986, P. 1174). According to MacKinnon, Fairchild, and Fritz (2007), compared with a mediator which is in a series of causal relationships between two variables, a moderator does not have direct causal effects on two variables. In the present study, there was on moderation hypothesis that would be tested.

Hierarchical regression has been employed to test the hypothesis: family science capital has a moderation effect on the path from science interest to science career intention. Since the independent variable (science interest) and the moderator variable (family science capital) were both continuous variables, the approach to testing the moderation effect employed hierarchical moderator regression analysis (Cohen et al., 2003; Baron & Kenny, 1986).

The following regression equation can represent the moderation hypothesis.

$$Y = \alpha + \beta 1X1 + \beta 2X2 + \beta 3X1X2 + \varepsilon$$

- Y： science career intentions;
- α : intercept;
- X1: family science capital;
- X2: science interest;
- ε : random disturbance (error) term.

Consistent with the guidance by Cohen et al. (2003), the first step for hierarchical moderator regression analysis in the present study was to standardise all variables to reduce the potential effects of multicollinearity. Then the interaction term (X1X2) was created by multiplying standardised X1 and X2. Subsequently, family science capital (X1) and science interest (X2) were regressed to form hierarchical model 1. Then the interaction term (X1X2) was added to hierarchical model 1 to form hierarchical model 2. The enhancement of the explanation of variance in science career intentions that accrued from the inclusion of the interaction term (in hierarchical model 2, in comparison to hierarchical model 1) would be tested for statistical significance. If it was statistically significant, the hypothesis would be supported, which indicated that statistically, family science capital significantly moderated the path from science interest to science career intentions (Cohen et al. 2003).

3.7 Qualitative Approaches

As discussed in the study design section, a qualitative study was designed based on the results of the quantitative investigation of the structure of the measurement model of "learning experiences". As discussed in the literature review chapter, previous literature has proposed many potential structures of "learning experiences", and these studies focused on providing statistical evidence for these potential structures. However, there was a lack of qualitative evidence for their proposed structures (more discussions about this are shown in the literature review chapter, section 2.6.3 critical discussion of the structure of learning experiences).

In the present study, the most widely used structure of measurement model of "learning experiences" was hypothesised initially as the structure of measurement model of learning experiences. This hypothesised model was a second-order model with four sub-factors of learning experiences, and the demonstrated figure of this model will be shown in the data analysis chapter, Figure 4.1. The follow-up qualitative case studies (data collected through a semi-structured interview method) were conducted to provide supplement evidence for the structure of learning experiences suggested by the quantitative study. The details of the study design will be shown in the data analysis chapter.

In this section, the qualitative approaches employed in the present study are introduced. Vaismoradi, Turunen, and Bondas (2013) have described the aims of qualitative approaches: "Qualitative approaches share a similar goal in that they seek to arrive at an understanding of a particular phenomenon from the perspective of those experiencing it" (p. 398).

Depending on the research questions, researchers could choose different qualitative approaches. In the present study, vignettes of participants were constructed to provide more broad information about the participants to readers. Furthermore, thematic analyses were conducted to respond to the research question of the qualitative study.

Based on data collected from a semi-structural interview, and also part of students' answers to questionnaires, vignettes of participants attending the interview study were conducted. Ely, Vinz, Downing, and Anzul (1997) have provided the function of vignettes:

> Vignettes are compact sketches that can be used to introduce characters, foreshadow events and analyses to come, highlight particular findings, or summarise a particular theme or issue in analysis and interpretation（p. 70).

Consistent with the statement from Ely et al. (1997), this study employed vignettes as the instruments which provided portraits of each case in the qualitative study. Portraits to represent participants' characters and experiences have been widely used ways of constructing vignettes (Ely et al., 1997). To enhance the trustworthiness of the vignettes, many direct quotes were involved in the vignettes (Spalding & Phillips, 2007).

In addition, a thematic analysis of student's answers to semi-structured interviews was conducted to answer the research question of the qualitative study. Thematic analysis is "a method for identifying, analysing and reporting patterns (themes) within data" (Braun & Clarke, 2006, p. 79). According to Braun and Clarke (2006, p. 87), there are six steps of thematic analysis: "familiarising with data", "generating initial codes", "searching for themes", "reviewing themes", "defining and naming themes", and "producing the report". The thematic analysis could provide detailed, complex, and rich information for the targeted themes. In the present study, it was employed to identify the relations between different learning experiences of participants, which provided evidence for the structure of “learning experiences” suggested by the quantitative study.

3.8 Ethics Consideration

This study includes two research parts: the quantitative part and the qualitative part. In the quantitative part, data were collected through questionnaires and 1161 high school students (aged 16-18) participated in the study. All the questions in the questionnaire were (modified) from previous peer-reviewed questionnaires. Participants in the pilot study did not report that there were any harmful or uncomfortable elements in the questionnaire. Students who were willing to attend this study received a link that included the information letter and consent form. The information letter includes a description of the present study, and the principles of voluntary participation, and confidentiality of the data. Only if students signed their consent forms would they be able to proceed to answer the questionnaire. In addition, in the information letter, students were told that there were two steps in the present study including a questionnaire to answer and a follow-up 30-minute interview. If they were willing to attend the follow-up interview, they should leave their contact address in the questionnaire.

In the qualitative part, data were collected through semi-structural interviews. Pre-set questions and the structure of the interview were previously discussed with my supervisor before data collection. Nine students among the participants who showed their willingness to do so went on to attended the online interview. Participants were told the topic of the interview and were informed that this interview would be audio-recorded in the information letter. Only if they signed the consent form would they proceed to the interview.

This study complies with the ethics requirement from the Department of Education's Ethics Committee. Confirmation of ethical approval for this study and consent forms are included in the appendices of this thesis.

Chapter 4 Data Analysis and Results

4. 1 Data Analysis Introduction

The analysis chapter consists of four sections:

- Section 1: preparation for the modelling construction for understanding students' science career choices;
- Section 2: preliminary tests and discussions about measurement instruments for the component variables;
- Section 3: investigation of the hypothesised structural models.
- Section 4: Comparisons of self-efficacy, self-concept, enjoyment of science, science career intentions, and family science capital among different background groups (gender, rural/urban, and parental educational level)

In the first section, three preparatory tasks before undertaking SEM employed in the present study are presented, including tests of the data for multivariate normality, screening for significant outliers, and preparing data for further cross-validation testing.

In the second section, the CFA and convergent validity, and discriminant validity testings of all the measurement instruments are presented. These testings were conducted to make sure all the measurement instruments were appropriate for the targeted Chinese participants. In addition, the variables "science interest", "self-efficacy”, “self-concept”, and “learning experiences” are specifically discussed in this section.

As mentioned in the study design section, methodology chapter (3.2.1), the two potential measurement approaches to the variable “scientific interest” - “interest in broad science topics” and “enjoyment of science” were compared through comparing their predictive effects on the variable “science career intentions”. The comparison results between these two measurement approaches to scientific interest are presented in this section.

In addition, the testings to investigate the separability between the construct “self-efficacy” and “self-concept” were conducted. If they were statistically separable, they would be respectively involved in the hypothetical structural models in the next step. The results of these separability testings are also presented in this section.

Apart from investigating the model fit of the “learning experiences” measurement model by CFA, the follow-up qualitative case studies were conducted to investigate the possible relations between the four sub-factors of learning experiences. The qualitative results are supplementary to the quantitative results of the “learning experiences” model structure. The results of these case studies are presented in this section.

It is noteworthy that the data analysis operations mentioned in the second section influenced the construct of the original hypothetical model III and IV. For example, after the structure investigation of “learning experiences”, the structure of the variable “learning experiences” was different from the original hypothesised structure. Hence, based on the testings in this step, hypothetical model III and IV were turned into hypothetical model III* and IV*.

In the third section, the results of the investigations on the hypothetical structural models are presented. As mentioned in the methodology chapter, study design section (3.2.2), three research tasks were conducted in the modelling processes.

The structural equation modelling analysis was employed to test the model fit of hypothesised model III* and IV* (constructs of model III* and IV* are respectively shown in Figure 4.27 and 4.28) and also to show path effects among variables in the hypothesised model.

The bootstrap analysis was employed to investigate hypothetical mediation effects (the hypothetical mediation effects are shown in the section 4.4.1).

The hierarchical moderator regression analysis was employed to test the hypothesis that the moderator variable “family science capital” would make moderation effects on the pathway from the independent variable “science interest” to the dependent variable “science career intentions”.

In the present study, the model construction procedures are complicated. In order to offer readers a clear and overview insight of the data analysis processes, the overview model construction flow is shown below in Figure 4.1.

In the fourth section, comparisons of self-efficacy, self-concept, enjoyment of science, science career intentions, and family science capital among different background groups (gender, rural/urban, and parental educational level) are shown.

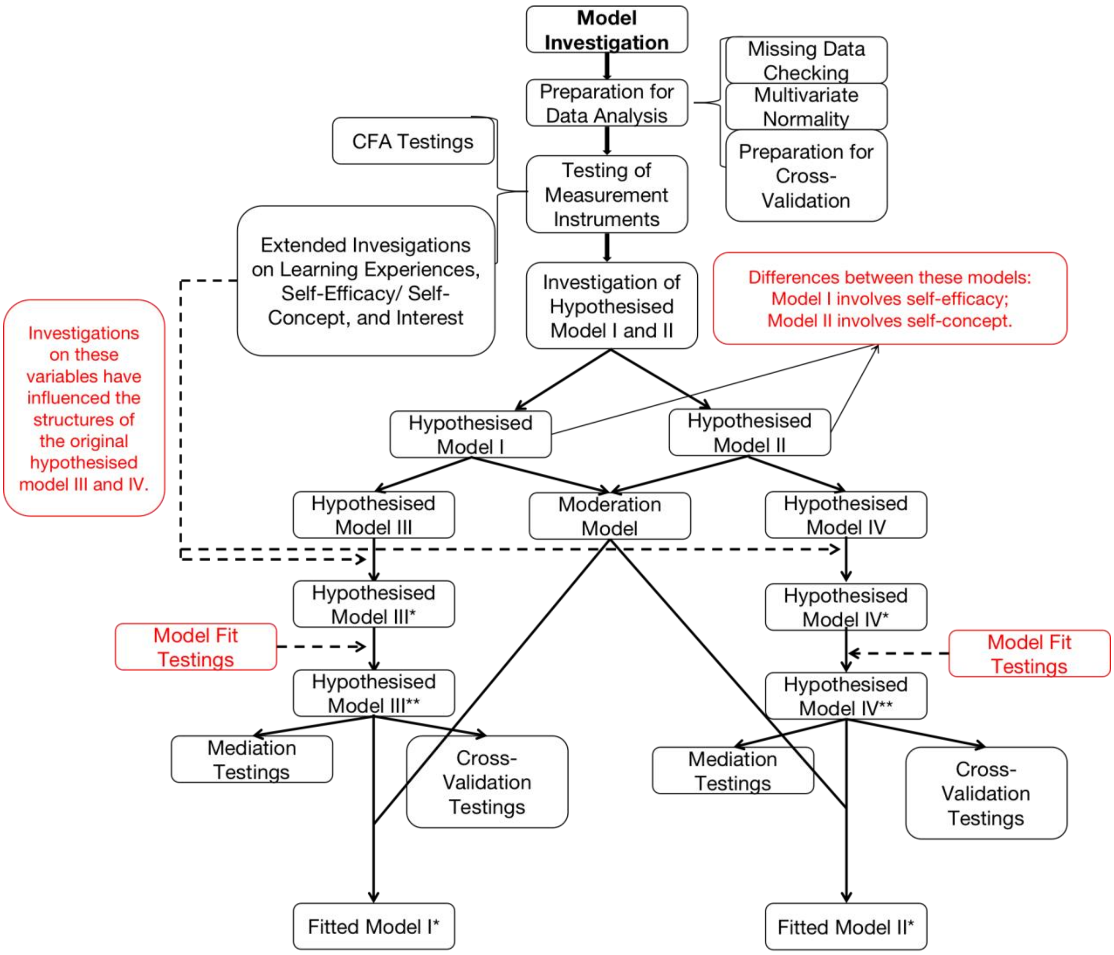


Figure 4.1 The overview flow of the data analysis processes

4.2. Preparation for Modelling Construction

4.2.1 Multivariate Normality Testing

Generally, a crucial assumption for data analysis by SEM, especially in Amos software, is that the data is normally distributed multivariate (Arbuckle, 2007). Because the default estimation method used in Amos, the maximum likelihood method (ML), is multivariate normality-based (Kline, 2010). This study employed Amos software (Amos 24) as the data analysis tool. If the data fail to meet the need for multivariate normality, the model fit indices estimated by the maximum likelihood method will be inflated or shrunk compared with what they should be in the multivariate normality situation (Byrne, 2016). Specifically, Byrne (2016) compared the Chi-squared value, CFI, and RMSEA estimated by the ML method against the Satorra-Bentler robust (S-B) analysis. The latter estimation method can address the problem of inaccurate goodness of fit indexes under multivariate non-normality. Unfortunately, the analysis software available for use in this study (Amos) does not have the function of Satorra-Bentler robust (S-B) analysis, so a suitable alternative approach was employed. The comparison between the ML method against the S-B method by Byrne (2016) showed that the Chi-squared values according to the ML method were inflated compared to that generated by the S-B method. CFIs generated by the ML method were reduced compared to that from the S-B method. RMSEAs in the ML method were inflated compared to the S-B method. Overall, the three spurious goodness of fit indices produced by the ML method consistently reflected that ML estimation under multivariate non-normality twisted the values of the model fit indices, which represented the models as worse fitted than they should be. Under conditions of multivariate non-normality, it is harder to generate a statistically acceptable model when using the ML method than it would be using S-B analysis (Byrne, 2016). Although ML estimation under multivariate non-normality can estimate parameters such as path effects or factor loadings in a statistically acceptable way in large samples, the standard errors of these estimates tend to be lower than they should be (Kline, 2010). The impacts of the underestimated standard errors are that the path effects or factor loadings will show as statistically significant in these estimates, although they are not in the population (Byrne, 2016).

Given the importance of multivariate normality, the preliminary step before data analysis in the present study was to test for multivariate normality. A prerequisite for assessing multivariate normality was the assessment of univariate normality, which is a necessary but not sufficient condition for multivariate normality (DeCarlo, 1997). Skewness and kurtosis are two indices that can examine the degree of non-normality. Generally, a variable with an absolute value of skewness of more than three is regarded as extremely strewed, and a conservative idea about the absolute value of kurtosis is that a value greater than 10 indicates serious kurtosis problems (Kline, 2010). The absolute values of skewness and kurtosis of the data in this study are shown in Table 4.1.

Table 4.1 The absolute values of skewness and kurtosis

the absolute value of skewness		the absolute value of kurtosis	
minimum	maximum	minimum	maximum
0.003	0.799	0.011	0.868

From the values in Table 4.1, based on the generally accepted rules of thumb noted above, the data were uni-variate normally distributed.

The following step was the assessment of multivariate normality. In AMOS software, it is possible to calculate the multivariate kurtosis and its critical ratio (CR). The CR value of multivariate kurtosis, in essence, represents Mardia's (1970, 1974) normalized estimate of multivariate kurtosis (Byrne, 2016). Bentler (2005) has stated that in practice if the sample has a CR value over 5, it indicates the sample's multivariate non-normality. In this study, the CR value was about 144, significantly over 5. Therefore, the data were not multivariate normally distributed. This is consistent with Byrne (2016), who has pointed out that in practice, most data in SEM studies cannot meet the requirement of multivariate normality.

Outliers refer to the cases which are highly different from other cases in a sample. Multivariate outliers refer to the cases (individual research participants) who have extreme scores on two or more variables (Kline, 2010). Given the multivariate non-normality of the data, screening the outliers may decrease the non-normality level. In AMOS software, a common method to detect multivariate outliers is by calculating the squared Mahalanobis distance (D2) for each case (Byrne, 2016). Mahalanobis distance calculates the distance of the case from the central location of all the cases (Filzmosera et al., 2005). For multivariate normally distributed data, the squared Mahalanobis distance (D2) values are approximately chi-square distributed with p degrees of freedom (Filzmosera et al., 2005). The number of degrees of freedom, p, is equal to the number of questions in the survey (Kline, 2010). According to Kline (2010):

> A value of D2 with a low p-value in the appropriate central x2-distribution may lead to rejection of the null hypothesis that the case comes from the same population as the rest. A conservative level of statistical significance is usually recommended for this test (e.g., $p < .001$). (p. 54)

However, Filzmosera et al. (2005) have insisted that defining the outlier threshold by some specific value is inaccurate, as the threshold could be influenced by many elements such as different sample sizes. Since the threshold value of the squared Mahalanobis distance (D2) has not been widely agreed upon, in Byrne's (2016) book of SEM, he gave an example of deleting the outliers based on the squared Mahalanobis distance (D2) just by the subjective judgment of how the number is distinctively distant from the centroid. In the present study, I screened the significant outliers by the method based on the subjective judgment suggested by Byrne (2016).

Table 4.2 The Mahalanobis D2 values of outliner cases

Observation number	Mahalanobis D2
144	166.571
892	151.818
870	145.887
712	131.872
1046	115.993
928	114.405

The cases 144, 892, 870, 712, 1046 and 928 showed distinctive D2 values compared with the rest of the data set. I, therefore, deleted these 6 cases to arrive at a new sample (called sample B; the original sample is called sample A). Then the multivariate CR value of sample B decreased to 126 (from 144, for sample A). Therefore, deletion of these 6 cases mitigated the non-normality of the data.

4.2.2 Post-hoc Analysis and Cross-validation

There was an interactive process going on here – a hypothesis model was developed, tested by CFA, and then respecified and checked again. An important issue that should be considered is the problems with this post-hoc analysis. Confirmatory factor analysis (CFA) is, as its name indicates, performed in order to confirm a theory-based hypothesis model. However, in practice, it is common that the original hypothesised models fail to meet the model fit, and it is necessary to respecify and re-estimate the modified model. The action of making modifications to the hypothesis model takes the process beyond the simple "confirmatory" function of CFA; the continuous use of CFA with this "exploratory" mission may lead to some issues (Byrne, 2016). Firstly, it is crucial to consider whether the re-estimation of the model is based on substantive principles. It is not the case that the only matter for consideration should be the improvement of the statistical fit of the model, according to factor analysis: it is also crucial that any modifications to the model should have substantive meanings in terms of the model's representation of the real world. Secondly, it may be inappropriate to create an over-fitted model – if the model meets the minimum fitness requirements, the temptation to add new parameters should be avoided.

Wheaton (1987) has stated that the over-fitted model with the inclusion of additional parameters may have some potential risks that

- The additional parameters may not be replicable in other samples.
- The additional parameters may lead to significant inflation of standard errors.
- The additional parameters may affect the primary parameters in the original model. which is all the more problematic if the substantive meaning of the additional factors remains unexamined.

Insofar as the considerations for post-hoc analysis, there are some rules for execution for model re-specification and re-estimation (Byrne, 2016):

- Both the feasibility and statistical significance of all the parameters should be considered.
- The model should meet the widely accepted model fit requirement.
- The model fit enhancement can be undertaken only with substantial evidence of model misfit shown in the primary model.

The characteristics of the specific sample may drive modification of the model tested in the study and may not be appropriate for the larger population (MacCallum et al., 1992). One approach to addressing this problem is called the cross-validation strategy, in which two independent samples from the same population are tested in the same respecified model. By comparing the similarity of these two samples' SEM results in the same model, the model's validation across different samples can be investigated. Cudeck & Browne (1983) have stated that, in practice, researchers could collect a large number of sample data points and randomly split them into two parts, thereby making it possible to cross-validate the results. In this sense, sample part 1 is the calibration sample used to specify and estimate a modified fit model. Sample part 2 is called the validation sample and is used to cross-validate the fitted model modified by the calibration sample.

After checking the missing data (the result showed that there were no missing data in the sample), assessing the multivariate normality, and screening out the outliers, the sample was randomly split into two parts: calibration sample and validation sample. The calibration sample was further used to explore a fitted model.

4.3 Preliminary Testings and Discussions about Measurement Instruments

This section explains why and how the questionnaires employed in this study have been subjected to model fit testings in the form of Confirmatory Factor Analysis (CFA). There are two reasons for testing them this way. Although all the questionnaires drawn from previous studies had been tested empirically before this study, the questionnaires applied for the present study did not faithfully copy every word from these previously tested instruments. The questionnaires in this study were adjusted to be more applicable for the targeted participants in the current study. Secondly, the context in China is different from the context of western countries, which are the predominantly targeted locations of investigations using these measurement instruments. Hence, the applicability of the measurement instruments used in the current study should be tested before applying them in the next research step-investigation of the hypothetical structural models.

Based on the results of CFA, some modifications have been applied to the measurement models in this study. Since the execution of post-hoc modification may result in type II error, as discussed in chapter 4.2, all the modifications in the present study were statistically reasonable and had substantive meanings (Byrne, 2016). Specifically, the CFA testing processes and related results and discussions of each measurement construct are laid out in this section.

In addition to CFA testings, in evaluating the measurement models, it is also essential to consider each model's convergent validity and discriminant validity (Hair et al., 2010). Hair et al. (2010, p. 678) defined convergent validity: "the items that are indicators of a specific construct should converge or share a high proportion of variance in common, known as convergent validity". According to Hair et al. (2010), three assessments can represent convergent validity.

The first important consideration is the size of the factor loading. Indicators' high factor loading values show that all the indicators can converge into a common point, which is one of the requirements for convergent validity. The standardised factor loading estimates should be no lower than 0.5 and ideally 0.7 or higher (Hair et al., 2010).

Reliability is also an indicator of convergent validity. Hair et al. (2010) defined composite reliability as assessing the degree of consistency between multiple measurements of a variable. Composite reliability >0.7 represents the good reliability of a measurement model (Hair et al., 2014).

To establish convergent validity, it is also necessary to consider the Average Variance Extracted index (Hair et al., 2014). The Average Variance Extracted index (AVE) provides information about how the amount of variance of observed variables (measurement questions) that is captured by latent variables (variables that cannot be directly measured) is related to the variance captured by measurement error (unknown variance contributing to observed variables). If the AVE is less than 0.5, the variance due to measurement error is larger than that due to latent variables. Then both the validity of individual measuring questions and the whole measuring model may be inadequate (Fornell & Larcker, 1981).

Measurement constructs have discriminant validity if all the constructs in a structural regression model can be differentiated from each other empirically (Fornell & Cha, 1994). The Fornell-Lacker criterion is an assessment to evaluate discriminant validity, which has been widely used in SEM studies (Fornell & Cha, 1994). This criterion compares a construct's square root of AVE with its correlations with other latent constructs. If the value of a construct's square root of AVE is higher than its correlation with other latent constructs, it means that the construct can account for a higher variance of its indicators than the variance of other latent constructs, which represents a construct that is distinct from other constructs.

The following paragraphs in this section present each measurement model's model fit testing (by CFA) and the necessary modifications based on those model fit testings. In addition, the results of convergent validity and discriminant validity testings of all the measurement instruments are also presented. All the testings mentioned above give assurance that the measurement instruments employed in this study are valid and appropriate for the targeted participants from China.

Furthermore, it is noteworthy that in addition to the applicability testings of the measurement instruments for all the variables involved in the present study, the current study has conducted extra research on these tasks:

- investigation of the hierarchical structure of "learning experiences" with both quantitative and qualitative research methods;
- separability testings between "self-efficacy" and "self-concept";
- comparison between two measurement approaches to "scientific interest".

4.3.1 Learning Experiences

4.3.1.1 Parceling strategy for learning experiences measurement model

Compared with the other measurement instruments used in this study, the measurement instrument for “learning experiences” had a hierarchical structure. As shown in Figure 4.2, it can be illustrated in this second-order measurement model. This model indicated that learning experiences (LE) measurement model used in the current study involved four sub-factors: mastery experiences (ME), vicarious learning (VL), verbal persuasion (VP), and affective state (AS) (Schaub, 2004). Each sub-factor had five questions, respectively.

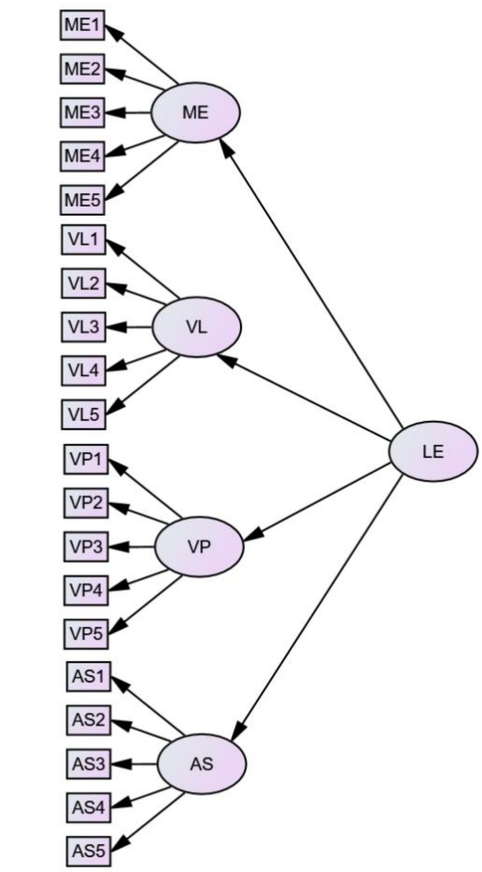


Figure 4.2 Hypothesised Second-Order Learning Experiences Measurement Model

NOTE: ME: mastery experiences; VL: vicarious learning; VP: verbal persuasion; AS: affective state; LE: learning experiences

In this study, I used the parcelling strategy to transform the second-order construct of learning experiences into a first-order construct with four factors. Little et al. (2002, p.152) have stated that "a parcel can be defined as an aggregate-level indicator comprised of the sum (or average) of two or more items, responses, or behaviours". When this measurement model was further applied in the structural regression model, each sub-factor in the second-order construct of LE would be replaced by the mean of the questions under this sub-factor, thereby making the second-order construct into a first-order construct. The structure of the first-order measurement model of learning experiences is shown in Figure 4.3.

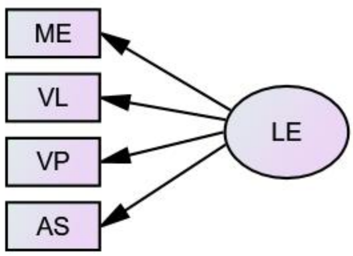


Figure 4.3 Hypothesised First-Order Learning Experiences Measurement Model Through Parcelling Strategy

NOTE: ME: mastery experiences; VL: vicarious learning; VP: verbal persuasion; AS: affective state; LE: learning experiences

The reason for employing the parcelling strategy is discussed below. Many previous studies discussed the pros and cons of the parcelling strategy. In terms of the advantages of parcelling, Little and his colleagues (2002, p.154) reviewed and summarised some advantages of parcelling strategy, noting that compared with the aggregated-level data, item-level data is likely to have the weaknesses such as "lower reliability, lower commonality, a smaller ratio of common-to-unique factor variance, and a greater likelihood of distributional violations”. In addition, the Likert-typed scales used in SEM studies are commonly regarded as assessing continuous variables (discussions about that are shown in the methodology chapter, section 3.4). The interval between scale points is considered equal for a continuous variable scale. However, the intervals between scale points are unlikely to be genuinely equidistant in practice. Fortunately, the parcelling strategy could mitigate this issue to some extent. Many studies such as McCallum, Widaman, Zhang, & Hong (1999) or Hau and Marsh (2001) found that items could have larger and less equal intervals between scale points than parcels.

Furthermore, the parcelling strategy can decrease the number of variables and thereby decrease the number of parameters in the model. Since the necessary number of cases in the sample is positively correlated to the whole free parameters of the model, decreasing the number of parameters can decrease the required sample size. It enhances the practical operability of SEM, which generally requires a large sample size (Bagozzi & Edwards, 1998).

On the other hand, there are still potential risks of the parcelling strategy; there are two concerns about parcelling strategy, according to Little et al. (2002). Firstly, when it is difficult to identify whether items underlying the same parcel are unidimensional or not, the parcelling strategy may be problematic. Bandalos and Finney (2001) have stated that unidimensionality is a prerequisite for parcelling.

Using multidimensional parcels may twist the measurement model by providing problematic factor loadings (Bandalos & Finney, 2001). Secondly, Bandalos and Finney (2001) argued that parcelling might mask some mis-specified errors, thereby improving model fit. As such, parcelling maybe not sensitive to identifying these mis-specified errors and may increase the Type II error rate (failing to reject a model that should be rejected).

In terms of the second-order learning experiences measurement model in the current study, it contained four sub-constructs: mastery experiences, vicarious learning, verbal persuasion, and affective state. The four sub-constructs were designed to be addressed by five questions each, which were derived from theory to be unidimensional. The unidimensionality of questions under each sub-construct met the requirement of items' unidimensionality under one parcel for parcelling strategy. In addition, the structural model investigated in this study was potentially complicated, with five latent variables and over 40 indicator questions with the original second-order structure of the learning experiences construct. However, employing the parcelling strategy allowed the model structure to be more parsimonious and permitted a more precise identification of the relations between latent variables, which contributed to achieving the research goal of this study.

4.3.1.2 Confirmatory factor analysis (CFA) of the parcelled version of the learning experiences measurement model

The parcelled version of the learning experiences measurement model, shown in Figure 4.3, was subjected to Confirmatory Factor Analysis to test whether or not the hypothesised construct converged with the real data. The results of CFA are shown in Table 4.3.

Table 4.3 The results of the CFA testings of the parcelled learning experiences Construct

CFI	RMSEA	SRMR
.999	.026	.015

Although all three model fit indices indicated that the parcelled learning experiences construct perfectly met the model fit requirements (CFI>0.8; RMSEA<0.08; SRMR<0.08), it still should be noticed that problematic relations between observed variables and latent variables might result in hidden problems of the measurement model (Kline, 2010). To represent the relations between all the observed variables and the learning experiences construct, the standardised regression weights are shown in Table 4.4.

Table 4.4 Standardised regression weights of regression estimates between the four sub-factors of learning experiences and the latent variable “learning experiences”

Variables	Standardised Regression Weight

VP<---LE	.846
VL<---LE	.853
ME<---LE	.717
AS<---LE	-.105

NOTE: ME: mastery experiences; VL: vicarious learning; VP: verbal persuasion; AS: affective state; LE: learning experiences

As shown in Table 4.4, the relation between the latent variable "learning experiences" and the sub-factor "affective state" was problematic. The standardised regression weight between these two variables was just -0.105, which was much lower than the lowest acceptable magnitude (|standardised regression weight| > 0.4) (Hair et al., 2010). Statistically, this indicated that affective state might not be consistent with the learning experiences construct.

The statistical result of the inconsistency of "affective state" with "learning experiences" construct indicated that the "learning experiences" construct with four sub-factors was not fit. Hence, the "learning experiences" construct was further divided into a new construct including three sub-factors: mastery experiences, vicarious learning, verbal persuasion, and an individual construct affective state. Since mastery experiences, vicarious learning, and verbal persuasion were all positive learning experiences, the new three-factor construct was termed "**positive learning experiences**".

Although the statistical evidence supported a proposition that affective state should be removed from the “learning experiences” construct in the present study, this finding still needed complementary evidence to support any conclusion that affective state was not consistent with the “learning experiences” construct for Chinese participants.

4.3.1.3 Statistical exploration of the relations between AS and ME, VP, VL

The result of confirmatory factor analysis indicated that the sub-factor “affective state" was not consistent with the “learning experiences” construct. This result implied that affective state might not be linearly correlated with the other three sub-factors of learning experiences.

To re-validate this finding, further bi-variate correlation analysis was executed on mastery experiences, vicarious learning, verbal persuasion, and affective state in pairs, respectively. The correlation results are shown in Table 4.5.

Table 4.5. Correlations between four sub-factors of learning experiences.

		ME	VL	VP	AS
ME	Pearson Correlation	1	.612**	.608**	-.032
	Sig. (2-tailed)		.000	.000	.444
VL	Pearson Correlation	.612**	1	.721**	-.105*

	Sig. (2-tailed)	.000		.000	.012
VP	Pearson Correlation	.608**	.721**	1	-.094*
	Sig. (2-tailed)	.000	.000		.024
AS	Pearson Correlation	-.032	-.105*	-.094*	1
	Sig. (2-tailed)	.444	.012	.024	

NOTE: ME: mastery experiences; VL: vicarious learning; VP: verbal persuasion; AS: affective state; LE: learning experiences

**. Correlation is significant at the 0.01 level ($P<0.01$).

*. Correlation is significant at the 0.05 level ($P<0.05$)

It is shown that mastery experiences, vicarious learning, and verbal persuasion were significantly correlated with each other, and the values of the correlation coefficients were acceptable (Cohen, Manion & Morrison, 2007). The affective state did not have a significant linear correlation relationship with mastery experiences. Although the correlation between affective state and vicarious learning and the correlation between affective state and verbal persuasion were statistically significant, the values of the correlation coefficients were too low to be meaningful in practice (Cohen, Manion & Morrison, 2007). The low linear correlation between affective state and the other three sub-factors in learning experiences construct could explain the inconsistency of affective state with “learning experiences” construct.

Further qualitative case studies were conducted to offer evidence to support that affective state was not linearly correlated with mastery experiences, vicarious learning, and verbal persuasion.

4.3.1.4 Qualitative case studies to investigate the relations between AS, and ME, VP, and VL

According to Bandura (1994), mastery experiences, vicarious learning, verbal persuasion, and affective state are four informative sources for self-efficacy. Lent, Brown, & Hackett (1994) used "learning experiences" to broadly represent the informative sources for self-efficacy and outcome expectation in the SCCT model. Lent et al. (1994) merely postulated the role of learning experiences in the SCCT model, but they did not theoretically explain the structure of learning experiences clearly. Many empirical studies have provided different suggestions for the structure of the latent variable "learning experiences" (as discussed in the literature review chapter, section 2.5.3.3). These studies just provided statistical evidence for the structure of "learning experiences". However, they did not explain the theoretical mechanism of the structures that they supported. In this study, quantitative results showed that affective state was not linearly correlated with the other three sub-factors in the "learning experiences" construct. The following qualitative case studies were conducted to find qualitative evidence to support the quantitative finding.

The Design of Case Studies

The case studies were designed to explore the possible reasons why the affective state (as measured on a Likert-typed scale in this and similar studies) was not linearly correlated with the other three learning experiences. Before the presentation of the design of case studies in this section, the theoretical discussions of the possible relations between affective state and the other three kinds of learning experiences are firstly presented. Before the discussion, it is noteworthy to mention that in this study, affective state was measured by the negative affective state such as anxiety to do science or fear to do science. In the following paragraphs, affective state indicates students' negative affective arousal.

Bandura has discussed the complexity of the relationships between the affective state and the other kinds of learning experiences. These theoretical discussions may shed light on the disputable relations between the affective state with the other three kinds of learning experiences. Looking through the theory lens of social cognitive theory by Bandura (1986, 1977, 1994), people's affective state influences their self-efficacy differently compared with mastery experiences, vicarious learning, and verbal persuasion. Bandura (1986) suggested that the nature of affective state is different from the other three types of learning experiences. He stated that people's affective state is not only a mode of learning but also a response to learning. People may experience a feeling of anxiety when they conduct a challenging task and are likely to interpret their performance in this task to be poor. This learning process teaches an individual that this task is too challenging to conduct, thereby decreasing their confidence level.

Furthermore, besides being a mode of learning, people's affective state also can be perceived as an emotional response to some stimulating experiences (Bandura, 1977). For example, people may feel upset when they are verbally criticised. The scores of school science examinations also are likely to stimulate people's affective arousal. What should be noticed is that the current study focused on students' negative affective state towards science, such as students' anxiety levels towards a few science-related tasks. Mallow and Greenburg (1983) have stated that the source of science anxiety may be from some intrusive image of painful memories. It implies that students' science anxiety may be associated with their painful and negative experiences.

Bandura (1977) discussed the relations between threatening situations and affective arousal and contended that threatening situations may stimulate people's affective arousal. What should be mentioned is that conjuring up the fear of an anticipating threatening situation could elevate this fear, and the cognitive fear of the anticipating threatening situation may be much higher than the actual fear when people encounter this threatening situation (Bandura, 1977). For example, bad results in examinations may stimulate students' anxiety, and their anticipation of bad performance in future examinations may make them more anxious.

Bandura (1977) also presented the moderating effect of self-efficacy which may reduce people's susceptibility to affective arousal when they face threatening situations. An individual who has stable high self-efficacy is not sensitive to being aroused by real or imaginative threatening situations. For example, students with high self-efficacy in science are less likely to be anxious about science examinations. In addition, according to Bandura (1994), persons with high self-efficacy tend to regard their states of affective arousal as energising facilitators of performance. By contrast, for those with insufficient self-efficacy, their affective states are more likely to be considered as debilitators. Hence, it implies that self-efficacy can buffer the stimulation of real and imagined threatening events in affective state.

In summary, the theoretical discussion of affective state indicates that the relation between the affective state with the other three learning experiences (mastery experiences, vicarious learning, and verbal persuasion) may be complicated. In nature, affective state can be a kind of learning experience that provides sources for self-efficacy and also can be a consequence of other learning experiences. In addition, affective state and self-efficacy can mutually influence each other. Affective state is not only the potential source for self-efficacy; self-efficacy also may reduce people's susceptibility to affective arousal. Self-efficacy may moderate the relation between affective state with the other three learning experiences. People with stable high self-efficacy may be less likely to have psychologically affective arousal. Hence, it is necessary to involve self-efficacy in discussing the relations between affective states with the other three learning experiences.

The case studies investigated the possible relations between affective state and the other three kinds of learning experiences. The data were collected from semi-structured interviews. Questions from the semi-structured interviews are shown in Table 4.6.

Table 4.6 The Questions for the semi-structured interviews

<table>
<tr><td rowspan="2">Background questions</td><td colspan="2">Have you chosen science courses? Why or why not?</td></tr>
<tr><td colspan="2">Do you intend to study science-related major in university? Why or why not?</td></tr>
<tr><td colspan="3">1. How do you feel about science?</td></tr>
<tr><td colspan="3">2. Do you ever feel anxious about science? What activities make you feel anxious?
(such as learning new science, doing science activities, solving science problems, working using science knowledge, having science classes)</td></tr>
<tr><td colspan="2" rowspan="3">3.Have you ever felt too anxious to do science?
(in class, exam, work, even the science-related activities)</td><td>3.1 yes</td></tr>
<tr><td>3.1.1
a) What activity (or activities) made you have this feeling
b) describe this feeling of that moment.</td></tr>
<tr><td>3.1.2
a) Did this fear about science contribute to your avoidance of learning science and doing other science related activities?
b) If you were persistent in doing science, please describe the reasons?</td></tr>
</table>

	3.1.3 Did you have the experience that even if you were very anxious, you could still do science well. What positive things have you done? Please describe it.
	3.1.4 Did you have the experience that others' encouragement could reduce your science anxiety? Or make it worse? Please describe it.
	3.1.5 Did you have the experience that looking at others doing science could reduce your science anxiety? Or make it worse? Please describe it.
	3.2 No
	3.2.1 Did you have the experience that even if you were very anxious, you could still do science well. What positive thing have you done? Please describe it.
	3.2.2 a) Did you have experience that you felt very anxious which made you do science badly or poorly? Please describe it. b) Do you think that it was your fear to science that made you do poorly in it at that time? c) Please think about the reasons why you performed successfully in the activity you described a few moments ago (3.2.1) but badly in this activity?
	3.2.3 Did you have the experience that others' encouragement could reduce your science anxiety? Or make it worse? Please describe it.
	3.2.4 Did you have the experience that looking at others doing science could reduce your science anxiety? Or make it worse?

	Please describe it.

Based on the theoretical discussion, the deductive themes about the possible relations between affective state with mastery experiences, vicarious learning, and verbal persuasion are shown in Table 4.7, for use in interpreting interview data. Based on thematic analysis, inductive themes about the possible relations between affective state and the other three kinds of learning experiences were expected to be constructed and summarised from the analysis of students' interview data. Based on students' answers, it was expected to establish possible mechanisms to explain the complex relations between affective state and the other three learning experiences (mastery experiences, vicarious learning, and verbal persuasion).

Table 4.7 Deductive themes, and codes

Themes	Codes
Theme 1. The possible relations between affective state and mastery experiences.	Code 1.1 Affective state can be negatively associated with mastery experiences 1.1.a: statements of a general nature that support this code 1.1.b: statements of a specific nature (e. g. examples) that support this code
Theme 2: The possible relation between affective state and verbal persuasion	Code 2.1 Affective state can be negatively associated with verbal persuasion 2.1.a: statements of a general nature that support this code 2.1.b: statements of a specific nature (e. g.

	examples) that support this code
Theme 3. The possible relation of affective state and vicarious learning.	Code 3.1 Affective state can be negatively associated with vicarious learning 3.1.a: statements of a general nature that support this code 3.1.b: statements of a specific nature (e. g. examples) that support this code
Theme 0. Self-efficacy could mediate the relation between affective state with other kind of learning experiences (mastery experiences, vicarious learning, and verbal persuasion).	Code 0.1 Mastery experiences, vicarious learning, and verbal persuasion positively contribute to self-efficacy
	Code 0.2 Self-efficacy could reduce people's susceptibility to negative affective arousal.
Note: Theme 0 introduces "self-efficacy" as the mediator between affective state with other kinds of learning experiences. Affective state indicates "negative affective state", such as anxiety to science.	

Nine students participated in the semi-structured interview. They were second or third-year high school students. Only two of them have not selected any science-related courses in high school. Moreover, five of them expected to have a science-related job in their 30s. The overview information about these nine participants is shown in Table 4.8.

Table 4.8 The overview information about nine participants attended the case studies

Student's name	Student' gender	Family socioeconomic background	Family science capital	School science courses' choice	career expectations in 30s
Tao	male	middle class family	higher than average	3 science courses	finance-related
Lu	female	working class family	lower than average	0 science courses	gymnast
Dong	male	working class family	higher than average	2 science courses	computer science
Hui	female	working class family	lower than average	2 science courses	computer science
Jiang	female	working class family	higher than average	2 science courses	Chemistry teacher
Tian	female	working class family	lower than average	2 science courses	teacher
Yao	female	working class family	lower than average	2 science courses	Major in electrical science or accounting to work in a state-owned enterprise
Yang	female	middle class family	higher than average	0 science courses	translator or gets a job in a company overseas

Xuan	male	middle class family	higher than average	3 science courses	a science-related job

Student Vignettes

As Ely et al. (1997) presented, vignettes are compact sketches which can be used to help readers to get broader pictures of participants. Consistent with the statement from Ely et al. (1997), this study employed vignettes as the instruments which provided portraits of each case in the qualitative study. The vignettes to portray nine participants in case studies are shown below.

1. Student Tao：

Tao was a second-year high school male student. His father was a doctor and has got a university degree. His mother was also a doctor. According to his parents’ occupation and educational level, it is implied that Tao is from a middle-class family in China (Li, 2015). His family science capital questionnaire’s mean score (4.67) was higher than the mean score (3.48) of all the participants’ family science capital. Tao has chosen all the three optional science courses (physics, biology, and chemistry) in high school but expressed that he expected to choose a finance major in his university and work in a finance-related trajectory. The reason why he has chosen finance as his future direction might be that he regarded “earning much money” as the most important factor for career choice and did not regard “changing the world” and “creating new things” as influencing factors at all. He totally agreed that “I need to work very hard on these science subjects in high school stage” and was happy to learn new scientific knowledge but did not want to have a science-related career in the future at all. He was doing science for a practical purpose – he wanted to get the best results he could get in school in order to do what he wanted at university, and he perceived that science subjects would help him to do that more than ‘arts’ subjects. His attitudes to science provide empirical evidence for Archer and her colleagues’ statement about the “doing-being divide” (ASPIRES, 2013a) that there is a division between the desire of doing science and the expectations of being science-related workers.

Interestingly, he expressed that although learning new science knowledge was a happy process, having a science job would be very boring. He evaluated his performance in school science subjects at a modest level. Generally, he did not feel anxious about school science, but occasionally he felt anxious before and during science examinations.

Though Tao was sometimes anxious about science, this did not block his positive science learning behaviours. Even with high science anxiety, he could also undertake science learning behaviours that provided him with the achievement of grasping new knowledge; this achievement could further positively contribute to Tao’s science self-efficacy.

My question: “how could you cope with this anxiety feeling for the science examination?”

Tao: “I could adjust myself. I could make up for the missing knowledge that I should grasp. I could study hard every day, which made me feel like I was not in a muddle. I could try my best to learn more.”

I further asked and tried to clarify his thought that the coping behaviour he did was to enhance his science self-efficacy by gaining mastery experiences of grasping more science knowledge and science problem-solving skills.

My question: “Can I understand your feeling that your anxiety about the science examination is derived from the lack of confidence in science knowledge? Hence, after grasping more science knowledge, you will feel more confidence and less anxiety.”

Tao: “Indeed. When I feel I have the capability to get a high score in the science examination, I will not feel too anxious.”

Tao also shared an experience about a critical science examination. Although he felt extremely anxious before this exam, he achieved a good result in the end.

Tao: “When I was preparing for Zhongkao (the high school entrance national examination), I was really afraid of failing this examination. So I was very anxious, which influenced my digesting function. I felt sick when I ate food. I did not want to study every day, but I still persisted in preparing for the examination. And the result for this examination is not bad.”

Others' encouragements might mitigate Tao's science anxiety to some extent.

Tao: "There was one time that I got a bad score for the scientific examination. One of my friends who also failed that exam came to comfort and encourage me. And I felt better by his words."

My question: "Why did his words make you feel less anxiety?"

Tao: "I felt psychologically balanced. It is like someone was with me, and I was not the only one who did bad."

My question: "Did you have the experience that others' encouragement could enhance your anxiety about science?"

Tao: "No, if others said that I am good at science, I would be very happy."

Observation of others doing science might mitigate his anxiety about science, especially when he did not try this science-related task by himself but was already frightened by his imaginary fear of the task.

My question: "Did you have experiences that observing others doing science-related activities could mitigate your science anxiety?"

Tao: "Yes, I had. I was told that new scientific knowledge was very hard to learn. So, I had been anxious to learn it. However, I accidentally watched someone teaching others to solve a problem about it. It looked like it was not hard as I imagined before. So, my anxiety about learning that knowledge was reduced. I guess that observing others doing science can let me know how hard it really is, instead of just being terrified by my imaginary fear.”

2. Student Lu

Lu was from a working-class family where both her parents have not been to university. Only her mother has been to high school. Her mother was a farmer, and her father was a technical worker. The mean score (2.67) of her family science capital questionnaire was lower than the mean score (3.48) of all the participants’ family science capital. She did not choose any optional science courses in the high school stage. According to Lu, her decision to give up science was related to her anxiety about science. And her anxiety about science was highly correlated with her feeling of lack of capability to understand new knowledge in science courses and to gain good results in science examinations.

Lu: “I was interested in learning science at the beginning. However, when the science courses gradually became harder and harder, I felt that they were very hard to understand, and I lost interest in them. I felt anxious when I could not understand the new knowledge taught in school science courses. I always felt deep anxiety before the scientific examination. Generally, I could review my notebook of science knowledge taught in the school science courses and think about the possible questions for science examinations. However, I did not feel that I gained the capability to succeed in science examinations through this kind of preparation. So I always felt anxiety.”

Others' encouragements could mitigate her anxiety about science to some extent, but the effects of encouragements were not maintained for a long time if she could not attain real achievements related to science to enhance her feeling of capability.

Lu: “I remembered there was one time in my physics lesson that I was carefully taking notes and listening to the teacher, but I just could not understand what the teacher said. After class, I was sad and crying in my seat. The monitor comforted me and encouraged me. I felt that I could not give it up when I was encouraged. However, other people's encouragements just could play psychological effects, which had little effect on my motivation to learn science. When the school science courses became harder and harder, my helpless feeling about science came back. Actually, I do not believe that I can do science well as others said. Unless I really can learn school science well, the effects of others' encouragements do not last long.”

Watching others doing science well might enhance Lu's anxiety about science. It was probable that getting science mastery experiences was very hard for her, which resulted in her perceived science self-efficacy being maintained at a low level, so it was a challenge for her to believe in science again. Although vicarious learning is an informative source contributing to science efficacy, Lu, with very low-level science self-efficacy, did not perceive watching others doing science as an implication that she could also do science well as others; actually, she debilitated herself when she encountered a science-related task, and then others' mastery experiences related to this task would turn into a kind of peer pressure for her.

Lu: “Watching others doing science, especially when those people could do science very well, would increase my pressure. Because I would perceive in mind that I could not do science well, but they could.”

3. Student Dong

Dong was from a working-class family where both his parents have not been to high school and were working in sales now. However, his family science capital questionnaire’ s mean score (4.67) was higher than the mean score (3.48) of all the participants’ family science capital. It implies that although both his parents did not work in a science-related domain, his family still provided him with a relatively strong science-connected atmosphere. He has chosen two optional science courses in the high school stage and expressed that he expected to choose computer science as his major in university. He regarded earning a lot of money, helping others, and making his parents happy as very important factors influencing his occupation choices but did not regard changing the world as a factor that influenced his career choices at all.

Although Dong could do well in school science, he still would feel a little bit nervous and anxious when he solved science-related questions and learned new scientific knowledge in school science courses. He did not think that learning school science was easy for him. He was determined to work hard to gain high scores in the college entrance examination. Hence, the anxiety feeling about science did not block his science learning behaviours. He had his own tips for coping with his anxiety feelings, which helped him refresh himself and devote himself to science learning again.

Dong: “I got upset when I did not understand formulas or when I tried to solve hard problems in science. However, I never ever thought to give up studying science. Because I want to do well in the university entrance examination, since I have chosen science, no matter how difficult it is, I will never give up. In this society, you need to go to college if you want to do big things. Since a degree from a good college can help you have a job you like, and you will have a better life.”

In China, the college entrance examination is a competitive examination, through which only the students who get higher scores can choose their preferred colleges and majors. Dong had a strong sense of competition in his school life. Watching others learn science or do science-related activities would make him feel peer pressure and trigger him to work harder. In another way, sometimes Dong gained more interest in science by watching others conduct science activities.

Dong: “If I want to give up, but I look around and see that the other students are learning, I will have a terrifying feeling, so I dare not give up. You know, if others are improving but I am not, I will lose my opportunity to a good college.”

Dong: “Sometimes when I see other people carrying out scientific activities, I think scientific activities are very interesting to generate some interest to relieve the pressure. For example, watching others doing some chemical experiments and physical experiments.”

Others’ encouragements were very important for Dong. He could reduce his anxiety and had the energy to devote himself to studying again through others’ encouragement.

Dong: “What I like most is the encouragement from others. I remember once, my math teacher said that I did a good job in the learning plan. From then on, I felt very comfortable and became a little interested in mathematics. Then, my math exam results improved a lot.”

4 Student Hui

Hui was from a working-class family where both her parents have not been to high school and worked in sales. Compared with the mean score (3.48) of family science capital from all the participants, the mean family science capital score (1.33) of Hui was relatively low. In Hui’s family, science-related topics were rarely discussed, and the science cultural capital of this family was low. She expressed that she wanted to study further in university and expected to major in computer science. She thought that this qualification provided her with opportunities to be a white-collar worker.

School science courses were hard for Hui. According to her, sometimes it was really difficult for her to understand new science knowledge taught in class, and she thought that she could not do well in school science examinations. Although she expressed that she did not have many mastery experiences in school science, she did not show extreme anxiety about science.

She also experienced a low mood when she felt the science knowledge taught in class was too hard to understand, which made her want to give up learning science. However, teachers' encouragements made her believe that hard work would be repaid, and those encouragements relieved her anxiety in science. Hence, she kept up working hard in science.

Hui: "I really wanted to give up a few times. Since I had studied very hard, I still couldn't make it, so I didn't want to work hard anymore. But the headteacher and other teachers said that 'You need to work very hard in the high school stage. If you work hard, you may succeed one day.' So I didn't want to give up."

Interestingly, her teachers' encouragements were not phrases such as "you can do science well", which could lead her to believe in her science ability. Instead, teachers' encouragements persuaded her to believe that even though she had some trouble in school science learning at that time, all these problems would be solved if she kept working hard. This implies that encouragements based on the value of hard work may have stronger effects than encouragements based on persuading students that they have the capability to be competent in particular tasks under circumstances in which students have already evaluated that the tasks are challenging for them.

This implication is consistent with Weiner’s attribution theory (1974) that people’s attributions of their success or failure will have significant effects on their future behaviour. According to Weiner (1974), hard work is a controllable factor; in contrast, capability, which seems more related to intrinsic personal characteristics, is less controllable. When people attribute their temporary failure in science to a lack of hard work, they still feel capable of making improvements by making more effort. However, a student who attributes his/her temporary failure in science to a lack of science capability is more likely to have a sense of helplessness.

In addition, students’ reflections on different kinds of encouragements are also consistent with Carol Dweck’s (2007) work on mindsets. Carol Dweck (2007) has stated that students with growth mindsets are more likely to regard things as developmental, and persons’ success as the result of their hard work, instead of just the automatic reflection of how capable they are. Hence, Hui’s answers imply that the encouragements on students’ efforts rather than their ability are a great strategy to give verbal encouragement.

Observation of others conducting science-related activities could release Hui’s anxiety about science.

Hui: “Once I went to the chemistry laboratory to do experiments, my classmates did very well, so I thought the chemistry experiment was very simple.”

Hui: “if others can do it well, I also can do it well.”

5 Student Jiang

Jiang was from a working-class family where neither of her parents has been to high school. However, her mean family science capital score was 4.00, which was higher than the mean family science capital score (3.48) of all the participants. Jiang expressed that she expected to choose chemistry as her major in university and expected to be a teacher in the future.

Jiang had her own method to balance her psychological world and knew how to reduce her own anxiety when she encountered hard science questions. She also would like to try all kinds of methods she could think of to improve her science learning in school. If she began to focus on the real ways to improve her learning results, rather than just being freaked out by science, she would forget her fear of science and be in a positive situation.

Jiang: “When I first entered high school to study physics, I was anxious. At that time, I was blindly anxious rather than analysing the cause of the problem from the essence. Later, I slowly adjusted myself and thought that there must be reasons for the problem, and I needed to find reasons out rather than just be anxious.”

The effects of watching others doing science were a double-edged sword for Jiang. On the one hand, when she encountered an imaginary hard task that she had not experienced by herself, watching others do it would relieve her fear. However, when she encountered a really difficult task by herself, watching others doing it well would add more peer pressure on her.

Encouragements also played two kinds of effects on Jiang. On the one hand, encouragement from the persons whom she admired might enhance her anxiety. She expressed that she was afraid to make them disappointed since these persons’ encouragements were perceived as expectations by Jiang. On the other hand, sometimes, when she was anxious, others' encouragements could release Jiang’s anxiety to some extent.

Jiang: “Recently, I just changed a physics teacher, who is extremely responsible and serious. He often praised me in class, and then I was afraid to disappoint him, and I was afraid that I would not do well in physics.”

6. student Tian

Tian was from a working-class family where neither of her parents has been to high school. Her mother was a housewife, and her father was a chef working in a small restaurant. The mean score of her family science capital was 1.67, which was lower than the mean score (3.48) of family science capital from all the participants. Although she has chosen two optional science courses in high school, she expressed that she expected to choose education as her major in university and was eager to be a teacher in the future. She regarded helping others as the most important factor which influenced her career choices. Overall, she thought that she was competent in acquiring new knowledge well, within the bounds of school science, and was confident in her ability in school science. However, she did not prefer to choose a science-related job in the future.

Tian expressed that she only had modest anxiety about science before school science assessments. It is noteworthy that her anxiety about science had different effects on the assessment results. For example, generally in her mind, her anxiety could affect the assessment results negatively. However, as she said, when she has prepared well for a science examination, the anxiety emotion could contrarily make her concentrate more on the examination. At that time, although Tian was worried about the consequence, thorough preparation allowed her to feel confident. When she felt that she had the capability to perform a task well, although she could also be worried about the results, Tian could devote herself to doing this task, and consequently, the results turned out to be not bad. Tian’s story supports the statement by Bandura (1977) that self-efficacy could reduce people’s susceptibility to negative affective arousal.

Tian: “I began to worry about the bad results for tests before I started exams, but when I fully prepared for the exam and did what I should do, I would be confident. Although I also would be anxious, this kind of anxiety could make me concentrate more on the test questions. The results would be better.”

Others’ encouragements had two contrasting effects on Tian’s cognition, which could both reduce her anxiety and enhance her pressure. The encouragements with positive effects on Tian came from those people who persuaded her to believe in the value of hard-working work and to believe that she would make progress and change the unsatisfactory situation if she worked hard at school science. However, the encouragements which were perceived as expectations by Tian made her have more pressure since she did not want to disappoint the people whom she admired.

Tian: “I didn’t do well in the opening exam. Then a month later was the monthly exam, the opening exam made me a little afraid of the exams, so I didn’t want to participate in the monthly exam. But when I had dinner that day, the headteacher asked me, “did the last exam hit you?” and then she said, “you don’t want to take the exam because you are afraid of failure. As long as you believe in yourself and work hard, you can make progress. You should believe that you can.” I felt that my anxiety about the exam reduced a lot because someone was encouraging me and believing in me. I thought I would try my best to be better.”

My question: “Was it the teacher’s trust in you that made you believe in yourself again?”

Tian: “Not really; I think it was that my good preparation and her trust cooperatively let me believe in myself.”

Tian: “My parents encouraged me, but these encouragements made me feel that too much hope rested on me. I felt that if I couldn’t do it well, I would disappoint my parents.”

Watching others doing science-related activities well might enhance Tian’s anxiety. Others’ good performance in science could be perceived as a kind of peer pressure for Tian.

Tian: “When others did experiments well, I worried that I was not as good as them. This comparison made me feel anxiety.”

My question: “Have you ever had such an experience? For example, it was very difficult to perform a task in your imagination, but when others made it, then you thought, ah! It turned out that this was not as difficult as you imagined before.”

Tian: “I do not think I will regard a hard thing as an easy thing only if I see that others can perform it well.”

7. Student Yao

Both parents of Yao were farmers who have not experienced high school education. The mean score of her family science capital was 1.33, which was lower than the mean score (3.48) of family science capital from all the participants. She expressed that she expected to choose electrical science or accounting as her major in university and was eager to work in a state-owned enterprise in the future.

Yao only showed anxiety for science examinations, but for the other science-related activities, she thought that they were either less important for her or easy for her. She thought that the results of science examinations were very important, and her anxiety about science examinations was derived from her lack of self-efficacy in getting good results in science examinations.

Yao: “When I did experiments, I felt like I could do them well. And I didn’t regard answering questions in science class well and right as important tasks. Hence, I did not feel anxiety about these activities.”

Others’ encouragements could mitigate her anxiety about examinations to some extent. However, the effects of that were very limited. She did not think others’ encouragements could aggravate her anxiety.

Yao: “For example, I was very nervous before science exams. And others would comfort me and try to let me not be nervous, but I would still be nervous.”

Watching others do science had different effects on her anxiety under different circumstances. On the one hand, watching others doing the science-related tasks might mitigate her anxiety. On the other hand, when watching others do science transformed a comparison between Yao and her peers in Yao’s mind; others’ achievements were likely to give Yao more peer pressure, which aggravated her anxiety.

Yao: “There was one time when I did an experiment, I was afraid that I was going to mess it up by shaking my hands. But when I saw that others have done it smoothly, I felt that I could do it well by myself and my fear was relieved.”

Yao: “But when I came across the questions that I couldn’t do in the exams if others can do them, I would be very anxious.”

8 Student Yang

Yang was from a middle-class family, where both her parents had business work. The mean score of her family science capital was 4.00, which was higher than the mean score (3.48) of family science capital from all the participants. She aspired to be a translator or to get a job in a company overseas. Insofar as that, she wanted to choose a major in English language and literature at university.

Yang has not chosen any optional science courses in high school. She thought that her abandonment of science was highly related to her feeling of inability in science. Compared with science knowledge in high school, it was easier for her to acquire liberal arts knowledge.

Yang: “Whenever I felt anxiety over a science-related activity, I would mess it up.”

Others’ encouragements had only limited effects on alleviating Yang’s anxiety in science, and the effects did not last for a long time. Observing others doing science-related activities could not boost her motivation for science. Although people around her have tried to persuade her to choose science, Yang firmly believed that she could not do science well.

Yang: “I am determined that I cannot do science.”

9 student Xuan

Xuan was from a middle-class family. His father was a doctor and got a bachelor’s degree, and his mother was a teacher. Xuan has chosen all three optional science courses in the high school stage. The mean score of his family science capital was 4.00, which was higher than the mean score (3.48) of family science capital from all the participants. What is interesting is that although Xuan’s father had a science-related job, Xuan stated that few people around him could talk about science-related topics with him. He expected to find a science-related job in the future.

Xuan, in contrast to the majority of other participants in the case studies, was eager to do science just because of his intrinsic interest in science. However, for the majority of other participants, the reason to work very hard in learning school science was to attain high scores in the college entrance examination, which would provide them with opportunities to go to prestigious colleges. Although Xuan was interested in investigating hard science questions, he expressed that he was tired of summative science assessments.

Xuan: “I enjoy the process of investigating science questions. When I came across a problem that I was interested in, I would start to do it. Of course, the process would be very difficult, and sometimes there was no progress in a week or two. Sometimes, a problem might be shelved for several months. Of course, there were also many times that I could succeed by constantly trying. You know, it takes inspiration to solve questions. Generally, I don’t give up.”

Xuan: “I feel that I am not very adapted to the exam-oriented education mode. I enjoy the feeling of inquiry, and the examinations require us to be compared with each other, which is not of great significance to me. In my opinion, the aim of school learning is not to strive for the first place, but to learn knowledge.”

Generally, Xuan hardly felt anxiety when he learned science or did science-related activities in school. He thought that he was good at school science. Although overall he felt capable in school science, he would also have feelings of inability and anxiety if he worked hard but did not make any improvement. However, Xuan was capable of coping psychologically with this anxiety.

Xuan: “My personal-psychological quality is very good, and I often adjust myself, so I generally do not have too much psychological pressure. Although school life is packed with pressure and endless to do-tasks, I try my best to keep a positive and happy learning life. I am used to walking casually on campus once a week and having a full meal every day, and I always eat whatever I want. Sometimes when I feel sad, I will go running to alleviate this feeling. I don’t have much entertainment in school. Recently, I liked to go to the corridor of the teaching building after school. I also like to appreciate flowers. If I have enough time, I will investigate mathematics.”

In addition, he would be positive to find coping strategies to solve the problem, when he encountered some problems in school science. For example, he would find teachers to analyse the reasons for his failure in the exam.

Xuan: “Last time I failed my biology test, I was a little worried and went to communicate with my teacher. The teacher could analyse your test paper and your recent learning status. Of course, he could provide methods and suggestions. After communicating with the teacher, I felt that my mind was comfortable.”

Others’ encouragements could alleviate Xuan’s anxiety to some extent and never enhance his anxiety. However, what is interesting is that he said he did not pay much attention to others. It implies that vicarious learning had little effect on him.

Xuan: “Actually, I don’t like to care about what other people are doing.”

Thematic analysis process

Theme 1: The possible relations between affective state and mastery experiences.

Based on the theoretical discussion of affective state, a deductive code about the possible relations between affective state and mastery experiences was designed:

Code 1.1:

Negative affective state is negatively associated with mastery experiences

Code 1.1 hypothesised that students’ negative affective state, such as anxiety and nervousness, is negatively associated with mastery experiences. Seven participants mentioned the experiences that they were anxious due to their bad performance in school science learning. The analysis from the case studies is consistent with Bandura’ s (1977) statement that affective state is aroused by threatening situations.

For example,

Lu: “I felt anxious when I could not understand the new knowledge taught in school science courses.”

Dong: “I got upset when I did not understand formulas or when I tried to solve hard problems in science.”

Negative affective state could be aroused by bad performance. Furthermore, it seems that students who are more likely to have mastery experiences in science are less likely to perform badly in science. Hence, code 1.1 is supported by the case studies, that affective state is negatively associated with mastery experiences.

However, student Tao, Dong, Jiang, and Xuan shared their experiences in the interviews that despite serious anxiety, they still achieved mastery experiences. This phenomenon may not support code 1.1.

According to Bandura (1977), theoretically, in accord with affective state, people tend to display avoidance behaviours when they encounter threatening situations and to be reluctant to practice. Consequently, as a vicious circle, people may have fewer mastery experiences and lower confidence without practice. Through analysing the interviews, I found that those students who had significant anxiety but also got successful experiences in science-related activities had coping strategies under threatening events. With coping strategies, they could actively engage in actions to solve problems, thereby securing achievement in the end.

Students coping strategies under threatening situations might be various. For example, student Tao shared an experience about a very important science examination. Although he felt extremely anxious before this exam, he achieved a good result in the end. Under this threatening situation, Tao devotedly prepared for the examination. His persistence overcame his avoidance idea, and in the end, he got a great result. Tao’s coping strategy was persistently hard working.

Tao: “When I was preparing for Zhongkao (the high school entrance national examination), I was really afraid of failing this examination. So I was very anxious, which influenced my digesting function. I felt sick when I ate food. I did not want to study every day, but I persisted in preparing for the examination. And the result for this examination is not bad.”

Similarly, student Dong also showed that he was very persistent and never gave up when encountering threatening situations about science.

Dong: “I got upset when I did not understand formulas or when I tried to solve hard problems in science. However, I never thought to give up studying science. Because I want to do well in the university entrance examination, I will never give up since I have chosen science, no matter how difficult it is.”

Jiang had her method to balance her psychological world and knew how to reduce her anxiety when she encountered hard science questions.

Jiang: “When I first entered high school to study physics, I was anxious. At that time, I was blindly anxious rather than analysing the cause of the problem from the essence. Later, I slowly adjusted myself and thought there must be reasons for the problem, and I need to find reasons out rather than be anxious.”

Similarly, student Xuan was also capable of coping psychologically with this anxiety.

Xuan: “My personal-psychological quality is very good, and I often adjust myself, so I generally do not have too much psychological pressure. ... Although school life is packed with pressure and endless “to-do” tasks, I try my best to keep a positive and happy learning life. ... Sometimes when I feel sad I will go running to alleviate this feeling.”

Based on the analysis of the students' interviews, there is a new inductive code under theme 1.

Inductive code 1.2:

Students' coping strategies under threatening situations may moderate the relation between their affective state and mastery experiences.

Theme 2: The Possible Relations Between Affective State and Verbal Persuasion

Based on the theoretical discussion, a deductive code under this theme was designed:

Deductive code 2.1:

Affective state is negatively associated with verbal persuasion

All the participants in the case studies expressed that positive encouragement might reduce their affective arousal to some extent, which supports code 2.1.

For example, student Tao said: “There was one time that I got a bad score for a science examination and felt really depressed about science. One of my friends who also failed that exam came to comfort and encourage me. And I felt better by his words.”

However, the effect of verbal persuasion on mitigating students’ negative affective state was limited and could not last long, especially for students who were self-doubting about their capability.

For example, student Lu said: “I remembered there was one time in my physics lesson that I was carefully taking notes and listening to the teacher, but I just could not understand what the teacher said. After class, I was sad and crying in my seat. The monitor comforted me and encouraged me. I felt that I could not give it up when I was encouraged. However, other people’s encouragements just could play a psychological effect, which had little effect on my motivation to learn science. When the school science courses became harder and harder, my helpless feeling about science came back. Actually, I do not believe that I can do science as well as others said. Unless I really can learn school science well, the effects of others’ encouragements do not last long.”

As discussed before, students’ answers indicated that encouragements might mitigate their negative affective arousal. By contrast, two students stated that encouragements might enhance their negative affective arousal when the encouragements were regarded as conveying unrealistically high expectations.

For example, student Jiang shared her story. She said that encouragement from the persons she admired could enhance her anxiety. She was afraid to disappoint them since these persons' encouragements were perceived as expectations by Jiang.

Jiang: "Recently, I just changed a physics teacher, who is extremely responsible and serious. He often praised me in class, and then I was afraid to disappoint him and that I would not do well in physics."

Similarly, Tian shared his story that encouragements enhanced his pressure.

Tian: "My parents encouraged me, but these encouragements made me feel that too much hope rested on me. I felt that if I could not do it well, I would disappoint my parents."

The case studies show that, under some contexts, students may regard verbal persuasion as "over-expectation" on them. In this situation, verbal persuasion may enhance students' negative affective state. A new inductive code 2.2 under theme 2 is shown below.

Inductive code 2.2:

Verbal persuasion regarded as over-expectation may enhance students' negative affective state.

Theme 3: The Possible Relations of Affective State and Vicarious Learning

Based on the theoretical discussion, a deductive code under this theme was designed.

Deductive code 3.1:

Affective state is negatively associated with vicarious learning

Five students expressed in the interview that vicarious learning helped them reduce their negative affective arousal. It is noteworthy that some students expressed that vicarious learning did not directly mitigate their negative affective state, but directly enhanced their self-efficacy, thereby mitigating their negative affective state.

For example, for student Tao, observing others doing science can enhance his self-efficacy and mitigate his anxiety about science, especially when he has not tried this science-related task by himself but has already been frightened by his imaginary fear of the task.

Tao: “I was told that new scientific knowledge was tough to learn. So I had been anxious to learn it. However, I accidentally watched someone teaching others to solve a problem about it. It looked like it was not hard as I imagined before. So my anxiety about learning that knowledge was reduced. I guess that observing others doing science can let me know how hard it really is, instead of just being terrified by my imaginary fear.”

For Student Hui, observing others conducting science-related activities also enhanced her self-efficacy and released her anxiety about science.

Hui: “Once I went to the chemistry laboratory to do experiments, my classmates did very well, so I thought the chemistry experiment was very simple.”

Hui: “if others can do it well, I also can do it well.”

In addition, for some students, watching others doing science triggered their interest in science, which further relieved their negative affective state.

For example, Dong: “Sometimes when I see other people carrying out scientific activities, I think scientific activities are very interesting, so as to generate some interest to relieve the pressure. For example, watching others doing some chemical experiments and physical experiments.”

However, vicarious learning could not only reduce students’ affective arousal: as students’ experiences showed, under some circumstances, when vicarious learning stimulated students’ peer comparison and competition, vicarious learning could, on the other hand, worsen their negative affective arousal. Five students expressed that vicarious learning has enhanced their negative affective state.

For example, for student Yao, watching others doing science had different effects on her anxiety under different circumstances. When watching others doing science well, science was transformed into a competition between Yao and her peers in Yao’s mind; others’ achievements were likely to give Yao more peer pressure, which aggravated her anxiety.

Yao: “when I came across the questions that I could not do in the exams, I would be very anxious if others could do them.”

For student Dong, watching others learning science or doing science-related activities made him feel peer-pressured.

Dong: “If I want to give up, but I look around and see that the other students are learning, I will have a terrifying feeling... You know, if others are improving but I am not, I will lose my opportunity to a good college.”

Similarly, for student Lu, vicarious learning did not contribute to her self-efficacy in science, instead of that, vicarious learning was transformed into pressure for her, which worsened her affective arousal.

Lu: “Watching others doing science, especially when those people could do science very well, would increase my pressure. Because I would perceive in mind that I could not do science well, but they could.”

Hence, there is a new inductive sub-theme under theme 3

Inductive code 3.2:

When vicarious learning stimulates students’ peer comparison and competition, this may lead to a negative affective state such as over-pressure.

In addition, different from other students, student Xuan is a special case. Vicarious learning did not have strong effects on him. He was more likely to focus on his own world and did not pay much attention to others’ behaviour.

Xuan: “Actually, I don't like to care about what other people are doing.”

Hence, based on Xuan’s story, one new inductive code is summarised under theme 3.

Inductive code 3.3:

Affective state is irrelevant to people’s vicarious learning.

Based on thematic analysis of the interview, under three themes (relations of the affective state with mastery experiences, verbal persuasion, and vicarious learning), in addition to the deductive codes from the theoretical discussion, there are new inductive codes summarised from students' experiences. Deductive codes and inductive codes, are summarised in Table 4.9

Table 4.9 Deductive and inductive themes, codes

Themes	Codes
Theme 1. The possible relationship between affective state and mastery experiences.	Code 1.1 Affective state is negatively associated with mastery experiences
	Code 1.2 Students' coping strategies under threatening situations may moderate the relation between their affective state with mastery experiences.
Theme 2: The possible relationship between affective state and verbal persuasion	Code 2.1 Affective state is negatively associated with verbal persuasion
	Code 2.2 Verbal persuasion regarded as over-expectation may worsen students' affective state.
Theme 3. The possible relationship of affective	Code 3.1 Affective state is negatively associated with

state and vicarious learning.	vicarious learning.
	Code 3.2 When vicarious learning stimulates students' peer comparison and competition, this peer comparison and competition may turn into negative affective state such as over-pressure.
	Code 3.3 Affective state is irrelevant with people's vicarious learning.
Note: Affective state indicates "negative affective state", such as anxiety to science.	

Report for Thematic Analysis

Mastery experiences, vicarious learning, verbal persuasion, and affective state are four sources of self-efficacy. In the SCCT model, Lent and his colleagues (1994) used the term "Learning Experiences" to contain all the information sources for self-efficacy and claimed that "Learning Experiences" has direct effects on self-efficacy. Hence, four sources for self-efficacy turn into four sub-factors of the learning experiences construct. However, this study found that affective state was not statistically consistent with the learning experiences construct. Affective state was not significantly linear-correlated with mastery experiences and had a low linear correlation with verbal persuasion and vicarious learning. The case studies also revealed that the relations between affective state and the other three kinds of learning experiences were complex. Under different contexts, the relations between affective state and the other three kinds of learning experiences could be negative, positive, and even not relevant.

All the participants who attended the interviews reported that they had experienced anxiety feelings for science-related activities. School science examinations were the most mentioned activities which stimulated students' anxiety. Seven participants mentioned that they would be anxious due to their bad performance in school science learning. Specifically, two students who have already given up science-related trajectories reported that they were intensively anxious when they learned science and felt insufficient confidence to grasp science knowledge. Based on the interview data, no matter how many science-related mastery experiences the participants in this study considered themselves already have attained, they still might feel anxiety in some science-related activities.

Several students who have chosen science courses in high school and reported that they generally just had modest levels of anxiety about science shared their strategies for coping when they encountered threatening situations related to science. According to them, although they also felt anxiety when they faced challenging situations related to science, they still had their own coping strategies to adjust themselves to these challenging situations. For those students, although their coping strategies showed individual differences, consequently, their coping strategies helped them to prevent avoidance behaviours regarding science learning when they were faced with science-related threatening situations. Also, persistent learning behaviours in science might provide them with mastery learning experiences, which could further contribute to their self-efficacy in science, and the enhanced self-efficacy in science could boost students to learn science more.

It implies that coping strategies help students to complete a virtuous cycle in which coping strategies help them to prevent avoidance behaviours about science learning, continuous science learning behaviours help to provide students with mastery experiences about science, and these enhanced mastery experiences contribute to students' self-efficacy in science, boosting students' science learning behaviours. This finding is congruent with Bandura's (1994) statement that people's perceived coping capability when they encounter threatening situations could influence their affective arousal level and avoidant behaviour. The anxiety and avoidant behaviours of people who either perceive themselves to be able to cope with threatening situations or who can cope with their anxiety and stress emotions tend to be reduced.

The relationship between verbal persuasion and students' anxiety was also complicated. For all the participants who attended the interview, encouragement could mitigate their anxiety about science to some extent. However, the effects of encouragement were not sustainable in the long term. Especially for students who had low self-efficacy, even though encouragement could reduce their anxiety for a while, if they could not attain sufficient science-related mastery experiences to enhance their self-efficacy in science, they would become anxious and self-doubting again before long. It is noteworthy that several participants reported that sometimes their anxiety level could be enhanced (rather than reduced) by others' encouragements. When people, especially those whom students respected and admired, encouraged students, the encouragements might be perceived as a kind of expectation by the students. Those students were afraid to make these people disappointed and therefore tried to work hard to meet their expectations, which at the same time enhanced their anxiety and stress. It is noteworthy that verbal encouragements focused on students' effort had significant effects on persuading students not to give up when they were intensively self-doubted. This finding is consistent with Weiner's attribution theory (1974) that hard-working is a controllable factor in the attribution of students' successes and failures, compared with ability, which is more related to uncontrollable personal traits. Insofar as that, verbal persuasion on the importance of hard-working makes students tend to regard gaining mastery experience as dependent on their effort rather than on their personal intelligence, which is relatively uncontrollable.

The relations between science-related vicarious learning and science anxiety were also complicated. Five students reported that watching others doing science could mitigate their anxiety in science. Especially, for those students who had lack of information about the science activities they were going to do, watching others do these activities could facilitate their confidence and reduce their imaginary anxiety about the tasks.

By contrast, some students could regard others' successful performance in science as a kind of pressure on themselves. Those students tended to have low self-efficacy in science. Since they already evaluated themselves as incapable before they indeed undertook the tasks, watching others doing the tasks well made them compare their own perceived inability with others' capability on the tasks, and hence they experienced more pressure.

Both the quantitative and qualitative data showed that the relations between affective state and the other three sources for self-efficacy (mastery experiences, vicarious learning, and verbal persuasion) were complex. This finding provides a new perspective for thinking about the structure of the learning experiences construct. The learning experiences variable is created to synthesise the direct, informative sources for self-efficacy. Based on the analysis results of the interview data and CFA of learning experiences construct, this study postulates that mastery experience, vicarious learning, and verbal persuasion constitute a new consistent construct termed **Positive Learning Experiences (PLE)**. Furthermore, **Affective State (AS)**, which is independent of the Positive Learning Experiences construct, can directly affect self-efficacy.

4.3.1.5 Model testings of the positive learning experiences construct and the affective state construct

The hypothesised positive learning experience construct is shown in Figure 4.4. Since there were only three items under the latent variable positive learning experience construct, according to the principle of estimation of structural equation modeling, the model was just-identified (Kline, 2010). Under the situation of “just-identified”, SEM cannot calculate model fit indices under this condition. Hence, for the positive learning experiences construct, only the reliability and validity testings were conducted. The composite reliability and AVE of positive learning experiences construct respectively were 0.848 and 0.652, which indicated that the convergent validity of positive learning experience construct was good.

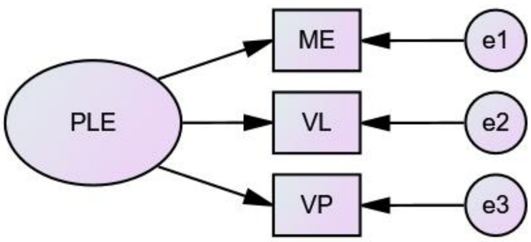


Figure 4.4 Hypothesised Positive Learning Experiences Model

Affective state was independent from positive learning experiences construct and it was also tested the model fit by confirmatory factor analysis.

The structure of the affective state construct is shown in Figure 4.5.

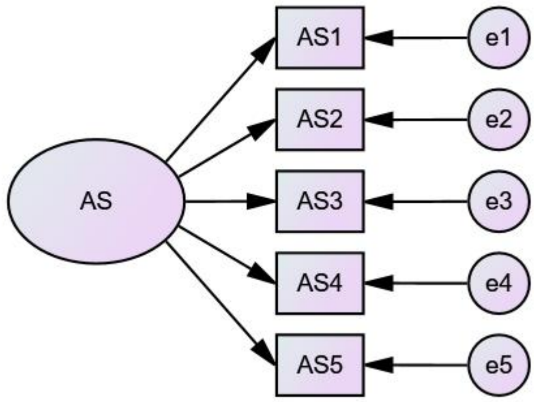


Figure 4.5 Hypothesised Affective State Model

The results of CFA of affective state construct are shown in Table 4.10.

Table 4.10 The results of CFA of affective state model

CFI	RMSEA	SRMR
0.949	0.123	0.045

Based on the indices shown in Table 4.10, RMSEA was higher than 0.08, which implied that this construct had the risk to be mis-specified. Then in order to further locate the possible problems of this construct, the factor loadings of all the items in this construct are presented. Table 4.11 shows all the items' standardised factor loadings in affective state construct.

Table 4.11 The standardised factor loadings of the items in affective state model

			The Standardised Factor Loadings
AS1	<---	AS	.404
AS2	<---	AS	.646

			The Standardised Factor Loadings
AS3	<---	AS	.782
AS4	<---	AS	.745
AS5	<---	AS	.694

As Table 4.11 shows, the standardised factor loading between item AS1 and the latent variable affective state was only 0.404. According to Hair et al. (2010), in a measurement construct, standardised factor loadings lower than 0.5 are not suggested to be included in the construct. The composite reliability and AVE of this AS measurement instrument were respectively 0.794 and 0.445. The low convergent validity of AS (AVE<0.5) might be due to the low factor loading of AS1. Hence, item AS1 was deleted from AS construct. The results of CFA of the modified affective state construct are shown in Table 4.12.

Table 4.12 The results of CFA of the modified affective state construct

CFI	RMSEA	SRMR
0.969	0.110	0.033

After deleting AS1, the value of RMSEA of the modified model was still not up to the requirement of good fit model (RMSEA <0.08). However, the CFI index and SRMR index were both perfectly acceptable. In addition, the composite reliability and

AVE were respectively 0.809 and 0.516, which represented that after deleting item AS1, the convergent validity of the AS measurement instrument was good. Hence, although the modified AS measurement instrument (shown in Figure 4.6) was not flawless, it would still be used in the further structural model investigation.

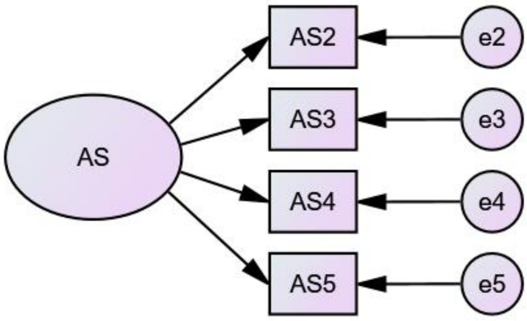


Figure 4.6 Final Fitted Affective State Model

4.3.2 Self-Efficacy

The self-efficacy measurement model was subjected to Confirmatory Factor Analysis to test whether or not the hypothesised construct converged with the real data. The original measurement model for self-efficacy is shown in Figure 4.7. Three key model fit indices which resulted from the CFA testings are shown in Table 4.13.

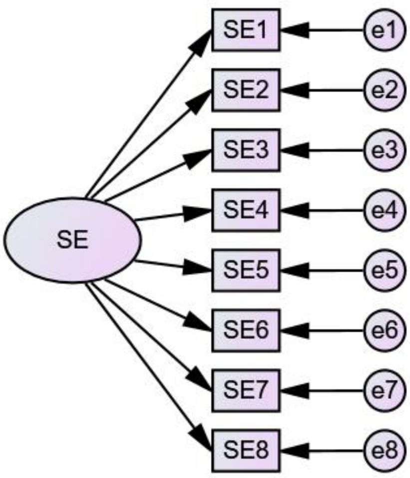


Figure 4.7 Hypothesised Self-Efficacy Model

Table 4.13 The CFA results of SE model

CFI	RMSEA	SRMR
0.778	0.218	0.090

As Table 4.13 shows, the original measurement model failed to converge the data well (because all three indices were outside the range of statistical acceptability). A possible reason for this model misspecification was that the size of some factor loadings was too low for them to be involved into the model (Kline, 2010). If the factor loading between an indicator and a latent variable is too low, it implies that this indicator may be less consistent with this measurement construct. Hence, it was necessary to check the factor loadings of all the indicators in the self-efficacy model. The standardised factor loadings from the CFA are shown in Table 4.14.

Table 4.14 The standardised factor loadings of items in SE model

			The Standardised Factor Loadings
SE 1	<---	SE	.712
SE 2	<---	SE	.705
SE 3	<---	SE	.740
SE 4	<---	SE	.586
SE 5	<---	SE	.595
SE 6	<---	SE	.770
SE 7	<---	SE	.725
SE 8	<---	SE	.763

It is shown that although all the standardised factor loadings were over the minimum size requirement of 0.5, item 4 and item 5 were apparently less correlated with the self-efficacy construct, compared with other items.

Furthermore, to locate the issues in this measurement model, I further took Modification Index (MI) into consideration. As discussed before, although MI is a good assessment to use in locating possible problems, it is still necessary to provide qualitative explanations for any model modification (Byrne, 2010). The statistically significant Modification Indices from the CFA of the original self-efficacy measurement model are shown in Table 4.15.

Table 4.15 The statistically significant MI of SE model

			MI
e4	<-->	e5	356.883
e7	<-->	e5	20.180
e7	<-->	e4	8.801
e7	<-->	e8	6.433
e6	<-->	e5	14.660
e6	<-->	e4	9.753
e6	<-->	e7	33.161
e1	<-->	e7	10.861
e2	<-->	e5	6.705
e2	<-->	e4	16.700
e2	<-->	e1	7.502
e3	<-->	e1	6.159
e3	<-->	e2	8.501

Apparently, the MI of e4-e5 was problematic. The modification index of 356.883 indicated that the error covariance between item 4 and 5 represented major model misspecification (Byrne, 2016). A modified SE measurement model (called SE model*) that incorporated a correlation between the errors of items 4 and 5 showed that its model fit was enhanced to an acceptable level. The model fit indices of the SE model* are shown in Table 4.16.

Table 4.16 The CFA results of SE model* (with correlation between item 4 error and item 5 error)

CFI	RMSEA	SRMR
0.977	0.072	0.031

Although statistically, with the guidance of the Modification Index, reasons for model misspecification could be located, it was still not rigorous to modify the model without substantive evidence to support the proposal that the error of item 4 and the error of item 5 was highly correlated with each other (Byrne, 2016). The high covariance between the item 4 error and item 5 error represented that the residual parts of items 4 and 5 that the SE construct could not explain were highly correlated with each other. It implied that the parts of items 4 and 5 that could be explained and those that could not be explained by the SE construct were both highly correlated with each other. If apart from the indication for self-efficacy, item 4 and item 5 still had correlated content with each other, this model modification was meaningful and had a substantive reason (Byrne, 2016). Item 4 is "I can identify some of the science issues associated with the disposal of garbage" and item 5 is "I can predict how changes to an environment will affect the survival of certain species". Although the associated science knowledge of item 4 and item 5 is both about biology, it is still unclear, in terms of their content, that they would be expected to be as closely correlated as the data suggested they were. In addition, although with the modification, the model fit of the self-efficacy model was acceptable, the convergent validity of this model did not meet the requirement, which implied that not all the items in self-efficacy construct could reflect self-efficacy well. The modified model's composite reliability was 0.880 and its AVE was 0.483. According to Fornell and Larcker, (1981), it is expected that the AVE of a measurement model with good convergent validity should be over 0.5. The modified self-efficacy model was neither legitimate with solid substantive reasons nor of high convergent validity. Insofar as that, the modification with the guidance of the Modification Index has not succeeded.

Since the model misspecification was mainly due to the high covariance between the item 4 error and item 5 error, the deletion of one of these two items from the self-efficacy construct could address the issue of high correlation. In the original self-efficacy model, the standardised factor loadings of item 4 and item 5 were 0.586 and 0.595 respectively. Except for these two items, the other items' standardised factor loadings were all over 0.7. The low standardised factor loadings of items 4 and 5 implied that apart from the issue of high error covariance, item 4 and item 5 themselves might be not consistent with the self-efficacy construct well. The low factor loadings of items 4 and 5 might account for the low convergent validity of self-efficacy. In this study, item 4, which had the lowest standardised factor loading, was deleted from the self-efficacy construct. The model fit indices of this modified SE model (called SE model**) with the deletion of item 4 from the original SE model are shown in Table 4.17. The three model fit indices indicated that the model could converge the data well, with all three indices in the acceptable range.

Table 4.17 The CFA results of SE model** (without item 4)

CFI	RMSEA	SRMR
0.970	0.080	0.032

The composite reliability and the AVE of the SE model** were 0.880 and 0.514 respectively, which met the requirement to indicate the convergent validity for this measurement model (Fornell and Larcker, 1981). This final fitted self-efficacy measurement model (SE model**) is shown in Figure 4.8.

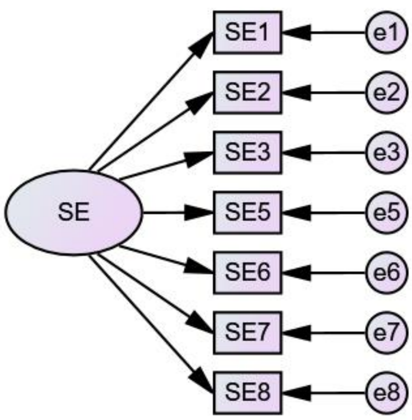


Figure 4.8 Final Fitted SE Model

4.3.3 Self-Concept

Similarly, to the self-efficacy measurement model, the self-concept (SC) measurement model has been subjected to the initial CFA testings. The measurement model of SC is shown in Figure 4.9. And the results of CFA are shown in Table 4.18.

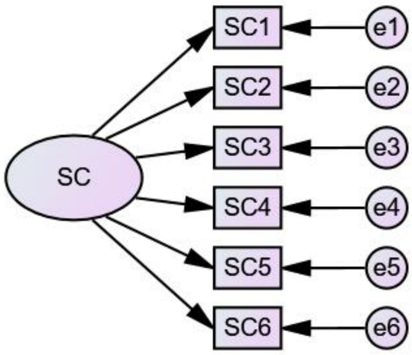


Figure 4.9 Hypothesised Self-Concept model

Table 4.18 The results of CFA on SC model

CFI	RMSEA	SRMR
0.885	0.270	0.060

As the model fit indices shown in Table 4.18, the original SC measurement model was not accepted since the index value of RMSEA was significantly over 0.08. To examine the problems of this measurement model, the sizes of the factor loadings of all the items were firstly checked. The standardised factor loadings are shown in Table 4.19.

Table 4.19 Standardised factor loadings of the SC model

			Standardized factor loadings
SC3	<---	SC	.875
SC2	<---	SC	.899
SC1	<---	SC	.893
SC4	<---	SC	.865
SC5	<---	SC	.797
SC6	<---	SC	.762

As the table shows, all the standardised factor loadings were over 0.7, which implied that all the items were consistent with the self-concept construct.

Then, the Modification Indices were used to locate reasons for the model misspecification. The statistically significant Modification Indices of SC model are shown in Table 4.20.

Table 4.20 The statistically significant MI of the self-concept model

			MI
e5	<-->	e6	225.602
e4	<-->	e5	5.396
e1	<-->	e6	40.887
e1	<-->	e5	25.528
e2	<-->	e6	36.937
e2	<-->	e5	37.779
e2	<-->	e1	106.832
e3	<-->	e6	11.383
e3	<-->	e5	17.442
e3	<-->	e1	12.872

			MI
e3	<-->	e2	8.696

As the table shows, the magnitude of the Modification Index of e5-e6 was very high, which indicated that the error covariance between item 5 and 6 represented major model misspecification (Byrne, 2016). With the addition of correlation between errors 5 and 6, the new modified model (called SC model*) enhanced its model fit. The results of CFA testings on the SC model* are shown in Table 4.21.

Table 4.21 The results of CFA on SC model*

CFI	RMSEA	SRMR
0.967	0.154	0.036

Whereas modification enhanced the model fit, the SC model* still could not meet the ideal model fit requirement, since the index value of RMSEA was over 0.08. It was necessary to further address the model issues with the guidance of the Modification Indices. The statistically significant modification indices of the SC model* are shown in Table 4.22.

Table 4.22 The statistically significant MI of the self-concept model*

			MI
e1	<-->	e6	6.523
e2	<-->	e5	4.944
e2	<-->	e1	40.708
e3	<-->	e6	7.472

			MI
e3	<-->	e5	15.194
e3	<-->	e4	11.516
e3	<-->	e1	15.878
e3	<-->	e2	11.710

It is apparent that the high covariance between error 1 and error 2 was problematic. After adding the correlation between error 1 and error 2, the self-concept model could converge the data. The results of the CFA on this SC model (called SC model**) are shown in Table 4.23.

Table 4.23 The results of CFA on SC model**

CFI	RMSEA	SRMR
0.992	0.079	0.018

As discussed before, although with the guidance of the Modification Indices, the modified SC** was well specified, the substantive meanings of these modifications should also be considered. Firstly, the correlation between the item 5 error and item 6 error is firstly discussed. Item 5 is “when I am being taught school science, I can understand the concepts very well” and item 6 is “I can easily understand new ideas in school science.” These two items are both about students’ self-evaluation of their capability for learning new things about science. Insofar as the overlapped content, it was legitimate to add the correlation between the item 5 error and the item 6 error.

Item 1 is “school science topics are easy for me” and item 2 is “I can usually give good answers to test questions on school science topics”. These two questions are both about students' self-evaluation of their school science ability. Hence, the modification of the addition of correlation between error 1 and error 2 was robust with substantive meaning. In light of the discussions above, the SC model** was statistically and substantively specified. The convergent validity of this final self-concept model was good with composite reliability of 0.935 and AVE of 0.708. The final fitted SC measurement model (called SC model**) is shown in Figure 4.10.

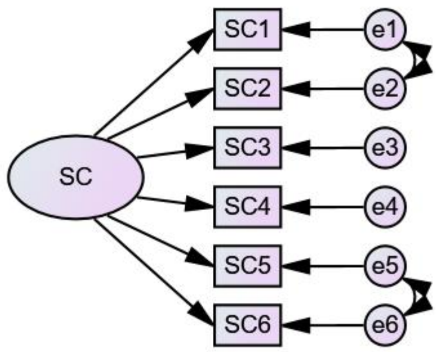


Figure 4.10 Final Fitted SC Model

4.3.4 The Investigation of the Differences Between Self-Efficacy and Self-Concept

As discussed in the previous chapter, the conceptual distinction between self-efficacy and self-concept has been argued in many previous studies and among these, insufficient studies have focused on the science domain (Jansen, Scherer & Schroeders, 2015). Insofar as that, in the current study, the preliminary step before the model structural investigation was investigating whether the modified science SE measurement model (shown in Figure 4.8) and science SC measurement model (shown in Figure 4.10) were statistically separable. Specifically, the separability testing was executed by creating a one-factor model (model A, as shown in Figure 4.11) which contained all the items from the modified SE and SC questionnaire; and a two-factor model (model B, as shown in Figure 4.12). The separability of the SE measurement model and SC measurement model could be considered by comparing the CFA results of model A and the CFA results of model B. If model A was rejected but model B was fitted to the data, this would lend statistical support to the hypothesis that self-concept is distinguishable from self-efficacy.

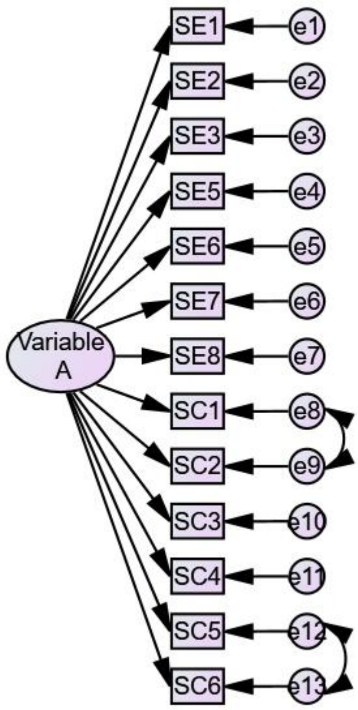


Figure 4.11 Model A

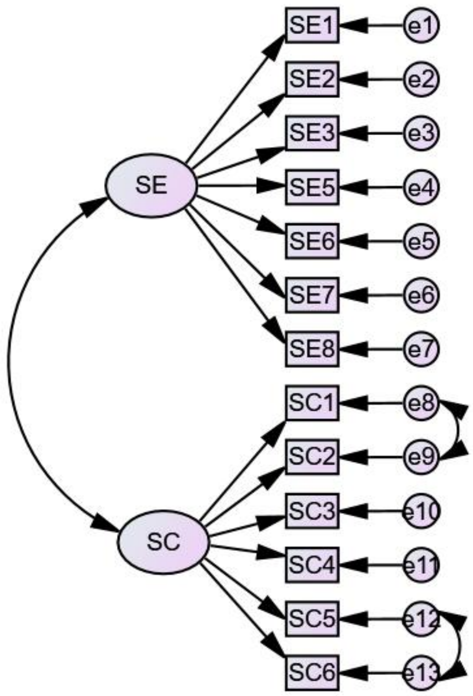


Figure 4.12 Model B

However, in fact, the Amos software could not execute the CFA on model A. There were many possible reasons for this error. As suggested by Amos software, one possible reason was that the observed variables were linearly dependent. To examine whether the observed variables were linearly dependent or not, the correlation testings between 6 items in the modified self-concept questionnaire and 7 items in the modified self-efficacy questionnaire were conducted and the results are shown in Table 4.24.

Table 4.24 The correlation testings between 6 items in the modified SE measurement instrument and 7 items in the modified SC measurement instrument

	SE1	SE2	SE3	SE5	SE6	SE7	SE8

SC1	Pearson Correlation	.313**	.267**	.308**	.613**	.310**	.307**	.301**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000
SC2	Pearson Correlation	.333**	.276**	.338**	.624**	.334**	.310**	.311**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000
SC3	Pearson Correlation	.393**	.316**	.361**	.706**	.367**	.345**	.369**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000
SC4	Pearson Correlation	.329**	.260**	.332**	.644**	.327**	.357**	.303**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000
SC5	Pearson Correlation	.409**	.324**	.398**	.832**	.391**	.362**	.426**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000
SC6	Pearson Correlation	.425**	.363**	.435**	1.000**	.385**	.337**	.420**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000

Note: **: Correlation is significant at the 0.01 level ($p<0.01$)

As Table 4.24 shows, the Pearson Correlation coefficient of item 6 in self-concept and item 5 in self-efficacy was 1, which indicated that these two items were linearly dependent with each other.

This was probably the reason for the execution error. Although after deleting either SC6 or SE5, the modified model could be identified by Amos software, neither of these two modified models was successfully specified. The results of CFA of these two models are shown in Table 4.25.

Table 4.25 The results of CFA of the model A* (derived from deleting item SC6 from model A) and the model A** (derived from deleting item SE5 from model A)

	CFI	RMSEA	SRMR
Model A* (deletion of SC6)	0.748	0.205	0.144
Model A** (deletion of SE5)	0.779	0.194	0.142

The results of CFA testings on two modified models (model A* without SC6 and model A** without SE5) indicated that statistically SE construct and SC construct could not be integrated into an inner-consistent construct.

Similarly with model A, model B also had the problem of linearly dependent between variable SC6 and SE5. To analyse the model fit of model B, model B* with the deletion of item SC6 and model B** with the deletion of item SE5 were designed based on the modification of model B. The CFA results of model B* and model B** are shown in Table 4.26.

Table 4.26 The results of CFA of the model B* (derived from deleting item SC6 from model B) and the model B** (derived from deleting item SE5 from model B)

	CFI	RMSEA	SRMR
Model B* (deletion of SC6)	0.875	0.145	0.110
Model B** (deletion of SE5)	0.977	0.063	0.046

Model B** was well fitted, but model B* was not fitted to the data. The comparison between the model fit between model B* and model B** implied that deletion question SC6 significantly influenced the model fit; so question SC6 could not be deleted. The comparison between model A**(not fitted) and model B** (well fitted) indicated that SE construct and SC construct were statistically separable. Insofar as that, SE construct and SC construct would be respectively involved into two hypothesised causal structural models, to investigate their respective roles in the formation process of students' science career intentions.

4.3.5 Science Interest

4.3.5.1 Enjoyment of science

The measurement model of enjoyment of science is shown in Figure 4.13

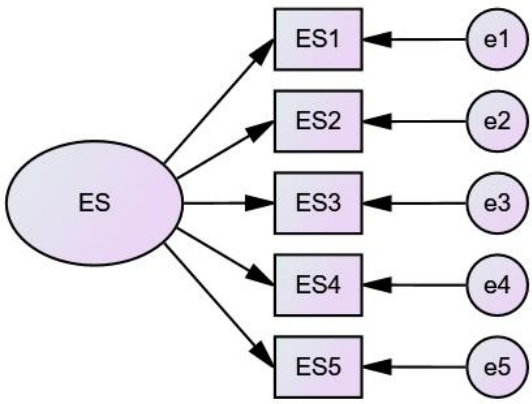


Figure 4.13 The hypothesised enjoyment of science model

The CFA was employed on this measurement model and the results are shown in Table 4.27.

Table 4.27 The results of CFA on enjoyment of science model

CFI	RMSEA	SRMR
0.992	0.085	0.011

Although the RMSEA value of this model did not perfectly meet the model fit requirement (RMSEA <0.8), the values of the three model fit indices overall represented that the enjoyment of science model was specified.

The standardised factor loadings of items from enjoyment of science model are shown in Table 4.28, which indicated all the items were consistent with the enjoyment of science construct.

Table 4.28 Standardised factor loadings of every item in enjoyment of science model

			Standardised factor loadings
ES3	<---	ES	.895
ES2	<---	ES	.904
ES1	<---	ES	.869
ES4	<---	ES	.893
ES5	<---	ES	.877

The measurement instrument' s composite reliability was 0.949 and its AVE was 0.788. The value of the composite reliability of this construct was too high, which might reflect some issues of the model. According to Hair et al. (2017):

> Values above 0.90 (and definitely above 0.95) are not desirable because they indicate that all the indicator variables are measuring the same phenomenon and are therefore not likely to be a valid measure of the construct. Specifically, such

> composite reliability values occur if one uses semantically redundant items by slightly rephrasing the very same question. (p. 12)

The use of redundant items has detrimental consequences for the measures' content validity (Rossiter, 2002). In addition, the redundant items may have high error term correlations, which are harmful to the model fit of the measurement model (Drolet & Morrison, 2001; Hayduk & Littvay, 2012). As Hair and his colleague argued, the high value of the composite reliability of the enjoyment of science construct might imply that there were redundant questions in this measurement model. Through analysing the content of all the five items in this model, I hypothesised that the semantical similarity of items 1, 4, and 5 might be accused to be the reason for the over-high composite reliability. Item 1 is "I generally have fun when I am learning science topics", item 4 is "I enjoy acquiring new knowledge in science" and item 5 is "I am interested in learning about science". All of these three items describe students' positive emotional perception during science learning. However, the correlations of all five items from the enjoyment of science construct which are shown in table 4.29 did not support this hypothesis. Ironically, table 4.29 shows that the highest correlation was between items 2 and 3. Based on the correlations between these five items, it was hard to say that items 1, 4, and 5 were more similar to each other. Hence, the hypothesis that overlapped content of items 1, 4, and 5 accounted for the high composite reliability, was statistically refused.

Table 4.29 The correlation matrix of five items in enjoyment of science model

		ES1	ES2	ES3	ES4	ES5
ES1	Pearson Correlation	1	.793**	.770**	.782**	.753**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	578	578	578	578	578
ES2	Pearson Correlation	.793**	1	.827**	.797**	.774**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	578	578	578	578	578
ES3	Pearson Correlation	.770**	.827**	1	.784**	.785**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	578	578	578	578	578
ES4	Pearson Correlation	.782**	.797**	.784**	1	.809**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	578	578	578	578	578
ES5	Pearson Correlation	.753**	.774**	.785**	.809**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	578	578	578	578	578

Note: **. Correlation is significant at the 0.01 level ($P<0.01$).

In addition, one possible result of redundant questions is the enhancement of error correlation (Hayduk & Littvay, 2012). However, the statistically significant Modification Indices of enjoyment of science construct represented that the error correlations were not excessively high (as shown in Table 4.30).

Table 4.30 The statistically significant MI of enjoyment of science model

			M.I.
e4	<-->	e5	12.151
e2	<-->	e5	6.593
e3	<-->	e4	5.131
e3	<-->	e2	8.525

In light of the previous discussions, the high composite reliability could not be explained by semantically redundant items which may violate the content validity of the measurement construct and did not result in unacceptable error correlations. Although the high composite reliability of the enjoyment of science measurement construct had potential risk to the measurement construct's validity, based on the discussions before, the enjoyment of science measurement construct used in this study was appropriate.

4.3.5.2 Interest in broad science topics

The measurement model of interest in broad science topics is shown in Figure 4.14

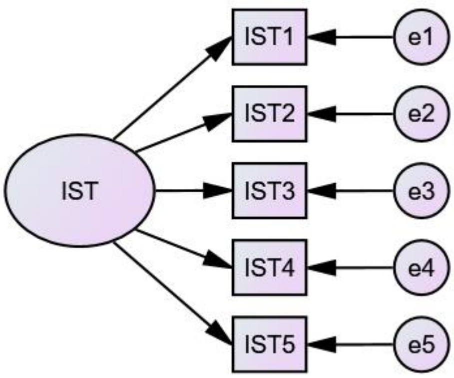


Figure 4.14 Hypothesised interest in broad science topics (IST) model

CFA was employed on this measurement model and the results are shown in Table 4.31.

Table 4.31 The results of CFA on interest in broad science topics model

CFI	RMSEA	SRMR
0.789	0.300	0.136

The value of CFI was less than 0.8, and the value of RMSEA and SRMR were both over 0.08. These model fit indices indicated that the interest in broad science topics model was misspecified.

To identify the possible reasons leading to the model misspecification, the factor loadings of all five items in this model are discussed, and the standardised factor loadings of the items in IST model are shown in Table 4.32.

Table 4. 32 The standardised factor loadings of the items in IST model

			Estimate
IST1	<---	IST	.566
IST2	<---	IST	.882
IST3	<---	IST	.898
IST4	<---	IST	.435
IST5	<---	IST	.439

The standardised factor loadings of items IST4 (0.435) and IST5 (0.439) were lower than the minimum acceptable value (0.5), indicated by Hair et al. (2010).

Items IST4 is “I am interested in the Universe and its history” and item IST5 is “I am interested in how science can help us prevent disease”. The other three items tightly pertained to school science subjects: chemistry, physics, and biology, and compared with these three items, items 4 and 5 might not be topics that were discussed and learned during school science classes for Chinese secondary school students. Considering the statistical results as well as the content of the items, items 4 and 5 were deleted from the interest in broad science topics questionnaire.

The composite reliability and AVE of the modified interest in broad science topics construct were 0.830 and 0.631 respectively, which represented that the convergent validity of the measurement model was good. The final fitted IST model is shown in Figure 4.14.

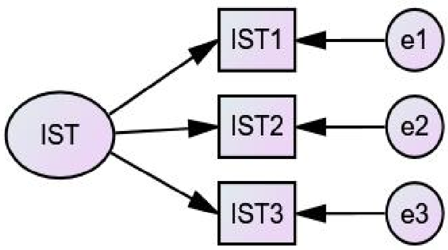


Figure 4.15 The final fitted IST model

4.3.6 Science Career Intentions

The measurement model of science career intentions is shown in Figure 4.16.

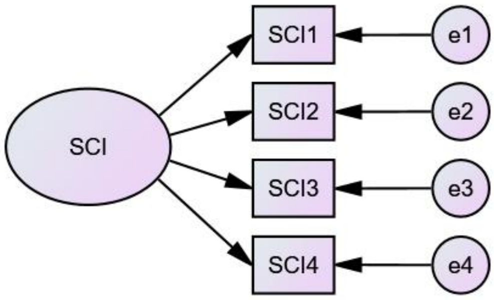


Figure 4.16 Hypothesised science career intentions model

The CFA was employed on this measurement model and the results are shown in Table 4.33.

Table 4.33 The results of CFA on science career intentions model

CFI	RMSEA	SRMR
0.895	0.362	0.063

The model fit indices indicated that the science career intentions model is mis-specified. The standardised factor loadings (shown in Table 4.34) were all over 0.7, which represented that all the items were consistent with this measurement construct.

Table 4.34 The standardised factor loadings of the items in science career intentions model

			standardised factor loadings
SCI4	<---	SCI	.711
SCI3	<---	SCI	.801
SCI2	<---	SCI	.880
SCI1	<---	SCI	.856

Hence, to locate the model issues, statistically significant modification indices are shown in Table 4.35.

Table 4.35 The statistically significant MI of science career intentions model

			M.I.
e2	<-->	e1	31.809
e3	<-->	e1	8.354
e3	<-->	e2	17.152
e4	<-->	e1	33.218
e4	<-->	e2	12.051
e4	<-->	e3	124.441

The modification index between the item 4 error and the item 3 error was too high, which might be problematic. After adding the correlation link between the item 4 error and item 3 error to this model, the science career intentions measurement model could converge the data. The results of CFA of the modified science career intentions model are shown in Table 4.36.

Table 4.36 The results of CFA of the modified science career intentions model

CFI	RMSEA	SRMR
0.997	0.086	0.008

Item 3 is "I intend to find a science-related job" and item 4 is "I am determined to use my science knowledge in my future career". In addition, the instruction of the science career intentions questionnaire provides the definition of science-related jobs: “ science-related job refers to the careers which work with science topics and also the careers in which scientific knowledge or skills are used as tools ” . Given the description of science-related jobs, a job where scientific knowledge can be often used tends to be a science-related job. In this sense, the content of item 3 is overlapped with item 4 to some extent. Hence, it was legitimate to add the correlation parameter between the item 3 error and the item 4 error.

The composite reliability and AVE of the modified science career intentions measurement construct were 0.8727 and 0.636 respectively, which indicated that the convergent validity of the measurement model was good. In light of the discussions above, the modified science career intentions model (as shown in Figure 4.17) was appropriate for the targeted participants in this study.

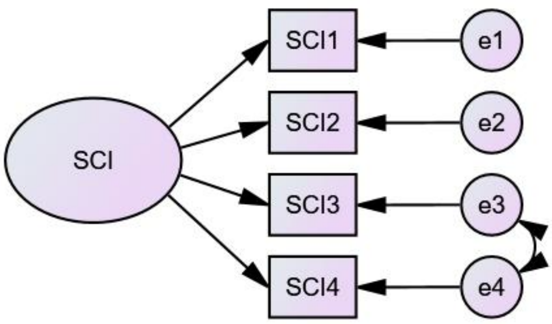


Figure 4.17 Final fitted science career intention model

4.3.7 Family Science Capital

The hypothesised measurement model of family science capital is shown in Figure 4.18.

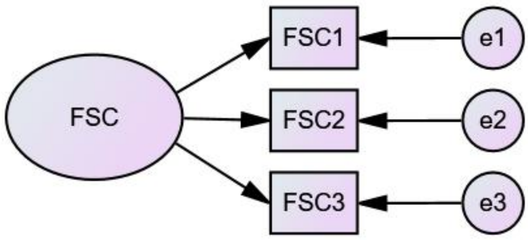


Figure 4.18 Hypothesised family science capital model

The family science capital model with only three items is a just-identified model, whose degree of freedom is 0 (Kline, 2010). As Kline (2010, p.125) said, “most structural equation models with zero degrees of freedom (df = 0) that are also identified can perfectly reproduce the data (sample covariances), but such models test no particular hypothesis”. A just-identified model in SEM analysis cannot produce the model fit indices, since it does not test any particular hypothesis. Although the model fit testing for the family science capital measurement model could not be conducted, it was still necessary to pay attention to the factor loadings of the items in this construct. The standardised factor loadings of all the items in family science capital construct (shown in Table 4.37) indicated that all the items were consistent with this construct.

Table 4.37 The standardised factor loadings of all the items in family science capital model

			the standardised factor loadings
FSC1	<---	FSC	.829
FSC2	<---	FSC	.726
FSC3	<---	FSC	.700

The composite reliability and AVE of family science capital measurement model were 0.797 and 0.568 respectively, which indicated this model had convergent validity.

4.3.8 The Relations Between Two Kinds of Science Interest with Science Career Intentions

To investigate which kinds of science interest contributed to science career intentions more, a hypothesised model was designed. The model is illustrated in Figure 4.19.

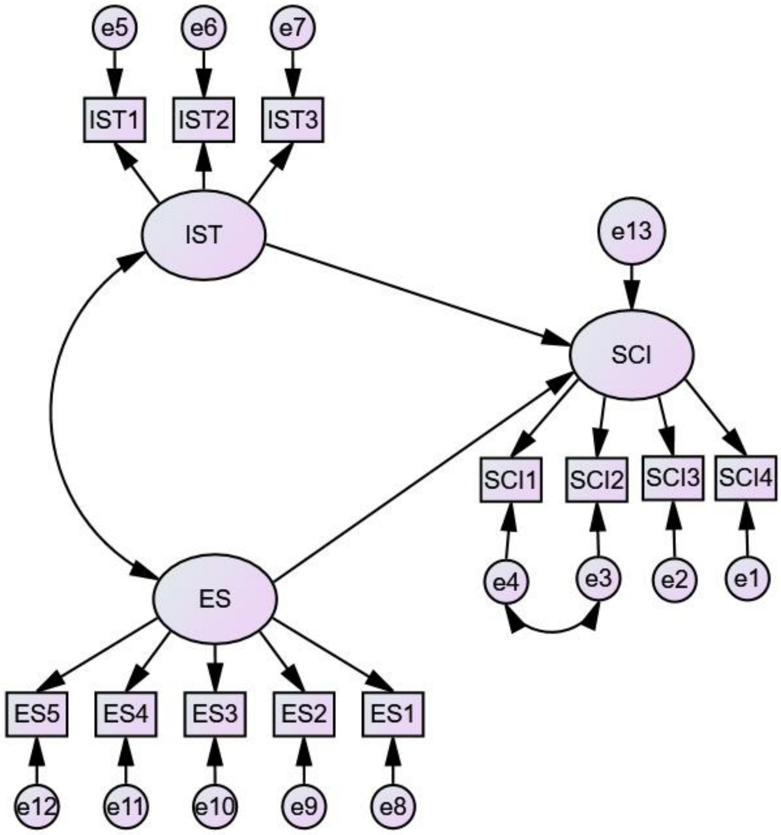


Figure 4. 19 The hypothesised model investigating the relations between two kinds of science interest (interest in broad science topics and enjoyment of science) and science career intentions.

Since the three model fit indices were all acceptable (shown in Table 4.38), the hypothesised model is statistically specified.

Table 4. 38 The results of CFA on the hypothesised model

CFI	RMSEA	SRMR
0.964	0.086	0.054

Both IST and ES could significantly predict SCI (P<0.001). The standardised regression weight of the path IST to SCI was 0.297 and the standardised regression weight of the path ES to SCI was 0.460. The results showed that compared with IST, ES could statistically account more for SCI. In addition, the IST and ES were significantly correlated with each other (p<0.001), and the correlation coefficient was 0.777.

To test whether the path coefficient from ES to SCI was significantly higher than that from IST to SCI, the critical ratios for differences (CRDIFF) method was employed. Referring to the explanation of CRDIFF from Amos, “the critical ratio for a pair of parameter estimates provides a test of the hypothesis that the two parameters are equal.” (shown from the instructions of Amos 24). If the value of critical ratio is over 1.96, it indicates that the two parameters are significantly different (Byrne, 2016). The CR value for the difference between the path coefficient from ES to SCI and the path coefficient from IST to SCI was 1.32, which was lower than 1.96 (Byrne, 2016).

This result indicated that the path coefficient from ES to SCI was not significantly higher than the path coefficient from IST to SCI.

The comparison between path ES to SCI and path IST to SCI indicated that students' attitudes to doing science were not more predictive of science career intentions than their attitudes to science, which did not support Ajzen and Fishbein's (1980) argument (which was discussed in Chapter 2.6.2.2).

Since the two kinds of science interest (ES and IST) had similar predictive effects on science career intentions, the size of prediction effects could not be the criteria to select a measurement approach to science interest. The IST questionnaire has been adapted by deleting two questions to fit the participants in this study. The modified IST questionnaire consisted of only three items, whose contents were related to interest in science topics of chemistry, biology, and physics. After modifying IST, the content of the original IST has changed to a large extent and the modified IST might have the risk of low content validity. Content validity "concerns whether test items are representative of the domains they are supposed to measure" (Kline, 2010, p.72). By contrast, since the ES questionnaire was fitted to the data in this study, it has not been modified. Based on the previous discussion, in this study, the variable science interest in hypothesised structural models would be assessed by ES measurement instrument.

4.3.9 CFA on Integrated Measurement Model

Although all the measurement constructs have been examined by CFA individually, these examinations did not scrutinize the possible collinearity between these measurement constructs. Hence, to check the collinearity between these measurement constructs, the CFA on the integrated measurement model was very necessary. Then discriminant validity testings of all the measurement constructs are shown followed by the collinearity test in this section. As Fornell & Cha (1994) indicated, the Fornell-Lacker criterion is an assessment to evaluate discriminant validity that is widely used in SEM studies. This criterion testing was conducted by comparing a variable's square root of AVE ('average variance extracted') and its correlations with all the other variables involved in this study. When a variable's square root of AVE is higher than all its correlations with the other variables, it implies that this variable can be discriminated from the other variables.

Firstly, two integrated measurement models which included all the variables in two hypothesised causal structural models about the formation of students' science career intentions were created. Two kinds of self-capability variables (self-efficacy and self-concept) have been involved in this study, in order to investigate each of the self-capability variables' roles in students' formation process of science career intentions. There were two hypothesised causal structural models, respectively involving two self-capability variables. Hence, there were two integrated measurement models, the integrated measurement model I with self-efficacy is shown in Figure 4.20, and the integrated measurement model II with self-concept is shown in Figure 4.21.

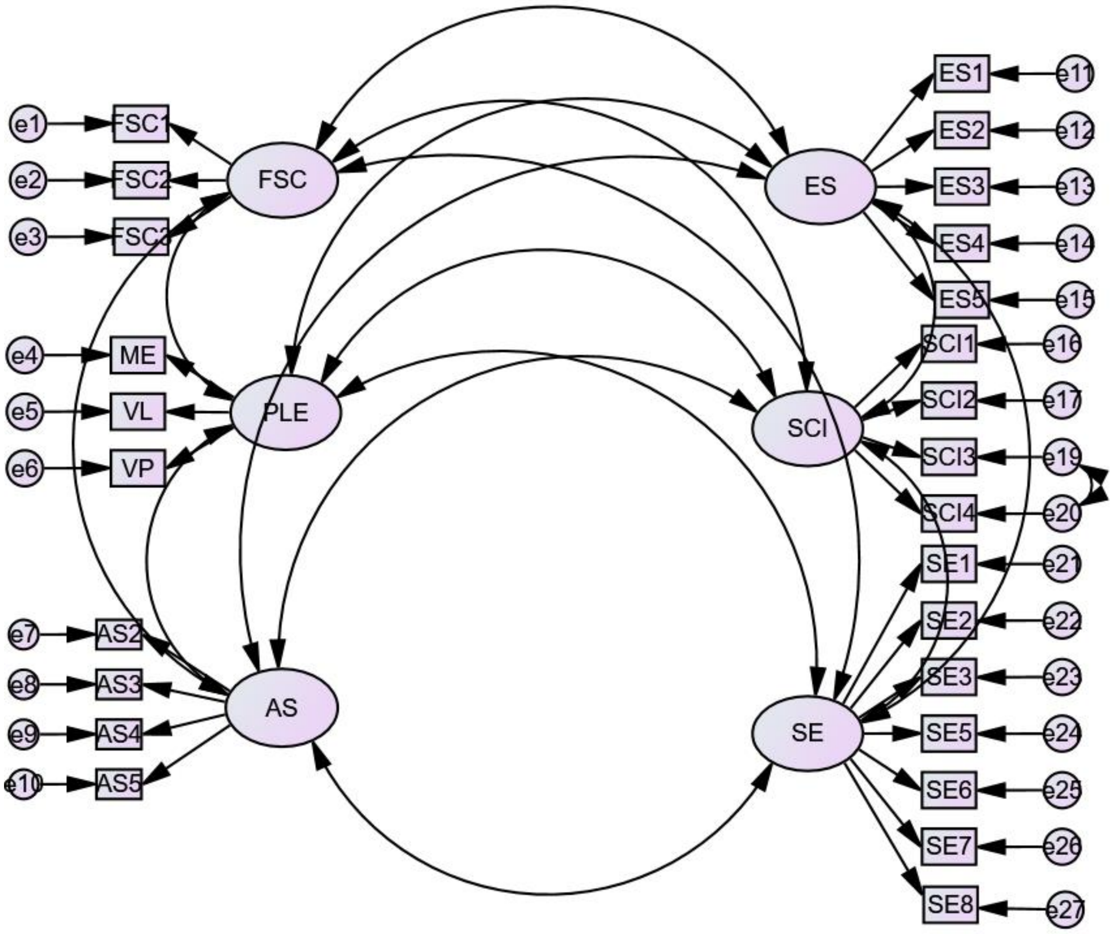


Figure 4.20 The integrated measurement model I

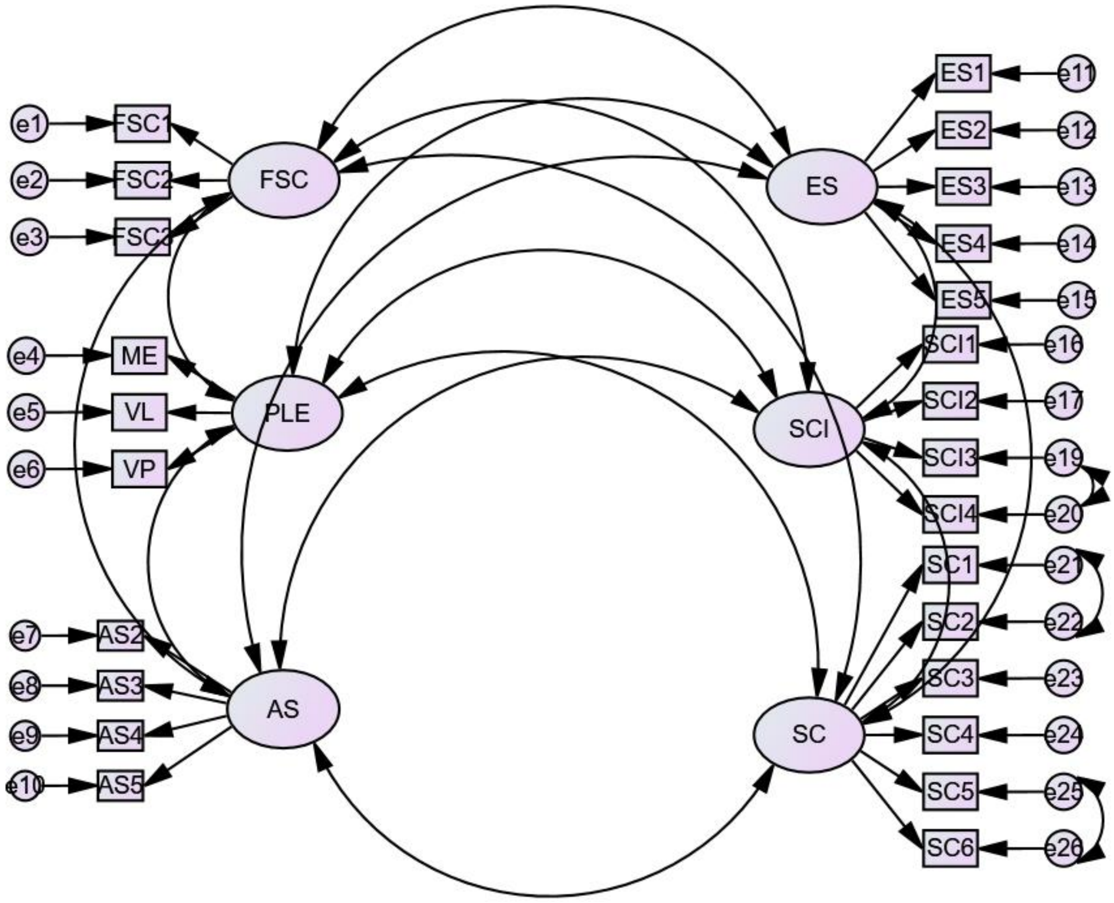


Figure 4.21 The integrated measurement model II

The CFA results of the integrated measurement model I are shown in Table 4.39 and all three model fit indices showed that the integrated measurement model I was well accepted. The CFA results of the integrated measurement model II are shown in Table 4.40 and all three model fit indices showed that the integrated measurement model II was well accepted.

Table 4.39 The results of CFA on the integrated measurement model I

CFI	RMSEA	SRMR
0.921	0.069	0.071

Table 4.40 The results of CFA on the integrated measurement model II

CFI	RMSEA	SRMR
0.935	0.070	0.076

Further to this, a collinearity test was conducted by calculating the correlations between each two measurement constructs in the integrated measurement model. A correlation value over 0.8 between two variables may imply that there is a possible risk of collinearity between these two variables (Gorard, 2001). The correlation values between each of the two variables of model I are shown in Table 4.41 and model II are shown in Table 4.42. All the correlation values were lower than 0.8, which implied that the variables involved in this study were at low risk of collinearity.

Furthermore, the discriminant validity test was conducted by comparing each measurement instrument's square root of AVE and its latent variable's correlations with the other latent variables (Fornell & Cha, 1994). Table 4.41 and Table 4.42 respectively present all the measurement instruments' square root of AVE and all the correlation coefficients between all the latent variables in model I and model II.

Table 4.41 The correlations between all the latent variables and all the measurement instruments' square root of AVE (in bold and red) in model I

Construct	FSC	PLE	SE	ES	AS	SCI
FSC	**.754**					
PLE	.594***	**.807**				
SE	.535***	.751***	**.716**			
ES	.427***	.668***	.735***	**.887**		
AS	-.135*	-.070 (p=0.164)	.074 (p=0.135)	.269***	**.718**	
SCI	.231***	.539***	.495***	.621***	.172***	**.797**

Note: *: Correlation is significant at the 0.05 level (P<0.05)

***: Correlation is significant at the 0.001 level (P<0.001)

Table 4.42 The correlations between all the latent variables and all the measurement instruments' square root of AVE (in bold and red) in model II

Construct	FSC	PLE	SC	ES	AS	SCI
FSC	**.754**					
PLE	.612***	**.807**				
SC	.571***	.665***	**.708**			
ES	.427***	.687***	.598***	**.887**		
AS	-.136**	-.062 (p=0.220)	-0.12 (p=0.799)	.270***	**.718**	
SCI	.232***	.544***	.411***	.621***	.173***	**.797**

Note: **: Correlation is significant at the 0.01 level (P<0.01)

***: Correlation is significant at the 0.001 level (P<0.001)

This table demonstrates the correlations between all the constructs. The red numbers are the values of the measurement instruments' square root of AVE. As

Table 4.41 shows, except for SE, whose value of the square root of AVE was a little bit lower than its correlation coefficient with PLE and ES, all the measurement instruments' values of the square root of AVE were higher than their latent variables' correlation coefficient with the other latent variables. It implied that the discriminant validity of each measurement instrument in model I was acceptable. In Table 4.42, all the measurement instruments' values of the square root of AVE were higher than their latent variables' correlation coefficient with the other latent variables. These results indicated that the discriminant validity of each measurement instrument in model II was good.

The descriptive analysis summary including means, standard deviations, and factor loadings of all the items in the refined measurement instruments and their composite reliability and AVE are shown in Table 4. 43.

Table 4.43 Means, standard deviations, factor loadings, CR and AVE of all the variables

Variable	M	SD	Standardised Factor Loadings	CR	AVE
PLE				0.848	0.652
ME	4.096	1.034	0.718***		
VP	4.898	1.135	0.846***		
VL	4.606	1.217	0.852***		
AS				0.809	0.516
AS2	3.77	1.526	0.623***		
AS3	4.15	1.562	0.777***		

Variable	M	SD	Standardised Factor Loadings	CR	AVE
AS4	4.73	1.459	0.758***		
AS5	4.58	1.528	0.706***		
FSC				0.797	0.568
FSC1	3.54	1.583	0.829***		
FSC2	3.59	1.473	0.726***		
FSC3	3.37	1.758	0.700***		
SE				0.880	0.514
SE1	4.659	1.319	0.710***		
SE2	4.863	1.371	0.718***		
SE3	4.280	1.421	0.743***		
SE5	3.853	1.244	0.529***		
SE6	4.514	1.382	0.782***		
SE7	4.261	1.456	0.738***		
SE8	4.913	1.340	0.766***		
SC				0.935	0.708
SC1	3.581	1.278	0.856***		
SC2	3.514	1.270	0.865***		
SC3	3.647	1.307	0.895***		
SC4	3.330	1.336	0.877***		
SC5	3.920	1.323	0.787***		
SC6	3.853	1.244	0.749***		
ES				0.949	0.788
ES1	4.68	1.349	0.869***		
ES2	4.61	1.380	0.904***		
ES3	4.51	1.421	0.895***		
ES4	4.86	1.321	0.893***		
ES5	4.80	1.349	0.877***		
SCI				0.873	0.636

Variable	M	SD	Standardised Factor Loadings	CR	AVE
SCI1	5.05	1.901	0.879***		
SCI2	5.20	1.625	0.908***		
SCI3	4.38	1.632	0.740***		
SCI4	4.47	1.580	0.632***		

Note: M: mean; SD: standard deviation; CR: composite reliability

***: Factor loading is significant at the 0.001 level ($p<0.001$)

Up to this stage, the measurement instruments have been tested and refined, to be applicable for the investigation of the hypothesised structural models.

4.4 The Investigation of the Hypothesised Models

The present study aimed at investigating whether the hypothetical models (the hypothesised models I and II; shown in Figures 4.22 and 4.23) would explain the formation process of Chinese high school students' science career intentions. As illustrated in the methodology chapter, considering the technical difficulty and complexity of testing the hypothesised moderation effect (family science capital would make moderation effects on the pathway from science interest to science career intentions) in the complex structural model, the moderation effect was individually investigated by moderation model (shown in Figure 4.24) and without the moderation effect, the hypothesised models I and II were turned into hypothesised models III and IV (shown in Figures 4. 25 and 4.26).

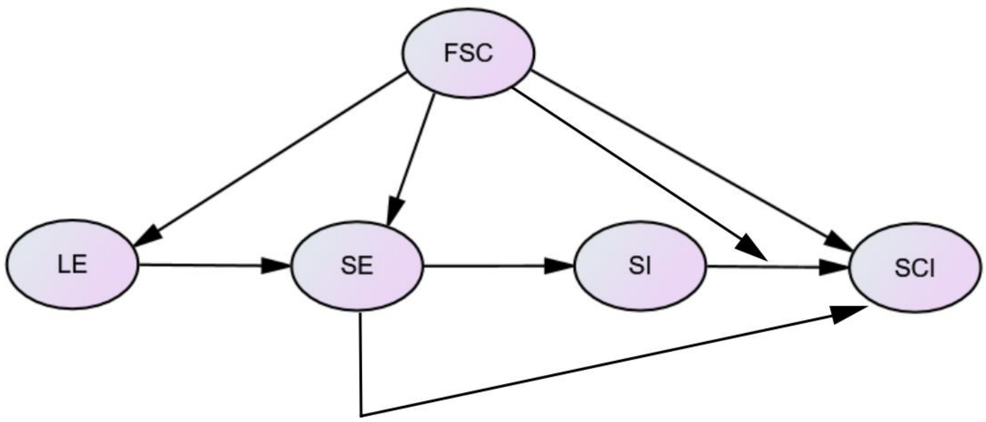


Figure 4.22 Hypothesised model I

Note: FSC: family science capital; LE: learning experiences; SE: self-efficacy; SI: science interest; SCI: science career intentions

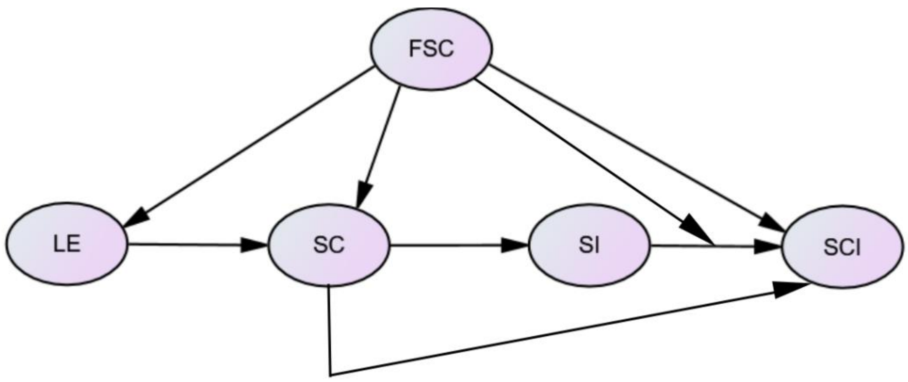


Figure 4.23 Hypothesised model II

Note: FSC: family science capital; LE: learning experiences; SC self-concept; SI: science interest; SCI: science career intentions

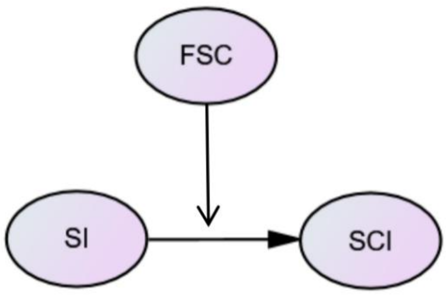


Figure 4.24 Hypothesised moderation model

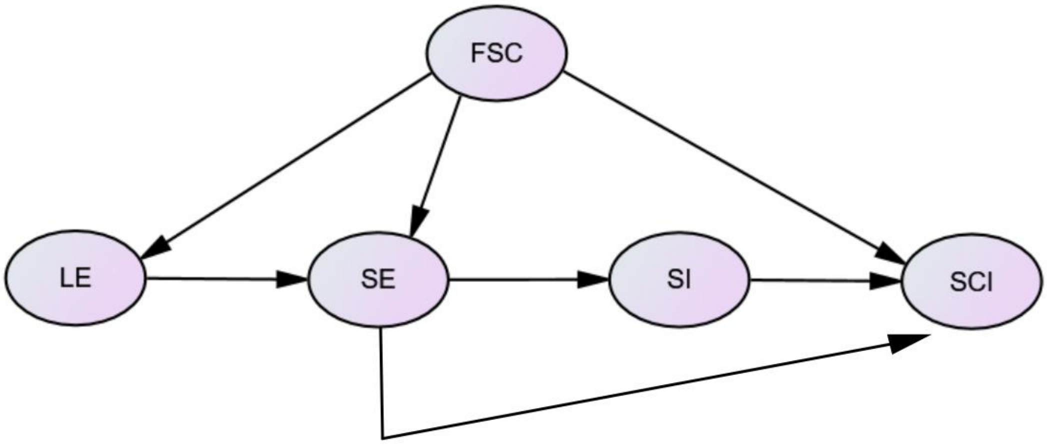


Figure 4.25 Hypothesised model III

Note: FSC: family science capital; LE: learning experiences; SE: self-efficacy; SI: science interest; SCI: science career intentions

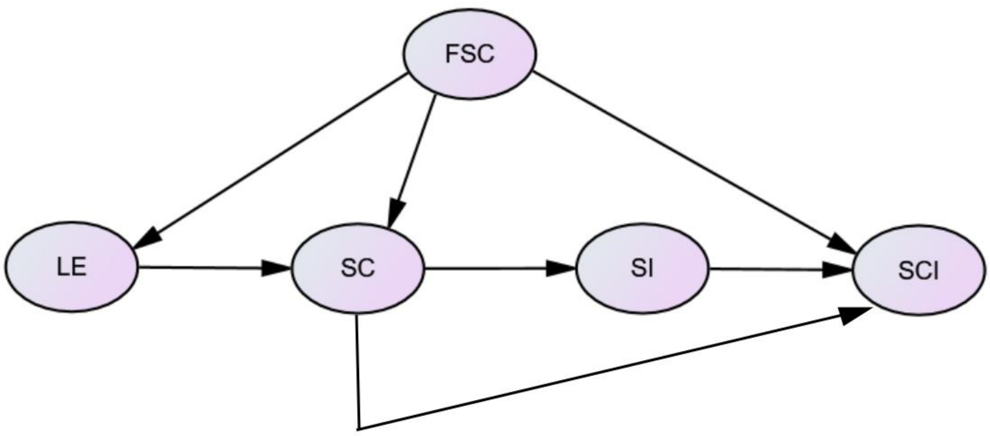


Figure 4.26 Hypothesised model IV

Note: FSC: family science capital; LE: learning experiences; SC self-concept; SI: science interest; SCI: science career intentions

To summarise, there are three kinds of analysis to operate

1. Structural equation modeling analysis to test the model fit of the hypothesised models III and IV.

2. Bootstrap analysis to investigate the four hypothesised mediation effects respectively in the hypothesised model III and IV:

Four hypothesised mediation effects in the hypothesised model III:

- FSC would make indirect effects on SE through the mediation of LE;
- SE would make indirect effects on SCI through the mediation effect of SI;
- FSC would make indirect effects on SCI through the mediation of LE, SE, and SI;
- LE would make indirect effects on SCI through the mediation effects of SE and SI.

Four hypothesised mediation effects in the hypothesised model IV:

- FSC would make indirect effects on SC through the mediation of LE;
- SC would make indirect effects on SCI through the mediation effect of SI;
- FSC would make indirect effects on SCI through the mediation of LE, SC, and SI;
- LE would make indirect effects on SCI through the mediation effects of SC and SI.

3. Hierarchical moderator regression analysis to test the hypothesis that family science capital would make moderation effects on the path from science interest to science career intentions.

4.4.1 Investigation of the Hypothesised Models

Based on the discussion about the measurement models in "section 4.2", two variables need to be specifically mentioned before the model fit testing of the hypothesised models III and IV.

Firstly, in the last section, the structure of learning experiences has been discussed. The results indicated that the four sub-factors learning experiences construct (including mastery experiences, vicarious learning, verbal persuasion, and affective state) was not fitted to the data in this study, given affective state was not consistent with this construct. Hence, the learning experiences construct was divided into two constructs: positive learning experiences (consisting of sub-factors mastery experiences, vicarious learning, verbal persuasion) and affective state. Hence, given the change of the learning experiences construct, the original ***hypothesised models III and IV*** were turned into ***the hypothesised models III* and IV**** (shown in Figure 4.27 and Figure 4.28).

Specifically, it is noteworthy that, between two optional measurement approaches to science interest variable, "interest in broad science topics" and "enjoyment of science", science interest variable in the hypothetical structural models would be measured by "enjoyment of science" measurement instrument. Hence, to make it clear, in the figures of hypothesised models III* and IV*, "enjoyment of science" replaces "science interest" as the variable name.

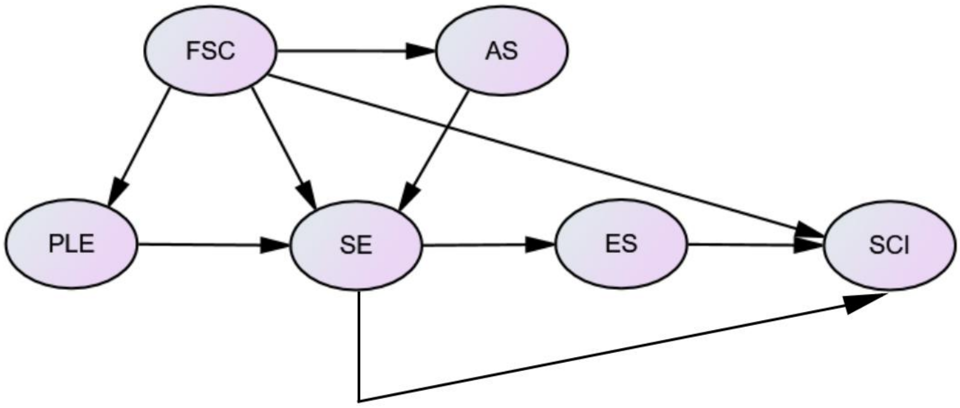


Figure 4.27 Hypothesised model III*

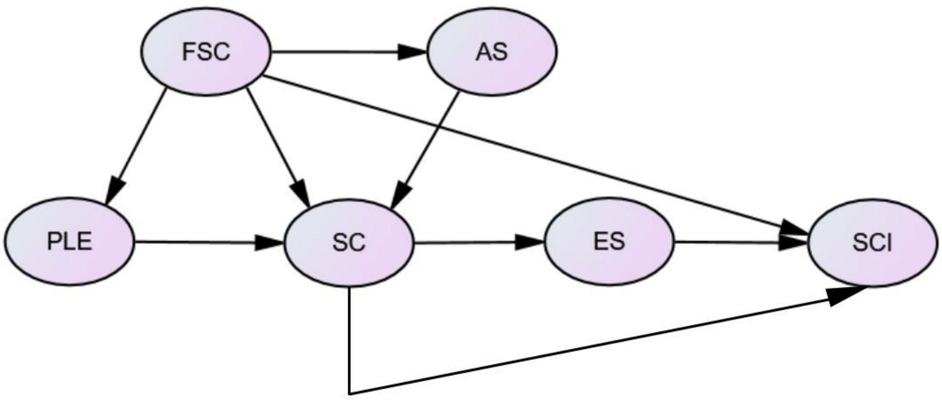


Figure 4.28 Hypothesised model IV*

4.4.1.1 Hypothesised model III*

The hypothesised model III* consisted of variables: family science capital, affective state, positive learning experiences, self-efficacy, enjoyment of science, and science career intentions.

The model fit indices of this model are shown in Table 4.44. The three model fit indices indicated that the data of the current study converged with the hypothesised model III*.

Table 4. 44 The model fit indices of the hypothesised model III*

CFI	RMSER	SRMR
0.909	0.073	0.083

Overall, the hypothesised model III* converged with the data. Detailed information, such as direct path effects, and indirect path effects are discussed further. Firstly, significance testings of paths in the hypothesised model III* were employed. The results of these significance testings showed that the path FSC to SCI was not significant ($p>0.05$) (which is shown in Table 4.45). Hence, the path FSC to SCI was deleted from the hypothesised model III*.

Table 4. 45 The results of significant testings of paths in the hypothesised model III*

			unstandardised path effects	S.E.	C.R.	P
PLE	<---	FSC	.425	.037	11.490	***
AS	<---	FSC	-.113	.043	-2.630	.009
SE	<---	PLE	.648	.061	10.592	***

			unstandardised path effects	S.E.	C.R.	P
SE	<---	FSC	.176	.041	4.314	***
SE	<---	AS	.177	.036	4.877	***
ES	<---	SE	.882	.052	17.036	***
SCI	<---	ES	.464	.061	7.579	***
SCI	<---	SE	.166	.075	2.222	.026
SCI	<---	FSC	-.055	.040	-1.371	.170

Note: S.E.: standard error;

C.R.: critical ratio;

***: $p<0.001$

It was interesting to find that after deleting the path FSC to SCI, the path SE to SCI turned out to be not statistically significant ($P>0.05$). It seemed that statistically, deleting the path FSC to SCI would saliently reduce the path effect of SE to SCI (the unstandardised regression weight turns from 0.166 to 0.122), thereby influencing the significance test of the path SE to SCI. This statistical phenomenon is called the suppression effect, which indicates that the reason for the insignificant relations between two variables may be due to the suppression of the third variable (MacKinnon & Lamp, 2021). In this study, the effect of FSC on SCI was negative. When the path FSC to SCI was deleted in the model, statistically, the path effect of “SE to SCI” actually shouldered part of the negative effect from the deleted path “FSC to SCI”, and therefore the unstandardised regression weight of the path SE to SCI was decreased. The rigorous explanations of the suppression effect need complicated mathematical analysis and this thesis just provides a brief introduction to that. Based on the analysis results, the path SE to SCI was also deleted.

To be distinguished from the hypothesised model III*, the modified hypothesised model without the path "FSC to SCI" and the path "SE to SCI" was named the hypothesised model III**. The model fit indices of the hypothesised model III** are shown in Table 4.46. The Δ CFI value (.01) has been widely used to compare the relative fit of structural models, based on the comparison of the hypothesised model III* and the hypothesised model III**, the Δ CFI was 0.00, which indicated that the hypothesised model III** was not relatively more fitted than model III* (Cheung & Rensvold, 2002).

Table 4.46 The model fit indices of the hypothesised model III**

CFI	RMSER	SRMR
0.909	0.073	0.085

The regression estimates of all the direct paths in the hypothesised model III** are shown in Table 4. 47. Based on the model fit testing and scrutiny of path effects from the structural model, the hypothesised model III** was accepted as a possible model to explain Chinese students' formation process of science career intentions, and the figure of hypothesised model III** is shown in Figure 4.29.

Table 4. 47 The regression estimates of all the direct paths in the hypothesised model III**

			Unstandardised path effects	S.E.	C.R.	P	Standardised path effects
PLE	<---	FSC	.427	.037	11.536	***	.592
AS	<---	FSC	-.113	.043	-2.624	.009	-.134
SE	<---	PLE	.643	.061	10.468	***	.584
SE	<---	FSC	.176	.041	4.290	***	.222
SE	<---	AS	.176	.036	4.838	***	.187
ES	<---	SE	.884	.052	17.073	***	.768
SCI	<---	ES	.553	.044	12.610	***	.625

Note:

S.E.: Standard Error

C.R.: Critical Ratio

***: the path effect is significant at the P<0.001 level

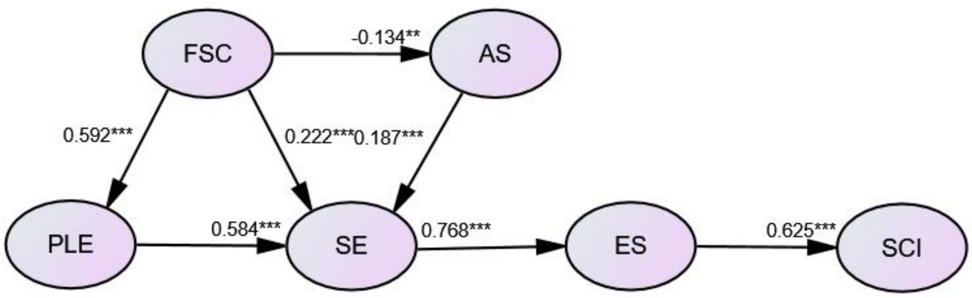


Figure 4.29 Model III** with path effects

Note: The numbers on the path indicate the magnitudes of the standardised path effects

**: the path effect is significant at the P<0.01 level

***: the path effect is significant at the P<0.001 level

4.4.1.2 Hypothesised Model IV*

As discussed before, hypothesised model IV* was designed as the comparative model of hypothesised model III*. The hypothesised model IV* consisted of variables: family science capital, affective state, positive learning experiences, self-concept, enjoyment of science, and science career intentions (shown in figure 4.28). The only difference between hypothesised model IV* and hypothesised model III* is that hypothesised model IV* replaces the variable self-efficacy in hypothesised model III* with self-concept. Through comparing these two models, the different roles of self-efficacy and self-concept in the formation processes of students' science career intentions are further discussed and presented in the thesis. Through analysis of structural equation modelling, the model fit indices of this model are shown in Table 4.48. The value of CFI of the hypothesised model IV* was over 0.90 and the value of RMSER was less than 0.08; both of these two indices indicated the model was fitted to the data. The value of SRMR was a little higher than 0.08 (which is the goodness of fit value used in the current study). According to Hu and Bentler (1999), a value of SRMR smaller than 0.08 indicates a good fit model, and a value of SRMR over 0.08 but smaller than 0.1 indicates the model fit is acceptable. Overall, the model fit of the hypothesised structural regression model IV* was acceptable.

Table 4. 48 The model fit indices of the hypothesised model IV*

CFI	RMSER	SRMR
0.922	0.076	0.097

The path effects in the hypothesised structural regression model IV* were examined by significance testings and the results are shown in Table 4.49.

Nonsignificant paths may lead to poor model fit and deleting any nonsignificant paths may enhance the overall model fit (Kline, 2010).

Table 4.49 The results of significance testings of paths effects in the hypothesised model IV*

			Unstandardised path effects	S.E.	C.R.	P
PLE	<---	FSC	.375	.034	11.066	***
AS	<---	FSC	-.107	.042	-2.528	.011
SC	<---	FSC	.127	.039	3.260	.001
SC	<---	PLE	.982	.076	12.930	***
SC	<---	AS	.078	.033	2.353	.019
ES	<---	SC	.678	.044	15.273	***
SCI	<---	ES	.792	.072	10.974	***
SCI	<---	SC	.177	.088	2.016	.044
SCI	<---	FSC	-.088	.065	-1.366	.172

Note:

S.E.: standard error

C.R.: critical ratio

***: $p<0.001$

The path from FSC to SCI was not statistically significant. This is similar to the hypothesised model III* in which the path FSC to SCI was not statistically significant either. The path FSC to SCI was deleted. As discussed before, the suppression effect of path FSC to SCI influenced the path effect of path SC to SCI. After deleting the path FSC to SCI, the unstandardised path effect of SC to SCI sharply declined from 0.177 to 0.118 and since the path effect of SC to SCI was weakened, the statistical significance of this path was not achieved. Hence, both the paths FSC to SCI and SC to SCI were deleted. To be distinguished from the hypothesised model IV*, the model without the paths FSC to SCI and SC to SCI was named the hypothesised model IV**. The model fit indices of the hypothesised model IV** are shown in Table 4.50.

Table 4. 50 The model fit indices of the hypothesised model IV**

CFI	RMSER	SRMR
0.921	0.076	0.099

Compared with the hypothesised model III**, the value of SRMR of the hypothesised model IV** was too high, which implied the issues from hypothesised model IV**. According to Kline (2010), SRMR is measured based on standardised residual covariances. Ideally, for model fitness, most of the standardised residual covariances should be less than 2 in absolute value (cited from the explanation of standardised residual covariances in Amos 24 software). Through examining the standardised residual covariances of the hypothesised model IV**, I found that in the hypothesised model IV**, many standardised residual covariances between items of SC construct were all higher than 2. In contrast, most of the standardised residual covariances between items of SE construct in hypothesised model III** were less than 2. This finding implied that the higher value of SRMR of the hypothesised model IV** compared with the hypothesised model III** may be due to the high standardised residual covariances involving items of SC.

Generally, the hypothesised model IV** could converge with the data in this study. The regression estimates of all the direct paths in the hypothesised model IV** are shown in Table 4. 51. The hypothesised model IV** was accepted as another possible model to explain Chinese students' formation process of science career intentions, which is shown in Figure 4.30.

Table 4. 51 The regression estimates of all the direct paths in the hypothesised model IV**

			Unstandardised path effects	S.E.	C.R.	P	Standardised path effects
PLE	<---	FSC	.377	.034	11.101	***	.605
AS	<---	FSC	-.106	.042	-2.522	.012	-.128
SC	<---	FSC	.126	.039	3.214	.001	.149
SC	<---	PLE	.979	.076	12.871	***	.724
SC	<---	AS	.078	.033	2.336	.019	.076
ES	<---	SC	.681	.044	15.329	***	.630
SCI	<---	ES	.858	.058	14.788	***	.624

Note: S.E.: standard error

C.R.: critical ratio

***: P<0.001

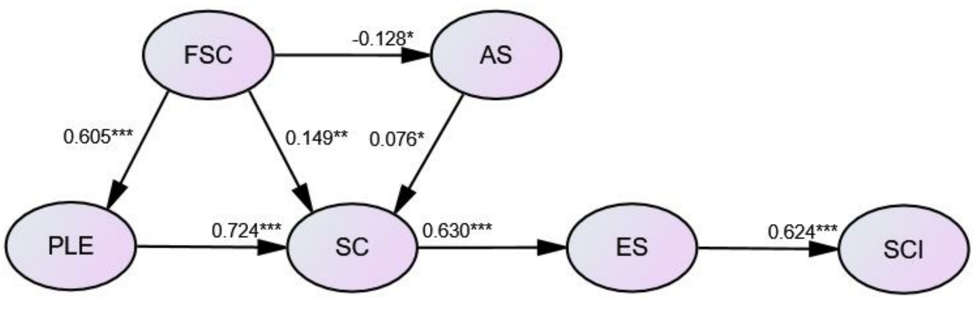


Figure 4. 30 Model IV** with path effects

Note: The numbers on the path indicate the magnitudes of the standardised path effects

*: the path effect is significant at the P<0.05 level

**: the path effect is significant at the P<0.01level

***: the path effect is significant at the P<0.001level

4.4.2 Cross Validation Testings

Modification of the model may be driven by the characteristics of the specific sample which is tested in the study and may not be appropriate for the larger population (MacCallum et al., 1992). A strategy to solve this problem is cross-validation testing in which two independent samples from the same population are tested in the same re-specified model. In this study, the hypothesised model III** and the hypothesised model IV** were established by conducting many modifications on the original hypothesised measurement models and structural models. Conducting cross-validation testing could mitigate the possibility of model fit error by chance. In the current study, the sample was randomly divided into a calibration sample and a validation sample. The calibration sample was used for model investigation (including measurement models and structural regression models) and produced the structure of baseline models which were fitted to the data. The baseline models were then tested for model equivalencies between the calibration sample and the validation sample. The model equivalencies between the calibration sample and validation sample indicated the cross-validation of the hypothesised models III** and IV**, which implied that these hypothesised models did not converge with the sample merely by chance.

In testing the equivalencies between models, the current study tested a set of parameters. According to Byrne (2016), the most common parameters to consider for model equivalencies are listed in a logically ordered and increasingly restrictive fashion: 1. measurement weights, 2. structural weights, 3. structural covariances, 4. structural residuals, and 5. measurement residuals. In practice, it is widely accepted that testing the equality of error variances (structural residuals and measurement residuals) between the baseline model and validation model is overly stringent and not necessary for cross-validation studies (Byrne, 2016). Hence, generally, the equality of measurement weights, structural weights, and structural covariances between the two models indicate these two models are equivalent. These three kinds of parameters were the indicators for model equivalence testings in the current study.

An automated multiple-group approach in the Amos platform was employed to conduct the cross-validation testing. Specifically, to compare the measurement weights, structural weights, and structural covariances between models with the calibration sample and validation sample, there were three comparative models designed. Model 0 was an absolute unconstrained baseline model. To test the invariance of measurement weights between the calibration sample and validation sample, model 1 constrained measurement weights to be equal across two samples. If there was no difference in model fit between model 0 and model 1, this supported the hypothesis that there was no difference in measurement weights between the two samples (in other words, it confirmed cross-validation at this level. To test the invariance of structural weights between the calibration sample and validation sample, model 2 constrained the measurement weights and structural weights to be equal across the two samples. If there was no difference in model fit between model 1 and model 2, this confirmed the cross-validation at the second level by Byrne. To test the invariance of structural covariances between the calibration sample and validation sample, model 3 constrained the measurement weights, structural weights, and structural covariances to be equal between the calibration sample and validation sample. If there was no difference in model fit between model 2 and model 3, it supported the invariance of structural covariance between the two samples and indicated cross-validation at Byrnes’ third level.

With the gradual addition of constraints, in the current study, each model was more restrictive than its predecessor. Then, each model was compared with its predecessor to see whether there was a significant model fit difference. Generally, there are two widely used approaches to test the model fit difference (Byrne, 2016). The first one is the traditional Chi-square difference approach (Byrne, 2016). However, in practice, Chi-square testing is influenced by the large sample size and multivariate non-normality (Kline, 2010). This study recruited a large sample, which might influence the accuracy of Chi-square testing. In addition, according to Byrne (2016), in practice, most data in SEM studies could not meet the requirement of multivariate normality, and the data in this study did not rigorously meet the multivariate normality either. Another widely used approach in practice is from

Cheung and Rensvold (2002). Cheung and Rensvold (2002) conducted a rigorous Monte Carlo study and proposed that the model fit change could be implied by the change of CFI values (> 0.01). In this study, as suggested by Byrne (2016), both approaches (Chi-square value difference approach and CFI value difference approach) to testing model fit difference were employed.

4.4.2.1 Cross-validation testings of the model III**

Chi-squared Value Difference Approach

As discussed before, there were three comparative models designed. The Chi-squared values of the three comparative models and the unconstrained baseline model are shown in Table 4.52.

Table 4. 52 Chi-Squared Values of Three Comparative Models and a Baseline Model (Model III**)

Model name	CMIN	DF	P
Model 0	2604.266	582	.000
Model 1	2621.805	602	.000
Model 2	2626.651	606	.000
Model 3	2626.682	607	.000

Note:

Model0: unconstrained baseline model

Model1: Measurement weights are constrained across calibration and validation samples

Model2: Measurement weights and structural weights are constrained across calibration and validation samples

Model3: Measurement weights, structural weights, and structural covariances are constrained across calibration and validation samples

DF: degree of freedom; CMIN: Chi-squared value

The model fit difference between model 1 and model 0 could be implied by the Chi-squared difference approach. △ Chi-squared value (2621.805-2604.266=17.539) between model 1 and model 0 with 20 degrees of freedom (DF model 1- DF model 0) was not statistically significant at a probability of less than 0.05 ($p=0.618>0.05$). This result implied that measurement weights between the calibration sample and validation sample were equivalent.

Similarly, the Chi-squared difference approach was also employed to test the model fit difference between model 2 and model 1. △ Chi-squared value (2626.651-2621.805 =4.846) between model 2 and model 1 with 4 degrees of freedom (DF model 2- DF model 1) was not statistically significant at a probability of less than 0.05 ($p=0.303>0.05$). This result implied that structural weights between the calibration sample and validation sample were equivalent.

Finally, the Chi-squared difference approach was employed to test the model fit difference between model 3 and model 2. △ Chi-squared value (2626.682-2626.651=0.031) between model 3 and model 2 with 1 degree of freedom (DF model 3- DF model 2) was not statistically significant at a probability of less than 0.05 ($p=0.860>0.05$). This result implied that structural covariances between the calibration sample and validation sample were equivalent. Overall, the measurement weights, structural weights, and structural covariances were equivalent across calibration and validation samples, which implied that the model III** had cross-validation between the calibration sample and validation sample.

CFI Value Difference Approach

Table 4.53 The CFI values of three comparative models and a baseline model (Model III**)

Model name	CFI
Model 0	.896
Model 1	.897
Model 2	.897
Model 3	.897

Note:

Model0: unconstrained baseline model

Model1: Measurement weights are constrained across calibration and validation samples

Model2: Measurement weights and structural weights are constrained across calibration and validation samples

Model3: Measurement weights, structural weights, and structural covariances are constrained across calibration and validation samples

The CFI value differences between model 1 and model 0, model 2 and model 1, and model 3 and model 2 were all less than 0.01, which are shown in Table 4. 53. Hence, based on the CFI value difference approach, the cross-validation between calibration sample and validation sample of the model III** also could be demonstrated.

4.4.2.2 Cross validation testing of the model IV**

Chi-Squared Value Difference Approach

Similarly, the Chi-squared values of three_comparative models and an unconstrained model are shown in Table 4.54.

Table 4.54 Chi-squared values of three comparative models and a baseline model (Model IV**)

Model name	CMIN	DF	P
Model 0	2370.693	530	.000
Model 1	2400.751	549	.000
Model 2	2408.522	556	.000
Model 3	2408.584	557	.000

Note:

Model0: unconstrained baseline model

Model1: Measurement weights are constrained across calibration and validation samples

Model2: Measurement weights and structural weights are constrained across calibration and validation samples

Model3: Measurement weights, structural weights, and structural covariances are constrained across calibration and validation samples

Δ Chi-squared value (2400.751-2370.693=30.058) between model 1 and model 0 with 19 degrees of freedom (DF model 1- DF model 0) was not statistically significant at a probability of less than 0.05 ($p=0.051>0.05$). This result implied that measurement weights between the calibration sample and validation sample were equivalent.

△ Chi-squared value (2408.522-2400.751=7.771) between model 2 and model 1 with 7 degrees of freedom (DF model 2- DF model 1) was not statistically significant at a probability of less than 0.05 ($p=0.353>0.05$). This result implied that structural weights between the calibration sample and validation sample were equivalent.

△ Chi-squared value (2408.584-2408.522=0.062) between model 3 and model 2 with 1 degree of freedom (DF model 3- DF model 2) was not statistically significant at a probability of less than 0.05 ($p=0.803>0.05$). This result implied that structural covariances between the calibration sample and validation sample were equivalent. Overall, the measurement weights, structural weights, and structural covariances were equivalent across calibration and validation samples, which implied that the model IV** had cross-validation between the calibration sample and validation sample.

CFI Value Difference Approach

Table 4. 55 The CFI values of three comparative models and a baseline model (Model IV**)

Model	CFI
Unconstrained	.918
Measurement weights	.917
Structural weights	.917
Structural covariances	.917

Note:

Model0: unconstrained baseline model

Model1: Measurement weights are constrained across calibration and validation samples

Model2: Measurement weights and structural weights are constrained across calibration and validation samples

Model3: Measurement weights, structural weights, and structural covariances are constrained across calibration and validation samples

The CFI differences between model 1 and model 0, model 2 and model 1, and model 3 and model 2 were all less than 0.01, which are shown in Table 4.55 Hence, the CFI value difference approach also provided evidence of cross-validation for the model IV**.

4.4.3 Investigation of Mediation Effects

Since the learning experience construct was divided into positive learning experience and affective state, the original hypothetical models were changed. Originally, there were four hypothesised mediation effects in each hypothesised model (the hypothesised model III and the hypothesised model IV). Given the change of the learning experiences construct, the hypothesised mediation effects in the hypothesised models were also changed. Specifically, the mediation effects in the hypothesised model III** and the hypothesised model IV** are discussed in this section.

4.4.3.1 The mediation effects in the hypothesised model III**

There were six hypothesised mediation effects in the hypothesised model III**.

Mediation postulate 1: FSC would make indirect effects on SE through the mediation of PLE.

Mediation postulate 2: FSC would make indirect effects on SE through the mediation of AS.

Mediation postulate 3: FSC would make indirect effects on SCI through the mediation of PLE, AS, SE, and ES.

Mediation postulate 4: SE would make indirect effects on SCI through the mediation effect of ES.

Mediation postulate 5: PLE would make indirect effects on SCI through the mediation effects of SE and ES.

Mediation postulate 6: AS would make indirect effects on SCI through the mediation effects of SE and ES.

As discussed in the methodology chapter, bootstrap analysis was employed to estimate mediation effects in the present study. The significant mediation effects could be supported if the range of values of 95% biased-corrected confidence intervals estimated by bootstrap analysis did not include zero.

The mediation postulates 1 and 2 both considered the indirect path between FSC and SE, and the differences were that postulate 1 considered PLE as the mediation factor, by contrast, postulate 2 considered AS as the mediation factor. In the present study, mediation postulates 1 and 2 were not only investigated, and the magnitudes of mediation effects of PLE and AS between FSC and SE were also compared.

The results of bootstrap estimates of mediation postulates 1 and 2 are shown in Table 4. 56

Table 4. 56 The results of bootstrap estimates of mediation postulates 1 and 2, the path effects difference between these two paths (Model III**)

Indirect paths	Bootstrap estimates			
	Mean B	Mean S.E.	95% bias-corrected CI	
FSC-PLE-SE	.274	.043	.200	.369
FSC-AS-SE	-.020	.012	-.048	-.001
IE difference	-.294	.046	-.394	-.213

Note: B: unstandardised path effects

S.E.: standard error

CI:confidence intervals

IE difference: indirect effects difference between indirect paths FSC-PLE-SE and FSC-AS-SE

As shown in Table 4.56, the confidence intervals of FSC-PLE-SE and FSC-AS-SE did not include zero, therefore the indirect path effects of FSC-PLE-SE and FSC-AS-SE were both significant. Both PLE and AS could mediate the path between FSC and SE. The IE difference in the Table 4.56 indicated the difference in the indirect effect between indirect paths FSC-PLE-SE and FSC-AS-SE. The confidence intervals of the IE difference did not include zero, which indicated that the indirect path effects of FSC-PLE-SE were significantly higher than the indirect path effects of FSC-AS-SE.

The results of bootstrap estimates of mediation postulates 3 to 6 are shown in Table 4.57.

Table 4. 57 The results of bootstrap estimates of mediation postulates 3 to 6 (Model III**)

Indirect effects	Bootstrap estimates			
	Mean B	Mean S.E.	95% bias-corrected CI	
FSC to SCI	.211	.034	.151	.287
SE-ES-SCI	.489	.060	.379	.613
PLE-SE-ES-SCI	.314	.056	.217	.438
AS-SE-ES-SCI	.086	.021	.048	.131

Note: B: unstandardised path effects

S.E.:standard error

CI:confidence intervals

All the indirect paths' confidence intervals did not include zero. Hence, mediation postulates 3 to 6 were all supported. Referring to previous results in model III**, although FSC did make significant direct effects on SCI, it made an indirect effect on SCI, through complex mediation effects of PLE, AS, SE, and ES. SE did not make significant direct effects on SCI, but it made indirect effects on SCT through ES. PLE and AS both made indirect effects on SCI through SE and ES.

4.4.3.2 The mediation effects in the hypothesised model IV**

There were also six postulates of mediation effects in the hypothesised model IV**.

Mediation postulate 1: FSC would make indirect effects on SC through the mediation of PLE.

Mediation postulate 2: FSC would make indirect effects on SC through the mediation of AS.

Mediation postulate 3: FSC would make indirect effects on SCI through the mediation of PLE, AS, SC, and ES.

Mediation postulate 4: SC would make indirect effects on SCI through the mediation effect of ES.

Mediation postulate 5: PLE would make indirect effects on SCI through the mediation effects of SC and ES.

Mediation postulate 6: AS would make indirect effects on SCI through the mediation effects of SC and ES.

There were also six postulates of mediation effects in the hypothesised model IV**.

Mediation postulate 1: FSC would make indirect effects on SC through the mediation of PLE.

Mediation postulate 2: FSC would make indirect effects on SC through the mediation of AS.

Mediation postulate 3: FSC would make indirect effects on SCI through the mediation of PLE, AS, SC, and ES.

Mediation postulate 4: SC would make indirect effects on SCI through the mediation effect of ES.

Mediation postulate 5: PLE would make indirect effects on SCI through the mediation effects of SC and ES.

Mediation postulate 6: AS would make indirect effects on SCI through the mediation effects of SC and ES.

Similarly, to the previous section on mediation effects in model III**, the mediation effects in model IV** were estimated by bootstrap analysis. The results of bootstrap analysis on path FSC-PLE-SC (mediation postulate 1) and FSC-AS-SC (mediation postulate 2), and the path effects difference between these two paths are shown in Table 4. 58. The results showed that the indirect path effects of FSC-PLE-SC were significant (confidence intervals did not include 0), but the indirect path effects of FSC-AS-SC was not significant (confidence intervals included 0).

Table 4.58 The results of bootstrap estimates of mediation postulates 1 and 2, and the path effects difference between these two paths (Model IV**)

Indirect paths	Bootstrap estimates			
	Mean B	Mean S.E.	95% biased-corrected CI	
FSC-PLE-SC	.369	.047	.284	.467
FSC-AS-SC	-.008	.007	-.028	.000
IE difference	-.377	.048	-.482	-.292

Note: B: unstandardised path effects; S.E.:standard error; IE difference: indirect effects difference between indirect path FSC-PLE-SC with FSC-AS-SC

The results of bootstrap analysis of indirect paths described from mediation postulates 3 to 6 in model IV** are shown in Table 4.59.

Table 4. 59 The results of bootstrap estimates of mediation postulate 3 to 6 (Model IV**)

Indirect effects	Bootstrap estimates			
	Mean B	Mean S.E.	95% biased-corrected CI	
FSC to SCI	.284	.044	.204	.379
SC-ES-SCI	.584	.061	.468	.709
PLE-SC-ES-SCI	.572	.090	.384	.740
AS-SC-ES-SCI	.045	.027	-.001	.105

Note: B: unstandardised path effects

S.E.:standard error

CI:confidence intervals

Only mediation postulate 6 - AS would make indirect effects on SCI through the mediation effects of SC and ES - was rejected (the confidence interval range included 0). Mediation postulate 3, 4, and 5 were all supported by bootstrap estimates. Referring to the results of model IV**, although FSC did not make direct effects on SCI, it made indirect effects on SCI. Similarly, SC did not make direct effects on SCI, but it made indirect effects on SCI. PLE made indirect effects on SCI, through the mediation of SC and ES. However, AS neither made indirect effects on SC nor on SCI.

4.4.4 Investigation of Moderation Effects

As discussed in the literature review chapter, students with high family science capital are more likely to gain guidance and support to get a science-related occupation, which may contribute to the translation path from "interest in science" to "intend to have scientific jobs". Hence, in the present study, it was hypothesised that family science capital would make moderation effects on the path between science interest (enjoyment of science) and science career intentions. Hierarchical moderator regression analysis was employed to investigate the moderation hypothesis. Firstly to reduce the influence of collinearity, the moderator variable "family science capital", the independent variable "enjoyment of science", and the dependent variable "science career intentions" were all standardised by SPSS software. Then, the interaction term ("enjoyment of science" * "family science capital") was created by multiplying together the standardised variables "enjoyment of science" and "family science capital".

To conduct the hierarchical moderator regression analysis, there were two layers to test the moderator hypothesis. The first layer model (model 1) included the main effects from variables which made direct effects on the dependent variable "science career intentions". Hence the first layer of hierarchical regression contained the independent variables “enjoyment of science” and “family science capital”. The second layer model (model 2) added the interaction term (“enjoyment of science” * “family science capital”) into the first layer model. If the inclusion of the interaction term in step 2 gave a significant enhancement of explanation of SCI compared to the step 1 model, the hypothesis was supported, that family science capital made moderation effects on the path from science interest to science career intentions (Cohen et al. 2003).

Table 4.60 Change statistics between model 1 and model 2

					Change Statistics		
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	Sig. F Change
1	.635	.403	.402	.77351659	.403	388.354	.000
2	.638	.407	.405	.77120377	.004	7.920	.005

Table 4.61 Coefficients of the independent variables in Model 1 and 2, and the results of collinearity testings

Coefficients								
		Unstandardized Coefficients		Standardised Coefficients			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	Stan.(ES)	.622	.025	.622	25.305	.000	.857	1.166
	Stan.(FSC)	.031	.025	.031	1.262	.207	.857	1.166
2	Stan.(ES)	.604	.025	.604	23.835	.000	.802	1.246
	Stan.(FSC)	.049	.025	.049	1.946	.052	.801	1.249
	Stan.(FSC) * Stan. (ES)	-.056	.020	-.067	-2.814	.005	.908	1.101

Note: Stan.: standardised score

As shown in Table 4.60, the R^2 difference between the first and second layer models was significant ($p=0.005 < 0.05$), which indicated that the addition of the interaction term in the model 2 significantly enhanced the explanation for SCI. The value of VIF of all the variables in the hierarchical model were all less than 2 (shown in Table 4.61), which indicated that the results of hierarchical regression analysis were not influenced by multicollinearity (Mason and Perreault, 1991). Hence, the hierarchical regression analysis indicated that family science capital made moderator effects on the path between enjoyment of science and science career intention. In addition, as shown in Table 4.61, FSC did not make significant direct effects on SCI (which was consistent with the results of model III** and model IV**), therefore, FSC only played as moderator on the pathway between students' enjoyment of science to science career intentions, it did not directly predict science career intentions.

4.5 Comparisons of self-efficacy, self-concept, enjoyment of science, science career intentions, and family science capital among different background groups (gender, rural/urban, and parental educational level)

In this section, comparisons of self-efficacy, self-concept, enjoyment of science, science career intentions, and family science capital among different background groups (gender, rural/urban, and parental educational level) are presented.

Gender

Table 4.62 shows that male students' self-efficacy, self-concept, enjoyment of science, family science capital, and science career intentions are higher than their female counterparts. Furthermore, the results of t-test indicate that the differences of self-efficacy, self-concept, enjoyment of science, family science capital, and science career intentions between two gender groups are statistically significant.

Table 4.62 Comparison of factors between male and female groups

					t-test for Equality of Means	
	Male or Female	N	Mean	Std. Deviation	t	Sig. (2-tailed)
SE	Male	491	4.8717	1.02970	7.286	.000
	Female	669	4.4155	1.08381		
SC	Male	491	4.1578	1.14855	12.175	.000
	Female	669	3.3572	1.04479		
ES	Male	491	5.0886	1.12517	9.516	.000
	Female	669	4.4269	1.22728		
FSC	Male	491	3.7361	1.39421	5.549	.000
	Female	669	3.2915	1.28061		
SCI	Male	491	5.1362	1.32459	6.591	.000
	Female	669	4.5859	1.45944		

Rural/Urban

As shown in table 4.63, the results of t-test show that apart from science career intention, urban students' self-efficacy, self-concept, enjoyment of science, family science capital are significantly higher than their rural counterparts. It is interesting to notice that in the present study, rural and urban students' science career intention levels are similar.

Table 4.63 Comparison of factors between rural and urban groups

	Urban or Rural	N	Mean	Std. Deviation	t-test for Equality of Means: t	Sig. (2-tailed)
SE	Urban	465	4.7919	1.10896	4.724	.000
	Rural	696	4.4880	1.05057		
SC	Urban	465	3.9029	1.22139	5.094	.000
	Rural	696	3.5524	1.09731		
ES	Urban	465	4.9062	1.19963	4.616	.000
	Rural	696	4.5684	1.23691		
FSC	Urban	465	3.7154	1.40419	4.936	.000
	Rural	696	3.3214	1.28299		
SCI	Urban	465	4.8430	1.46486	.552	.584
	Rural	696	4.7956	1.41185		

Family educational level

Based on whether participants' mother/female carer has been to high school, there are two groups shown in table 4.64. Table 4.64 indicates that students whose mother has been to high school have significantly higher self-efficacy, self-concept, and family science capital than their counterparts. The two groups have similar level of enjoyment of science, and science career intentions. Based on whether participants' father/male carer has been to high school, there are two groups shown in table 4.65.

Similar with the group comparison between mother educational level, table 4.65 indicates that students whose father has been to high school have significantly higher self-efficacy, self-concept, and family science capital than their counterpart.

Table 4.64 Comparison of factors between groups with different mother/female carer educational level

	Mother Education Level	N	Mean	Std. Deviation	t-test for Equality of Means t	Sig. (2-tailed)
SC	1.0	351	3.8067	1.19400	2.491	.013
	2.0	715	3.6172	1.15384		
SE	1.0	351	4.7051	1.10588	2.278	.023
	2.0	715	4.5432	1.08324		
ES	1.0	351	4.8074	1.21554	1.918	.055
	2.0	715	4.6517	1.25948		
FSC	1.0	351	3.7901	1.31244	5.722	.000
	2.0	715	3.2937	1.19400		
SCI	1.0	351	4.7123	1.15384	-1.758	.079
	2.0	715	4.8759	1.10588		

Note: Whether your mother/female carer has been to high school? Yes: 1 No:2

Table 4.65 Comparison of factors between groups with different father/male carer educational level

	Father Education Level	N	Mean	Std. Deviation	t-test for Equality of Means: t	Sig. (2-tailed)
SC	1.0	346	3.7977	1.26492	1.999	.046
	2.0	708	3.6379	1.11677		
SE	1.0	346	4.7113	1.17553	2.055	.040
	2.0	708	4.5583	1.04851		
ES	1.0	346	4.8116	1.27590	1.719	.086
	2.0	708	4.6712	1.22958		
FSC	1.0	346	3.7736	1.40409	5.370	.000
	2.0	708	3.3027	1.30275		
SCI	1.0	346	4.7840	1.48913	-.836	.414
	2.0	708	4.8623	1.39721		

Note: Whether your father/male carer has been to high school? Yes: 1 No:2

Chapter 5 Discussion

The lack of students who are intended to work in science-related fields remains a concerning problem in many countries (Moote et al., 2021). Investigation into the mechanism of students' development of science career intentions could shed light on the reasons for students' falling interest in science aspirations. Archer, Moote, MacLeod, Francis, and DeWitt (2020) emphasised that both personal agency (e.g. self-efficacy) and science capital are pivotal factors that shape students' likelihood of science aspirations. However, there was a dearth of studies combining these two crucial factors to create an integrated model of students' development of science career intentions. The present study has drawn on SCCT and family science capital theory, and by combining these two theories, this study has designed two alternative hypothesised models (model I and model II). These two models differ in the variables which represent self-perceived capability (self-efficacy has been involved in model I and self-concept has been involved in model II). As discussed in the methodology chapter, to facilitate the statistical analysis, they were split into two hypothesised structural regression models: model III (shown in Figure 3.2) and model IV (shown in Figure 3.3), and a hypothesised moderation model (shown in Figure 3.1). The study then tested the fit of the data to these three hypothesised models, in order to determine whether the models were aligned well with the empirical data.

After analysis of the data, some modifications have been made to the two hypothesised structural regression models, to make each of these two models a better match to the data. The modified models which converged the data in this study were named model III** and model IV**. The hypothesised moderation model which indicated that family science capital had moderation effects on the pathway from science interest to science career intentions was also supported by the data in this study. Since these two modified structural regression models and the moderation model were supported by data from participants in this study, they indicated that the modified hypothesised model I (termed model I*, shown in Figure 5.1) consisting of the components of model III** and the moderation effect and the modified hypothesised model II (termed model II*, shown in Figure 5.2) consisting of the components of model IV** and the moderation effect could demonstrate possible mechanisms to explain participants' development of science career intentions.

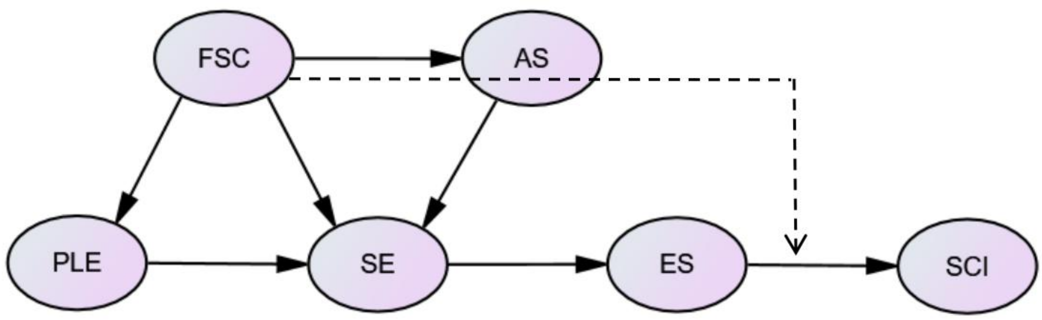


Figure 5.1 Model I*

Note: The dashed line represents the moderation effects of FSC on the pathway from ES to SC

FSC: family science capital; LE: learning experiences; SE: self-efficacy; SI: science interest; SCI: science career intentions

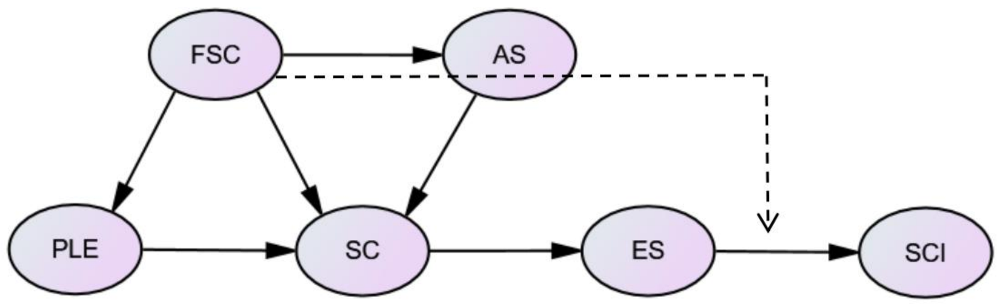


Figure 5.2 Model II*

Note: The dashed line represents the moderation effects of FSC on the pathway from ES to SCI

FSC: family science capital; LE: learning experiences; SC self-concept; SI: science interest; SCI: science career intentions

In this chapter, the descriptive data from this study are firstly discussed; these data include students' science career intentions, students' interest in science, students' self-efficacy and self-concept in science, their science-related learning experiences, and their family science capital. Then, the details of the fitted model I* and II* are demonstrated. The theoretical and applied significance of the findings of this study is then considered. Following that, the strengths and limitations of this study are discussed. Finally, there are some suggested implications for future research directions.

5.1 Discussion of the Descriptive Data

The descriptive data including students' science career intentions, students' interest in science, students' self-efficacy and self-concept in science, their science-related learning experiences, and their family science capital are first discussed here. Based on the discussion of these descriptive data, this study gets the first insight into Chinese high school students' attitudes and intentions to science.

5.1.1 Science Career Intentions

Students' science career intentions consisted of two dimensions in this study. Given the participants were high school students, their academic persistence and intentions in science were the preliminary preparations for science-related careers in the future. Hence, the science career intentions questionnaire in this study assessed students' academic intentions in school science as well as career intentions in science.

Students' commitment and engagement in high school science were strong. Science-related courses were not compulsory in high school for participants in this study. Over 60% of the students expressed agreement (including answers of "strongly agree", "agree", and "a little bit agree") with "I already have taken science courses in high school" and "I am committed to study hard in my science classes". Under Chinese education policy, high school students in Hebei province have the freedom to choose any three selective subjects among biology, chemistry, physics, politics, history, and geography to learn during high school period and also these subjects are the examining subjects in Gaokao (national college entrance examination in China). As mentioned in the literature review, in the Chinese educational system, the importance of academic achievement in Gaokao has been never underestimated (Li, 2015). Students who have high academic attainment have more freedom in trajectory choices (Du and Wong, 2019). Considering the characteristic of the Chinese educational system, students' academic choices in high school may be academic outcome-oriented. Hence, students' high commitment and engagement in school science on the one hand may reflect their academic preference and intentions in science, and on the other hand, their academic choices may also be the temporarily compromised choices that students may consider which subjects they can acquire relatively highest scores among all the selective subjects as well as which subjects they intend to learn.

Compared to students' high engagement in high school science, students' intentions in science careers were not that high. Approximately, 28% of students clearly expressed that they intended to find a science-related job, 14% of students just a little bit agreed that they had the intention of a science career and 22% of students denied that they had the intention. About 29% of students either agreed or strongly agreed with the statement that "I am determined to use my science knowledge in my future career" and 16% of students a little bit agreed with that.

In addition, about 35% of students showed neutral attitudes toward whether to have a science-related career in the future, implying that their occupational planning had not matured yet. The participants in this study were first- or second-year high school students, who were about to face the important stage to choose their university majors. Their intentions to science may largely influence their future academic choices (Lent et al., 1994). If students just have ambiguous goals, when they face choosing majors in university, they may hardly mobilise their personal agency in this important choosing process and put themselves in a passive situation (Bandura, 1986). Hence, considering a large number of students without mature occupational planning, occupational education seems urgently required for high school students.

Furthermore, students' science career intentions were different among different gender groups. In the present study, male students' science career intentions were significantly higher than their female counterparts. This result is consistent with many previous studies (e. g. Archer et al., 2013a; Mau & Li, 2018; Schreiner & Sjoberg, 2004).

5.1.2 Interest in Science

In terms of students' interest in science, in this study, there were two approaches to assessing it- the "interest in broad science" questionnaire and the "enjoyment of science" questionnaire. Firstly, the results of the "interest in broad science" questionnaire indicated that about 65% of students agreed (including answers of strongly agree, agree, and a little bit agree) that they were interested in the "Universe and its history" and about 64% students agreed that they were interested in "how science can help us prevent disease". By contrast with that, students who agreed (including answers of strongly agree, agree, and a little bit agree) that they were interested in "biosphere", "motion and forces", and "energy and its transformation" were respectively about 52%, 43%, and 42%. Drawing on the data from PISA 2015 project, secondary school students from four places in China (B-S-J-G) also expressed similar discrepancies in interest in different science-related topics (OECD, 2016).

There were on average 65% of B-S-J-G students in PISA 2015 expressed interest in topics about “biosphere, motion and forces, and energy and its transformation”. By contrast, over 79% of students expressed interest in the topics of “the Universe and its history ” and “how science can help us prevent disease”. It is noteworthy to mention that “the Universe and its history ” and “how science can help us prevent disease” are loosely related to school science, by contrast, “biosphere, motion and forces, and energy and its transformation” are what high school students can directly learn from school. There were salient discrepancies between students’ interest in the school science loosely relevant topics and the tightly relevant topics, indicated by the data in the PISA2015 project from China (B-S-J-G) as well as the data in the present study from Hebei province. This discrepancy is consistent with the statement from Schreiner and Sjoberg (2004) that students’ falling interest in school science does not indicate their falling interest in other science-related domains. The discrepancy between students’ interest in science topics learned in and out of school is also in alignment with the claim from Osborne et al., (2003) that the format of school science education may suppress students’ interest in school science.

In addition, in this study, there were about 55% of students expressed that they enjoyed doing science-related activities. Compared with the data in PISA 2015 project, 78% of secondary students from four places in China (B-S-J-G) expressed enjoyment of science, which is higher than high school students in this study (OECD, 2016). As mentioned before, students’ average interest in science-related topics is also lower than that of B-S-J-G students shown in the PISA 2015 project. There are two potential reasons for this phenomenon. Firstly, according to Thomson & De Bortoli (2008), students with an advantaged social-economic background are more likely to have an interest in science. Compared with Hebei province where the participants in the present study come from, B-S-J-G are four economically advantaged places in China. The comparisons of parental occupations between participants in this study and B-S-J-G participants in the PISA 2015 project also indicate the social-economic background discrepancy (This comparison has been discussed in the methodology chapter, section 3.3.3). Hence, the lack of interest in science from students in the present study may due to their lower social-economic background. Secondly, many studies have found that students' interests in science decline as they grow up (e.g. Archer et al., 2013; Schreiner & Sjoberg, 2004). Therefore, participants in the present study who are high school students (16-18 years old) may have less interest than younger B-S-J-G students (10-14 years old) in the PISA project.

In the present study, students' enjoyment of science was different among gender and rural/urban groups. Male students' enjoyment of science was significantly higher than their female counterparts. This result is consistent with many previous studies (specifically discussed in the section 2.3.1). Urban students' enjoyment of science was significantly higher than their rural counterparts. This result implies that students' living environment influences their interest in science.

5.1.3 Self-Efficacy and Self-Concept in Science

Self-perceived capability concepts are specifically discussed in this study. There are two self-perceived capability concepts discussed in the present study: self-efficacy and self-concept. This study found that there were salient differences between students' answers to self-efficacy and self-concept. On average, about half of students expressed that they could do science-related tasks, as indicated by the self-efficacy questionnaire. However, about 24% of students expressed that they were good at school science, as shown from the questionnaire on self-concept. Students' self-concept in the domain of school science was lower than their self-efficacy in various science-related tasks. However, science-related tasks in the self-efficacy questionnaire are related to more advanced and complicated science knowledge than high school science. For example, these science-related tasks are "I can recognize some science questions that underlie newspaper report on a health issue" or "I can discuss how new evidence can lead you to change your understanding about the possibility of life on Mars". However, many students reported that they could do these tasks, but were not good at school science. This discrepancy between self-efficacy in science-related tasks and self-concept in school science needs more discussion in the next paragraph.

According to Möller and Marsh (2013), self-concept is not simply derived from objective achievement but comes from processes of comparison with different types of reference evidence. For example, when students say "I can do well in school science", they generate this perception by evaluating their performance against their own standards as well as by comparison with other referents such as their classmates' academic outcomes in school science. Marsh (1987) and Seaton, Marsh, and Craven (2009) state that social comparison is one of the important sources for self-concept, that students may compare their performance in a domain with their peers' performance in the same domain and based on this comparison process, students evaluate their capability in this domain. In addition, the educational system of Chinese high schools is significantly influenced by Gaokao (Li, 2015). What should be noticed is that Gaokao is a selective summative assessment, in which only students with comparatively high academic attainment have the authority to choose a higher-level university. Under this situation, in Chinese high schools, the personal perceived success in school science may not just be evaluated by their standard criteria, but also be influenced by performance comparison with their peers. Considering the comparison of school science performance among students, it is reasonable that only a small proportion of students felt capable in school science.

Students' self-efficacy and self-concept were different among gender groups, rural/urban groups, and groups with different parental educational levels. Male students' self-efficacy and self-concept were significantly higher than their female counterparts. Tellhed, Bäckström & Björklund (2016) and Chi et al. (2017) found that females' lower self-efficacy in science could significantly explain their lower intentions in science than their male counterparts. This finding is consistent with the result of the present study. Urban students' self-efficacy and self-concept were significantly higher than their rural counterparts. Students whose parents had been to high school had higher self-efficacy and self-concept than those students whose parents had not been to high school. Students' living background including social background and family background both could influence students' self-efficacy and self-concept in science.

5.1.4 Learning Experiences

In the present study, learning experiences have been divided into positive learning experiences, including mastery experiences, vicarious learning, verbal persuasion, and affective state (assessed by the students' anxiety/fear level of doing some science-related tasks). Overall, about 49% of students expressed that they had experiences of vicarious learning such as seeing the teacher they admired do science projects. About 56% of students expressed that they had experiences of verbal persuasion, such as being encouraged by their teacher or peer that they should do science. By contrast with these two kinds of positive learning experiences, only 36 % of students expressed that they had experiences of mastery experiences, such as performing well in school science courses.

What should be noticed is that, among the questions of mastery experiences, about 44% of students agreed that "Overall, I performed well in science courses in school" and by contrast with that, there were only 21% of students thought "I have demonstrated skill at conducting research for my experiment reports". The comparison between students' answers to these two questions implies that in Chinese high school education, education on cultivating students' investigative and practical skills to conduct scientific research is needed.

In addition, over half of students reported that they were nervous or anxious while solving science problems, which implies that solving science problems is a challenge for them. Although it seems like solving science problems is a challenge for students, the majority of students did not think that they would be fearful of using scientific knowledge in their future jobs.

5.1.5 Family Science Capital

Students' family science capital was assessed by family members' science-related occupations, parental attitudes to science, and students' science-related communications in their daily lives. The data indicate that students' parental attitudes toward science might not be very positive. According to students, only about 20% of their parents thought that science was interesting. In addition, the data showed that there was only about 25% of students whose family members had scientific jobs or knew someone to have casual science talks with in their daily life. It implies that overall, for participants in the present study, family science capital is the restrictive capital that only a small group of students can attain. Archer et al. (2015) have also discussed the privileged nature of family science capital and that the advantaged social groups are more likely to attain science capital.

The present study indicated that students whose parents had higher educational level had higher family science capital. Urban students had higher family science capital than rural students. These results imply that students' family science capital is not only related with their own family background but also related with their living social background. In addition, male students' family science capital was higher than their counterparts. This result is consistent with Moote et al (2021). Moote and her colleagues conducted a study on British high school students (aged 17-18) and found that male students had higher science capital than their female counterparts. The reason why science capital is more likely to cluster in male groups needs further investigation.

To summarise, important results of the descriptive data are further emphasised here. Firstly, the present study found that although students' engagement in school science was high, their intentions to have a science job in the future were not strong. In addition, differently from the results from ASPIRES project that the majority of students held positive attitudes toward science but did not want to have science-related jobs (Archer et al., 2013), this study found that there was no salient discrepancy between students' attitudes towards science and their science career intentions. Thirdly, students' self-efficacy in science-related tasks was higher than students' self-concept in school science, which may reflect the comparison nature of self-concept. Furthermore, shown in the section 4.5, students' science-related factors (e. g. self-efficacy, self-concept, family science capital) are significantly different among different social groups (male/female, rural/urban, and different family educational level). This section provides an overview of participants' attitudes toward science. In the next section, the models which can explain participants' development of science career intentions are specifically discussed.

5.2 Discussions of Model I* and Model II*

Models I* (shown in Figure 5.1) and model II* (Figure 5.2) were supported by the data from this study. These two fitted models provide explanations for Chinese high school students' formation process of science career intentions. Figure 5.3 and Figure 5.4 demonstrate these two models with the standardised regression weights (β); the standardised regression weights indicate the predictive sizes of all the direct paths. In this section, the interactions of variables in each model are discussed.

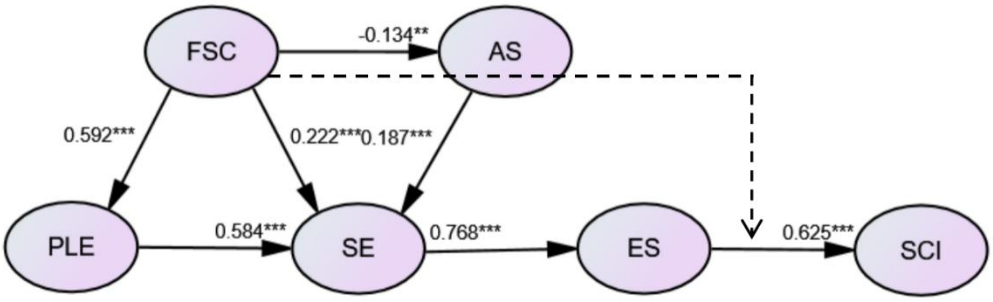


Figure 5.3 Models I* with the standardised regression weights of all the significant direct paths

Note: The numbers on the path indicate the magnitudes of the standardised path effects; The dashed line indicates the moderation effects; *: P<0.05; **: P<0.01; ***: P<0.001

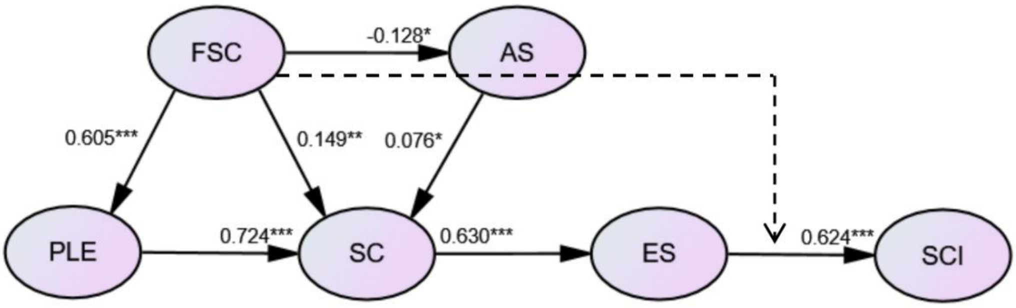


Figure 5.4 Model II* with the standardised regression weights of all the significant direct paths

Note: The numbers on the path indicate the magnitudes of the standardised path effects; The dashed line indicates the moderation effects; *: P<0.05; **: P<0.01; ***: P<0.001

5.2.1 Self-Efficacy and Self-Concept in the Structural Models

These two models incorporate two different concepts of self-perceived capability-self-efficacy and self-concept. As shown in Figures 5.3 and 5.4, the present study found that both self-efficacy and self-concept significantly and highly predicted students' enjoyment of science, but self-efficacy could better predict enjoyment of science.

Neither self-efficacy nor self-concept directly predicted students' science career intentions; this is different from the hypothesis of the SCCT choice model from Lent et al. (1994), in which self-efficacy would directly predict science career choices. What should be mentioned is that many empirical studies using SEM method to investigate the model structure under different contexts indicated disputable results about this postulate. For example, Lent et al. (2003) investigated American first-year university students' academic intentions in engineering with an SCCT model, and in this study, students' self-efficacy was significantly predictive of their academic intentions. By contrast, Jiang and Zhang (2012) have drawn on Lent et al. (2003)'s study and investigated Chinese vocational school students' science academic intentions in engineering based on the SCCT model, and found that students' self-efficacy did not significantly predict their engineering academic intentions.

In addition, the current study found that both self-efficacy and self-concept made indirect effects on students' science career intentions, through the total mediation of enjoyment of science. These results imply that for Chinese participants in this study, what "they can do" does not directly predict what "they intend to do for job", and by contrast, what "they like to do" highly predict what "they intend to do for job". Compared with the disputable results of direct effects between self-efficacy and goal from previous studies, Brown and Lent (2017) who reviewed numerous SCCT-related studies from a diverse range of contexts found that the majority of SCCT-related studies have indicated that self-efficacy could make indirect effects on goal, through the mediation of interest. It is noteworthy that the significance testing of SEM may be influenced by many reasons, such as different software used for analysis (Kline, 2010). Hence, given the limitation of the SEM method, to provide solid evidence for the relations between self-efficacy, interest, and science-career intentions for Chinese high school students, studies with various research strategies to mutually validate the results are future research angles.

In this study, the self-efficacy questionnaire assessed students' self-perceived ability in various science-related tasks, which are related to school science but are not limited to that. By contrast, the self-concept questionnaire assessed students' self-evaluation of their capability only in the school science domain. This study found that students' self-concept in school science predicted enjoyment of science less than their self-efficacy in science. Furthermore, self-efficacy had a stronger indirect effect on science career intentions compared with self-concept. Jansen et al. (2015) have also employed the same measurement approaches as this study but in contrast, they found that self-concept was more predictive of German secondary school students' science aspirations than self-efficacy. They argued that self-concept indicated more general self-perceived capability in the science domain than self-efficacy and they thought that career choices were more likely to be driven by general ability in a domain.

However, Jansen and his colleagues' explanations may not apply to the Chinese context. Given the high emphasis on the importance of Gaokao, some Chinese students who have chosen scientific subjects as their selective subjects in Gaokao may work very hard on these scientific subjects to gain a high score in Gaokao and thereby have a high self-evaluation of their ability in school science (namely high self-concept in school science). However, the motivation to work hard on school science is driven by the pressure of Gaokao: even if they can do school science well, they may not enjoy doing science. In contrast with that, the specific science tasks involved in the self-efficacy questionnaire are not only limited to school science and are not directly related to the content of students' school examinations. Participants' ability on various scientific tasks does not directly contribute to their Gaokao outcome and they might be less likely to practise their ability due to the expectation of success in school science examinations.

5.2.2 Learning Experiences in the Structural Model

"Learning experiences" has been divided into positive learning experiences (including mastery experiences, verbal persuasion, and vicarious learning) and affective state. As discussed in the data analysis part, the CFA results showed that the "affective state" was not statistically consistent with the "Learning experiences" construct. Except for the affective state, the other three sub-factors of learning experiences were significantly and highly correlated with each other. Statistically, affective state was not significantly bi-correlated with mastery experiences, and although the significance testings showed that affective state was correlated with verbal persuasion, and vicarious learning, the correlation effects were very small. The statistical results imply that affective state is not consistent with the four sub-factor "learning experiences" construct. Similarly, with the current study, Tokar et al. (2012) have investigated the structure of LE (using the same questionnaire that was used in this study) and found that, in contrast to the robust inter-correlations between the other three sub-factors, affective state only had modest correlation with the other three sub-factors respectively.

Theoretically, according to Bandura (1977), although all these four kinds of "learning experiences" are sources of self-efficacy, the mechanism of affective state's relation with self-efficacy is different from the other three kinds of "learning experiences". Affective state is not only a mode of learning but also a response to other learning experiences (Bandura, 1986). For example, students' anxiety may be aroused when they get bad performance in a science-related task. Similar to the other three kinds of learning experiences, affective state could be a kind of factor which influences self-efficacy; different from the other learning experiences, self-efficacy could decrease people's susceptibility to negative affective state (Bandura, 1994). For example, as Bandura (1977) presented, students with high self-efficacy might be less likely to regard their affective arousal as debility.

To explain the inconsistent results of the "affective state" from the statistical investigation, case studies including 9 high school students who have different family socioeconomic and family science capital background was further conducted. The case studies indicate that there might be complicated relations between affective state and the other three kinds of learning experiences (the detailed discussions have been shown in chapter 4.2.1), beyond the effects theorised by Bandura. According to students' experiences, affective state could be positively, negatively, or even not related to the other three kinds of learning experiences at all – the crucial aspect was context, with different situations leading to different relationships between affective state and the other three components.

In this study, considering the CFA results of "learning experiences" structure, "learning experiences" construct was divided into positive learning experiences (including mastery experiences, verbal persuasion, and vicarious learning) and affective state. As demonstrated by Figure 5.3 and Figure 5.4, this study found that "positive learning experiences" positively predicted both self-efficacy and self-concept in science. Based on the comparison between Figure 5.3 and 5.4, "positive learning experiences" such as achievement in science, encouragements by others, or watching others doing science, had more predictive effects on self-concept than on self-efficacy.

Consistent with Bandura's (1986) statement, the present study found that students' negative affective state which was assessed by students' anxiety and stress level in doing some science-related tasks negatively predicted students' self-efficacy and self-concept (Note: Consistent with Tokar et al. (2012), the scores of students' answers to affective state questionnaire were reversed in the present study, so the path effects between affective state and self-efficacy/self-concept shown in figure 5.3 and 5.4 are positive). These results indicate that students' anxiety or nervousness about science is likely to reduce the self-evaluation of their science ability. The path effects between affective state and self-concept were lower than that between affective state and self-efficacy. Since most of the items in the affective state questionnaire assessed students' affective arousal for some activities in school science, it was expected that affective state would make higher effects on self-concept in school science than self-efficacy. A possible explanation for the unexpected result could be that it may result from a statistical effect: the path effects from affective state to self-concept may be statistically suppressed (hidden) by the high path effects from positive learning experiences to self-concept. Hence, I contend that the higher magnitude of the path effects between affective state and self-efficacy than that between affective state and self-concept in the present study could not provide solid evidence that students' affective state is more predictive of self-efficacy than self-concept.

5.2.3 Enjoyment of Science in the Structural Model

Consistent with the original SCCT model from Lent and his colleagues (1994), the present study found that students' enjoyment of science directly predicted students' science career intentions. The magnitudes of the standardised path effects of enjoyment of science to science career intentions were high. Jiang and Zhang (2012) investigated Chinese vocational school students' science academic intentions based on the SCCT model, where the standardised path effect from students' electric power engineering interest to academic intentions in electric power engineering was only 0.29. Garriott et al. (2013) also investigated American low-income high school students' science intentions based on the SCCT model, and the results indicated that the standardised path effect from interest to science intentions was 0.41, which is also lower than the 0.62 effect found in the present study.

In addition, Archer and her colleagues (2010, 2013) found that British secondary school students had a "doing-being divide" in science, in other words, students might enjoy doing science but did not expect to work in science. This phenomenon is not unique to British students. For example, Garriott et al. (2017) have investigated the development of Mexican American high school students' science career intentions and found that students' interest in science did not significantly predict their science career intentions, but interestingly in their study, students' self-efficacy in science and their family support significantly predicted their science career intentions. Compared with these two studies, it seems that Chinese high school students are more likely to choose science-related careers based on the extent of their enjoyment of doing science. It implies that the "doing-being divide" may not be applicable in a Chinese context.

5.2.4 Family Science Capital in the Structural Model

Family science capital is a new variable for the SCCT choice model. In terms of its role in SCCT, there were four postulates in this study:

Postulate1: Family science capital would directly make effects on learning experiences.

Postulate 2: Family science capital would directly make effects on career goals.

Postulate 3: Family science capital would act as a moderator of the path between interest and career goals.

Postulate 4: Family science capital would directly make effects on self-efficacy/self-concept.

Among the four postulates, numbers 1, 2and 4 were investigated in the present study by SEM research strategy in hypothesised structural regression models, and postulate 3 was investigated separately.

As demonstrated in Figure 5.3 and Figure 5.4, this study found that family science capital positively predicted students' positive learning experiences. These results imply that students who have high family science capital are more likely to have positive science learning experiences, such as more experiences of science-related achievement, verbal persuasion of doing science from others or seeing people around them doing scientific activities. Conceptually, science capital contains "all the science-related knowledge, attitudes, experiences and social contacts that an individual may have" (Godec et al., 2017, p. 5). Hence, students with high family science capital are more likely to know people who are professionals in science, and to talk with these people in their daily lives, thereby living in science-intense atmospheres (Archer et al., 2012). Under these living circumstances, it seems that students are more likely to see others doing science-related activities, and to be encouraged to do science-related activities, and the more they do science, the more possible chances they have in which to experience achievement in science activities.

What should be noticed is that in models I* and II* in the present study (shown in Figures 5.3 and 5.4), the variable "affective state" represents reversed values for anxiety about science. As demonstrated in Figures 5.3 and 5.4, this study found that family science capital positively predicted students' affective state (such as anxiety), which implies that students who have high family science capital are more likely to feel anxious, nervous, or pressured about science. Family science capital is a kind of relatively privileged resource for middle or upper-middle-class families, and those families are more likely to pay more attention to students' education, provide more support, and have higher expectations for their children (Archer et al., 2010). However, as Kulakow, Raufelder, and Hoferichter (2021) stated, parental support and pressure on students both may contribute to students' stress levels. Ringeisen and Raufelder (2015) also found that students' emotionality was related to parental support and pressure. Especially considering the feature of Chinese culture that obedience and family obligation are strongly emphasised under Confucian values, family influences are very important for Chinese students (Chao & Sue, 1996). Hence, I infer that students with high family science capital can acquire more family support and also gain more pressure from family, hence, those students are more likely to have a highly anxious affective state.

Consistently with the finding from Archer et al. (2015) that students with high family science capital were more likely to have high science self-efficacy, the present study also found that students' family science capital positively contributed to students' self-efficacy in science. In addition, the present study also found that family science capital positively predicted students' self-concept in school science. In terms of the magnitudes of the path effects, family science capital was more predictive for self-efficacy than self-concept. Specifically, the results showed that family science capital not only could directly predict self-efficacy and self-concept, but it also could indirectly predict self-efficacy and self-concept. The indirect effects between family science capital and self-efficacy were through two mediation routes: via positive learning experiences, and via affective state; the indirect effects mediated through positive learning experiences were significantly stronger than those mediated through affective state. By contrast, family science capital only had significant indirect effects on self-concept through positive learning experiences; affective state did not significantly mediate the relation between family science capital and self-concept.

One of the important findings from ASPIRES is that students with high family science capital are more likely to have aspirations in science (Archer et al., 2013). The results from the present study showed that, in the Chinese context, family science capital could not directly predict students' science career intentions, but (through the remote mediation of positive learning experiences, affective state, self-efficacy, and enjoyment of science), it could indirectly predict science career intentions. Hence, postulate 2 about family science capital was not supported in this study.

The results of hierarchical moderator regression analysis indicated that family science capital significantly moderated the path between students' enjoyment of science and their science career intentions (shown in the data analysis chapter, section 4.4.4). It was expected that family science capital would moderate the relationship between students' science interest and science career intentions, since students with high family science capital are more likely to gain science-related support and help from their families, and support is hypothesised as the moderator on the path between interest and career intentions in SCCT (Lent et al., 2000). However, the present study found that family science capital did not play as support but played as the barrier which negatively moderated the translation path from students' interest in science to science career intentions. This finding is specifically discussed later.

Families with high science capital are more likely to provide science-related knowledge assistance, occupational information, and enrichment of activities, which may contribute to students' interest in science (Archer et al., 2012). However, the current study found that in this kind of family, daily communication with scientific professionals might hinder students' interest from translating into their career intentions. This result may be due to Chinese people's unsatisfactory occupational well-being in science-related jobs. For example, Yang, Jin, Wang, and Yao (2005) found that Chinese scientific researchers had a higher level of anxiety and were more likely to have physical problems, due to high career pressures. Yang, Jin, and Wang

(2006) further found that the occupational stresses of Chinese scientific technicians were also high. In addition, according to a survey by the Chinese Medical Association, about 54% of physicians have expressed that they don't want their children to go to medical school (Wang, 2003). These findings imply that the well-being of many science-related practitioners in China may not be satisfactory. In the present study, students with high family science capital are more likely to know the real science-related occupational environments and contents. The unsatisfactory occupational experiences from familiar people may influence students' translation paths from interest to career intentions.

In practice, the hypothesis that familial and social supports act as the moderator on the path between interest and career intentions has been rejected in SCCT-related empirical studies many times (e.g. Lent et al., 2001; Garriott et al., 2013). According to Lent et al. (2001), it seems that familial and social supports cannot positively moderate the path between interest and career intentions, whereas barriers can negatively moderate this path.

In summary, this study found that family science capital predicted positive learning experiences, anxious or nervous affective state, self-efficacy, and self-concept in science. However, family science capital did not directly predict students' science career intentions. In addition, family science capital could play as a kind of barrier which negatively moderated the translation path from the enjoyment of science to science career intentions. In the SCCT choice model from Lent et al. (2000), distal contextual factors make direct effects on learning experiences, and proximal contextual factors (supports or barriers) make direct effects on goals or also moderate the path between interest and goals. Considering in the present study, family science capital could make direct effects on learning experiences, and also have moderating effects on the path from the enjoyment of science to science career intentions, I infer that in relation to the theory, family science capital may play the role of distal contextual factors as well as proximal contextual factors (barriers) in the SCCT choice model.

5.3 Theoretical and Applied Significance

5.3.1 The Applicability of SCCT in the Chinese Context

This study supports the proposition that the formation process of Chinese secondary school students' science career intentions would be explained by the hypothesised models. These hypothesised models were designed based on SCCT. SCCT was proposed by Lent and his colleagues (1994) in the US, and there have been few empirical studies related to SCCT conducted in the Chinese context (Sheu & Bordon, 2017). Overall, the hypothesised models supported by data from Chinese participants in this study indicate that consistent with the SCCT choice model by Lent et al. (1994), Chinese high school students' interest in science could directly predict their science career intentions, and self-efficacy could directly predict interest in science. As personal cognitive variables, self-efficacy and interest could mediate the relation between students' learning experiences and their science career intentions.

This study provides support for the validity of SCCT in the Chinese context, but with one important deviation. In contrast to the original SCCT choice model, the present study indicates that Chinese high school students' self-efficacy could not directly predict their science career intentions.

5.3.2 The Development of SCCT Model

The present study refined SCCT by deeply discussing three variables of SCCT which include interest in science, science self-efficacy (self-concept), and learning experiences, and adding a new variable (family science capital) into it.

Interest

This study investigated two approaches to assessing interest in science. One way was assessing students' interest in some specific science topics about chemistry, biology, and physics. Another way was assessing students' enjoyment of doing science, which referred to the joy gained from doing science activities. According to Lent and Brown (2006), in SCCT studies, researchers tended to focus on assessing interests in tasks conducted before the entry of careers on a relatively concrete level, such as interests in a single activity domain or a set of conceptually linked tasks. By involving these two kinds of interest as independent variables as well as science career intentions as a dependent variable in a model, the unique variances of science career intentions due to these two kinds of interests were respectively presented. Results from this study showed that the root square of each kind of interest's AVE was higher than the correlation coefficient between each other, which indicated that these two kinds of interests had discriminant validity with each other (Ab Hamid, Sami, & Sidek, 2017). In addition, both of these two kinds of interest had unique predictive effects on science career intentions, which implied that these two kinds of interest contributed to science career intentions through different mechanisms. In addition, the significance testing showed that predictive effects on science career intentions from these two kinds of interest were not significantly different. This result is not consistent with Ajzen and Fishbein's (1980) argument that people's attitudes to the actions that are performed on the "object" (referring to "enjoyment of doing science" in the present study) are more predictive of behaviour intentions than people's attitude towards some "object" (referring to "interest in broad science topics" in the present study).

The discussion of the predicting effect sizes between different kinds of interests with science career intentions in this study also provides implications for future studies that different kinds of interest can be explored about their roles in SCCT. People's "interest in science" is complicated. For example, "interest in science" can be the enjoyment of science which specifically focuses on people's joy gained by doing science. Or it can be interest in some specific tasks or activities, such as going to science museums, conducting scientific experiments, listening to science-related lectures, etc. Furthermore, it can be a generally positive attitude towards science. As discussed in the literature review, students' different kinds of "interest in science" are not always equivalent to each other. For example, Schreiner and Sjoberg (2004) found that students' falling interest in specific science domains was not equal to their falling interest in general science. As indicated by SCCT, interest is one of the most important predictive factors for career intentions, but the conceptual classifications of interest need to be investigated more. Hence, discussion on different kinds of interest, with the investigation of which kinds of interest make relatively strong predictive effects on career intentions and the reasons why the predictive ability is strong may be new angles for future researchers.

Self-Efficacy and Self-Concept

In the present study, the differences between self-efficacy and self-concept are specifically discussed. The separability of self-efficacy and self-concept was tested through the CFA model investigation. The results indicated that they were not manifestations of the same latent variable, which meant that self-efficacy and self-concept could be statistically distinguished. On the foundation of the separability testing, these two variables were separably involved in two structural models describing students' development of science career intentions. The different relations of self-efficacy and self-concept with other variables in these two models were compared in the last section. Overall, the results indicated that self-efficacy and self-concept played similar roles as personal-cognitive factors which bridged the environmental factors (e. g. family science capital) and people's interest and career intentions in science. Specifically, the present study found that self-efficacy might predict enjoyment of science more than self-concept.

It is noteworthy that the percentage of students who expressed having self-efficacy in science was saliently higher than the percentage of students who expressed having self-concept in school science (shown in section 5.1). This discrepancy can be explained by the comparative nature of self-concept (which has been discussed in section 5.1). Students generate their high self-concept in school science (e. g. I am good at school science) by comparing with other references, such as peers (Möller & Marsh, 2013). By contrast, the generation of self-efficacy is mainly based on the interpretation of personal previous experiences (Bandura, 1994). Hence, only a small percentage of students who are relatively better at science compared with their peers may express a high self-concept in school science. The discrepancy between students' self-efficacy and self-concept in the present study may indicate the theoretical differences between these two concepts.

Learning Experiences

The structure of "learning experiences" is specifically discussed in the present study. The results of this study provide implications for the design of measurement approaches to "learning experiences". LEQ (Schaub, 2004) has been widely used as the measurement approach for the learning experiences construct; it consists of four sub-factors of learning experiences - mastery experience, verbal persuasion, vicarious learning, and affective state. Under the context of this study, affective state is not consistent with the other three sub-factors. This finding implies that under different contexts, the structure of the learning experiences measurement instrument may be different. For future studies employing LEQ, it is suggested to consider the relations of the four sub-factors under their specific contexts, and conduct legitimate modifications on LEQ to make it more applicable to their contexts.

5.3.3 Family Science Capital Theory

This study locates the specific roles of family science capital in the development of students' science career intentions, which complements the science capital theory from Archer and her colleagues. Family science capital is derived from Bourdieu's capital theory (1977, 1984, 1986), which denotes that capitals are resources in society that are legitimate, exchangeable, and valuable, and which could generate and provide social advantages to people who own them in a given field. Archer and her colleagues (2012, 2013, 2015) investigated the influence of family science capital on students' science aspirations and found fruitful results. As Archer et al. (2012) stated, science is more likely to be embedded into daily life for students with high family science capital, and under the interaction of family habitus and science capital, students are more likely to think science is desirable for them and have science aspirations. But what should be mentioned is that they found that family science capital was not deterministic for students' science career intentions.

Consistent with Archer et al. (2012), this study found that family science capital could not directly influence students' science career intentions. Instead, this study indicates that family science capital could act as representing distal contextual factors that directly contribute to students' positive learning experiences about science, such as science achievement, science-related encouragements from others, and more opportunities to watch others doing science. This study supports the findings from Archer et al. (2012) that students with high family science capital are more likely to have more science-related experiences in their daily lives. Through the link between science learning experiences and science career intentions in the model of SCCT, this study explains why those students with high family science capital are more likely to think science is desirable for them. It is noteworthy that the present study found that family science capital also could directly influence students' self-efficacy in science.

The mediation role of personal agency (e.g self-efficacy) between family science capital and science career intentions is the important result of the current study and this result has important implications for social equity. As a kind of capital, science capital is more likely to be clustered in some specific social groups (Moote, Archer, DeWitt & MacLeod, 2021). According to Archer et al. (2012), family science capital is a kind of privileged resource which is more likely to be acquired by middle or upper-class families. Even if we know its important contribution to students' academic and vocational trajectories, for some disadvantaged families, family science capital is like "the flower on the cliff", which is too hard to attain.

What should be emphasised here is that the current study does not try to propose that science-related careers should be targeted future trajectories for all students. This study just proposes that science-related careers are potential career choices for students. However, for some students from disadvantaged families, since the lack of science-relevant cultivation, those students may lose their motivation to choose science. According to Archer et al. (2015), capital could generate capital. In this sense, students who lack family science capital are less likely to further generate science capital. This study found that family science capital did not directly contribute to science career intentions, but through contributing to students' personal agency, it indirectly influenced people's career intentions. These results imply that although enhancing families' science capital has many practical challenges, the interventions could work on enhancing students' personal agency in science to mitigate students' lack of intentions in science. For example, intervention on enhancing students' personal agency in science could be designed through enhancing students' positive learning experiences, such as setting various students' science-related activities in school, giving more encouragement to students in science, and even sharing the experiences of role models in science. These implementations may to some extent compensate for the influence of students' lack of family science cultivation. These implementations may mitigate the influence of unequally gathered capital among different families, which may contribute to social equity.

In addition, a notable finding of the present study is that family science capital also could play as a kind of barrier which negatively moderated the translation path from interest to intentions. Previous studies have discussed the cultural value of science capital (Archer et al., 2015). For example, parental knowledge about science and science occupations may provide direct guidance and support for students' science academic outcomes and science aspirations (Smart & Rahman, 2009). Cleaves (2005) stated that the lack of awareness about science occupations and underestimation of their science abilities are two possible reasons why young people do not choose science-related careers. Hence, in this sense, family science capital was expected to play the role of support which would positively moderate the path from interest to intentions.

However, the present study proposes a new perspective to consider the influence of "awareness about science occupations" on career intentions. Students from families with high science capital are more likely to have awareness about science occupations from people around them, however, these people's unsatisfactory feedback and experiences in scientific careers may obstruct the translating path from interest in science to science career intentions. Since family science capital as a barrier on the translation path from interest in science to science career intentions has not been discussed in previous literature, further research which provides qualitative evidence and more quantitative evidence from other contexts for this topic is required.

5.4 Strengths and Limitations

5.4.1 Strength

To enhance the research validity of the model fit investigation, this study has employed a series of measures. Firstly, although all the measurement instruments in this study have been peer-reviewed, to make them applicable to the participants in this study, they have been modified. All the modified measurement instruments have been respectively tested to be assured of their composite reliability, construct validity, convergent validity, and discriminant validity.

Specifically, all modifications not only complied with the statistical requirements of model fit but also had substantive meanings. Especially for the investigation of the "learning experiences" measurement model, both quantitative and qualitative methods were conducted and the results from these two methods mutually supported the modifications to the "learning experiences" measurement model. The consideration of substantive meanings and statistical requirements of the modifications on measurement models enhances the validity of these measurement instruments (Byrne, 2016).

To escape the situation of model fit just by chance, this study has conducted cross-validation testing. Cross-validation testing requires randomly dividing the data into two samples (the calibration sample and the validation sample), and that each sample needs to meet the big sample size requirement of SEM（Kline, 2010). Hence, for the study to be suitable for cross-validation testing it needs a large sample size. This large sample size requirement may restrict many studies from cross-validation testing. The large sample size of the present study provides accessibility for cross-validation testing, which further enhances the research validity.

5.4.2 Limitations

Firstly, as discussed in the methodology chapter, since the sampling procedure did not strictly comply with random sampling methods, there is a possibility of sample bias existing. For example, participants voluntarily joined this study, which might result in the participants in this study being more likely to be students who were interested in the research topic of science career intentions. It is possible that students who had not chosen science subjects and had a lack of interactions with science were less likely to engage with studies investigating science career intentions.

What is more, this study has recruited both rural school students and urban school students. This study includes the variable family science capital, and urban students are more likely to have greater social, cultural, and economic resources and to have high family science capital than rural students (Archer et al., 2015). However, the strict percentage of rural school students and urban school students from Hebei province was unknown when data were collected. According to the announcement from the Hebei province government, students who entered 2018 Gaokao from rural families were about twice the number of students from urban families (https://gaokao.eol.cn/he_bei/201712/t20171219_1574171.shtml). This data implied that students from urban schools were fewer than students from rural schools in Hebei province. This study tried to collect more students from rural schools to achieve a sample that mirrored the student population, and the numbers of students from rural schools and the students from urban schools in this study were 696 and 465. This implies that the sampling objective was not fully achieved, hence the results of this study might not be strictly representative of the population distribution of Hebei province high school students. However, in practice, this limitation is often encountered in fieldwork. Furthermore, this only impacts the qualitative and descriptive aspects of the present study – the statistical modeling of SCCT has no requirement for sample sizes to match population distributions.

Secondly, there are system limitations to the method of SEM. As Bollen (1989) stated, SEM is a disconfirmatory technique. “If a model is consistent with reality, then the data should be consistent with the model. But, if the data are consistent with the model, this does not imply that the model corresponds to reality” (Bollen, 1989, p. 68)

That means although the hypothesised models have converged with the data in this study, there are still disputable points of whether the model actually corresponds to reality. For example, the causal relationships between variables cannot be supported only by the results of SEM alone (Kline, 2010). Indeed, according to Kline (2010), the causal relations cannot be definitively evidenced by any nonexperimental statistical methods.

The estimation method used in this study is maximum likelihood estimation, which requires the multivariate normality of the sample. However, according to Byrne (2016), in practice, in SEM studies with big samples, it is very hard to achieve this requirement. The data from this study do not strictly show multivariate normality, which might influence the accuracy of results from maximum likelihood estimation.

5.5 Implication for the Future Research Directions

Considering the systematic limitation of SEM (being a disconfirmatory model), to be assured of the accuracy of the model in explaining students' development of science career intentions, there are some further studies to do. Since it is hard to identify the path direction from SEM, longitudinal studies are good future angles to solve this problem. For example, in the present study, the statistical results indicate that family science capital can be identified as a distal contextual factor. These results imply that in temporal logic, family science capital occurs temporally precedent than students' learning experiences and their personal cognition such as self-efficacy and interest in science. To investigate these hypotheses, further studies are needed in the future.

Furthermore, family science capital as the barrier which negatively moderates the translation path from the interest in science to science career intentions has not been discussed in previous literature. Further research on investigating what components of family science capital functions may play as the barriers may help us understand this topic more. Investigation on this topic also has practical implications for family education on occupational guidance. Parents may attain clear suggestions on what communications or practises in their daily life may hinder their students' science career intentions.

In addition, this study has not involved all the variables from SCCT. For example, another personal cognitive factor - outcome expectations - has not been included in this study. As discussed in the literature review, considering the examination-emphasis culture of the Chinese context, it is hypothesised that self-efficacy exerts significantly greater effects on students' development of science career intentions than outcome expectations. Considering the model complexity and the corresponding requirement for a large sample size (the more complex the model, the larger the sample size is required), only one of the two personal cognitive factors was addressed, namely self-efficacy. Future studies can further compare the predicting effects of self-efficacy and outcome expectations in SCCT and investigate whether in the Chinese context self-efficacy plays a more dominant role than outcome expectations.

This study has recruited participants of different genders and from different social groups (rural and urban; middle class and working class). As discussed in the literature review, the comparisons of science perceptions between students of different genders and students from different social-economic backgrounds have been focused on by many previous studies. For example, Mau and Li (2018) found that male students were more likely to have strong science engagement. In addition, Thomson and De Bortoli (2008) found that students who continued to choose science-related trajectories were more likely to have higher social-economic status. The previous literature implies that the comparisons of science perceptions between students of different genders and students from different social-economic backgrounds are worthy of investigation. Given this study focuses on the mechanism of the formation process of students' science career intentions, the comparative study of the differences in students' science career intentions between different social groups has not been further presented in this thesis. However, those data will be used for paper writing in the future.

In the end, although this study found that interest in science was a strong predictor for students' science career intentions, interest in science could not explain all the reasons for students' science career intentions. Future studies are expected to continuously refine the original SCCT choice model. More personal cognitive factors or contextual factors are expected to complement and develop the original SCCT choice model, to make the mechanism underlying career intentions development more transparent, comprehensive, and understandable.

Chapter 6 Conclusion

This study focuses on a widely discussed issue among many countries - students' lack of intentions in science-related careers. To investigate Chinese high school students' science career intentions, the current study has drawn on two theories: social cognitive career theory and science capital theory. With inspiration from these two theories, two models (model I* and model II*) have been designed and empirically supported by the data in the present study, which implies that Chinese high school students' science career intentions can be explained by these two models.

Based on the review of previous literature, personal agency (e.g. self-efficacy) and family science capital, which respectively are the pivotal factors in social cognitive career theory (SCCT theory, e.g. Lent et al., 1994) and in science capital theory (e.g. Archer et al., 2015), have been theoretically discussed as well as empirically supported in their linkage with students' science career intentions, across many studies. Instead of being passively influenced by environmental factors, the active agency of individuals - the power of "self" - has been increasingly emphasised by vocational researchers for decades (Hartung & Subich, 2011). Especially towards the end of the 20th century, with the development of social cognitive theory by Bandura (1986), many vocational researchers paid attention to the vital role of personal agency in the development of career intentions. However, compared with SCCT theory, science capital theory focuses more on the environmental affordances contributing to students' science career intentions. In the last decade, as led by Archer and her colleagues, 'science capital' which is an integrated device to represent the economic, social, and cultural capital related to science, has provided a new perspective in science career intentions research (Archer et al., 2013).

Although these two theories have made significant contributions to science career intentions research, there have not been studies integrating these two theories together using a structural equation modelling approach. SCCT focuses on the importance of personal agency and science capital theory focuses on the importance of environmental affordances. The combination of these two theories provides complements for each individual theory and the integrated models derived from these two theories might depict more comprehensive pictures of the development of students' science career intentions.

In this chapter, the results of the current study and the theoretical and applied contribution of these results are first summarised. In addition, this study has employed a (quantitative-dominant) mixed methods approach to provide empirical evidence for model I* and model II*. Critical discussions of the method employed in this study are subsequently presented. Finally, the implications for future studies and suggestions for educational policies are discussed.

6.1 Summary of results

Two models are evidently supported by the data in the current study: model I* and model II*. Model I* involves the variables family science capital, positive learning experiences, affective state, self-efficacy, enjoyment of science, and science career intentions. To compare the different roles of two similar constructs, self-efficacy and self-concept, in students' development of science career intentions, this study has designed a comparative model, namely model II*. Model II* replaces the variable self-efficacy in model I* with self-concept.

Overall, as indicated by model I* and model II*, personal-cognitive factors (e.g. self-efficacy, self-concept, and interest) can bridge the relations between family science capital and science career intentions. In this sense, theoretically, family science capital can play a role in representing distal contextual factors in the SCCT choice model. According to SCCT, distal contextual factors do not directly make effects on career intentions, but instead, through the mediation of people's personal cognitive factors, distal contextual factors make indirect effects on career intentions (Lent et al., 2000).

These results complement the understanding of science capital theory. Archer et al. (2012) conducted a qualitative study and found that some students, despite having high family science capital, still did not have strong science aspirations. However, Archer and her colleagues did not provide further explanations for these cases. The current study provides quantitative empirical evidence for the "indeterministic relation" between family science capital and science career intentions.

In addition, these results also provide a specific example of a distal contextual factor in the SCCT choice model. For decades, vocational researchers have been well aware of the importance of environments (Brown, 2002). Some environmental factors, those which impact almost irresistibly on individuals, may certainly to a large extent influence people's life trajectories – for example, the impacts of serious socio-economic deprivation. However, as Lent et al. (2000) state, the majority of environmental factors are firstly subjectively digested by personal cognition and thereby affect people's behaviours. Otherwise, it is hard to explain the thousands of examples of children who are brought up in disadvantaged environments but nevertheless achieve great academic/vocational attainment.

The results of the current study support the crucial role of personal agency to buffer the influences of the environment on individuals. These findings also have implications for intervention studies contributing to social equality. Since family science capital is more likely a kind of privileged resource for students from advantaged families, students from disadvantaged families may lack science aspirations as a consequence of insufficient family science cultivation. Intervention studies that mitigate the influence of the lack of family science capital on science career intentions may contribute to social equality. The mediation of personal agency between family science capital and science career intentions may provide a perspective of the intervention studies. In addition to intervention studies that directly enhance students' science capital, intervention studies on enhancing students' self-efficacy may also mitigate the influence of the lack of family science capital on science career intentions. Those intervention studies will be discussed more in the next section-implications for science education policies.

In addition, both model I* and model II* indicate that students' enjoyment of science could significantly and strongly predict their science career intentions. A widely proposed idea in the science education research field in the last decade was the paradox between students' attitudes to science and their intentions to have science-related careers. For example, based on the results from the ASPIRES project, Archer et al. (2010) have discussed British secondary school students' positive attitudes to science but lower aspirations in science, namely the phenomenon of the " doing-being divide". Similarly, on the front page of the report of the ROSE project, Schreiner and Sjoberg (2004) discussed the paradox of people's positive attitudes toward science and lower aspirations in science and provided evidence for this phenomenon from many countries (e.g. the US, and several European countries). Based on these studies, we might have a presumption that interventions on enhancing students' attitudes to science might not have salient contributions to their career intentions. However, the present study indicates that Chinese students' science career intentions can be directly predicted neither by their self-perceived ability in science nor by their family resources and supports related to science, but can be directly predicted only by their enjoyment of doing science. This result provides implications for intervention studies to emphasise the pivotal importance of enjoyment.

In the current study, self-efficacy and self-concept have been compared through different approaches. Self-efficacy in the current study has been assessed by students' perceived ability in a variety of science-related tasks. Self-concept has been assessed by students' perceived ability in school science, namely whether they believe themselves to be 'good' at school science. Firstly, the measurement approaches to self-efficacy and self-concept are statistically distinguishable. The results of confirmatory factor analysis indicate that a latent variable including all the items from self-efficacy and self-concept is not fitted to the data, but the individual models of self-efficacy and self-concept are respectively fitted to the data. These results support the conclusion that self-efficacy and self-concept are distinguishable at the statistical level.

In addition, the discrepancy between students' reported values of self-concept and self-efficacy implies the "comparison nature" of self-concept, which is different from self-efficacy. The higher values of students' expressed self-efficacy (compared to self-concept) represent the distinction between these two constructs; quantitative and statistical evidence from the present study supports this theoretical argument. Considering the "comparison nature" of self-concept, students evaluate themselves as to whether or not they are "good students in school science" by reflecting on references around them. Hence, compared with self-efficacy, which is mainly generated by previous learning experiences, the development of students' self-concept in science not only needs previous learning experiences but also needs perception from comparison with references. According to Nagengast and Marsh (2012, p. 1), the "Big-Fish-Little-Pond Effect" indicates that "being schooled with other high-achieving peers has a detrimental influence on students' self-perceptions". The explanation of this effect is due to students' comparisons with other high-achieving peers, which may disturb the self-evaluation of their academic ability in school. In the current study, the lower values of students' expressed self-concept in school science also represent the "comparison nature" of self-concept and imply that comparison with social references (e.g. other students in school) may detrimentally influence students' self-perception in science.

Furthermore, the role of self-efficacy in model I* and the role of self-concept in model II* are also compared. Both of them could play as mediators of the remote indirect relation between family science capital and science career intentions. Specifically, under the Chinese context, the current study indicates that self-efficacy is more predictive of enjoyment of science than self-concept and therefore, self-efficacy makes stronger indirect effects on science career intentions than self-concept. These findings are not consistent with the study conducted in the German context by Jansen et al. (2015). Jansen et al. (2015) found that German secondary school students' science career intentions were more predicted by their self-concept in science than by their self-efficacy, and argued that careers in science were more related to students' general self-perceptions in science, in other words, their self-concept in science. However, this explanation is not applicable to Chinese students. To explain the stronger predictive effects of self-efficacy on science career intentions, it is necessary to emphasise that the present study found that neither self-efficacy nor self-concept could directly influence science career intentions; rather, both of these two variables made indirect effects on science career intentions through the mediation effects of enjoyment of science. This result indicates that enjoyment of science plays a pivotal role in bridging self-efficacy/self-concept with science career intentions. However, for Chinese high school students, the translating path from self-concept to the enjoyment of science needs more discussion. According to Bandura (1986), people who think they are capable of doing a task are more likely to show interest in the task. Chinese high school students who are under high pressure from examination-oriented school education are likely to work hard in order to win the competition in school science and to secure the self-perception that they are good at school science (high self-concept in science). However, these processes might be driven by the pressure of schools' and/or families' expectations of high academic attainment in school courses. It is legitimate to speculate that environmental pressure to gain high academic attainment may detrimentally influence the translation between students' self-concept in science and enjoyment of doing science.

There are also important findings that are not consistent with the original hypothesis. Firstly, the widely used measurement approach to learning experiences

(LEQ) is not suitable for participants in the present study. The current study indicates that one of the sub-factors of learning experiences - affective state - is not consistent with the holistic construct of learning experiences. The measurement construct of learning experiences has been divided in the current study into two components: positive learning experiences (consisting of three sub-factors: mastery experiences, vicarious learning, and verbal persuasion) and affective state. "Positive learning experiences" positively contributes to self-efficacy/ self-concept and "affective state" negatively contribute to self-efficacy/ self-concept.

The follow-up qualitative case study provides some perspectives to help understand the inconsistency of affective state with the whole learning experiences construct. Students' affective states (assessed by anxiety and nervousness in the present study) may have complex relationships with mastery experiences, vicarious learning, and verbal persuasion. These findings shed new light on the widely accepted understanding of these relationships. Many previous studies claimed that students who had high previous mastery experiences, vicarious learning, and verbal persuasion by others were more likely to have lower negative emotions (e.g. Sheu et al., 2018). However, in the present study, the case studies indicate that students who have good coping strategies with their emotions are less likely to be influenced by prior bad performances. Furthermore, vicarious learning and verbal persuasions can both contribute to students' anxiety levels as well as mitigate the anxiety level. The different effects depend on whether students regard these experiences as negative pressure on them or inspirational 'energy' for them. Those findings have applied implications for future studies that the measurement instrument of learning experiences (LEQ) needs checking for construct validity under different contexts before being employed in specific studies.

In addition, the current study indicates that family science capital might present a barrier that hinders the translational pathway from the interest in science to science career intentions. This finding is not congruent with the hypothesis that family science capital would be a support that facilitates the translational pathway from interest in science to science career intentions. This hypothesis was made based on previous studies from other countries, which asserted that families with high science capital were more likely to provide support for science-related knowledge and vocational guidance in scientific careers for their children. The paradox between the hypothesis and the results in the current study might reflect scientific practitioners' vocational well-being and attitudes to science careers in the Chinese context. Students who have more communication with scientific practitioners have more awareness about what scientific jobs are really like. However, the enhancement of awareness about science jobs does not facilitate students' science career intentions, instead, those students might be less likely to have career intentions in science since they know about what the scientific practitioners' lives are like. This hypothesis needs investigation in future studies.

6.2 Critical discussions of the method

This study employed a quantitative-dominant mixed methods approach to provide empirical evidence of the fitness of two models - model I* and model II*. To investigate the potentially influential factors behind science career intentions, previous studies mainly focused on five domains: family factors, school factors, psychological factors, gender, and race. The multivariate regression analysis has been one of the most employed quantitative methods in this field. However, the diffuse literature on potential factor exploration may not provide a comprehensive picture to depict the mechanism of the development of students' science career intentions. Hence, in the present study, different from potential factor exploration studies, the analytic models, which not only represent which potential factors influence students' science career intentions but also how these factors interact with each other to generate students' science career intentions, have been designed and tested. The approaches to test those analytic models include quantitative and qualitative approaches. The quantitative research plays the dominant role in the current study, and the qualitative research is conducted in order to complement the results of the quantitative study. Specifically, the quantitative approaches are presented in the next paragraph.

The development of statistical analysis methods based on computer programs provides opportunities for the investigation of complex analytic models. Hence, the present study mainly employed quantitative methods to test the fitness of the hypothetical models. Specifically, confirmatory factor analysis was employed to confirm that the measurement instruments applied in the present study were applicable to the participants in the context of the study. Structural regression modelling was employed to test whether the hypothesised structural models were fitted to the data. In addition to the model fit testings, the present study also focused on the mediation and moderation effects in the hypothetical models, which were also investigated by statistical methods. The details of the flow of the quantitative analysis were shown in Figure 3.1.

This series of statistical analyses with advanced statistical techniques provide evidence that model I* and model II* could depict Chinese high school students' formation process of science career intentions. However, those statistical methods are not flawless. First of all, in model I* and model II*, there are many causal relations between variables. However, as Kline (2010) stated, there are no non-experimental methods that can really test causality relationships. Theoretically, the structural regression modelling analysis employed in the present study can merely indicate that there are relationships between variables in the models, but this method can not indicate the exact directions of the paths. For example, in model I*, self-efficacy is the predictive variable for interest in science. However, Nugent et al. (2015) have also employed structural regression modelling to provide evidence that interest in science was the predictive factor for self-efficacy. In this sense, the statistical methods employed in these two studies do not have the function to identify the direction of paths. In addition, since the statistical analysis has been conducted through computer programs, the significance testing of paths in structural models may produce different results through a different software (Kline, 2010).

All these flaws in technique require that the design of hypothetical models and the modifications along the modelling processes should be based on theoretical support and substantive evidence (Bryne, 2016). Otherwise, the fitted model, in the end, may not robustly answer the research question. Hence, in the present study, a follow-up qualitative case study investigating the relationships between affective state with the other three sub-factors of learning experiences was necessary to conduct. It provides substantive evidence for variable change, from “learning experiences” to “positive learning experiences” and “affective state”. The follow-up qualitative study aims at providing possible explanations of the reasons why affective state is not statistically correlated with the other three kinds of learning experiences. The results of the case study indicate the complex relationships between affective state and the other three kinds of learning experiences, which provides substantive evidence for the inconsistency of the affective state in the original “learning experiences” construct. Compared with the modelling process, merely based on statistical methods, the current study may enhance the content validity of models by employing mixed methods.

In addition, the possible error that the model is statistically fitted to the data simply by chance should also be considered, when a study employs statistical methods (Bryne, 2016). In the present study, cross-validation testing was employed to mitigate the possibility of this kind of error.

It is also worth mentioning that this study just collected data from Hebei province. There are salient differences in education policies between different provinces. For example, Hebei province implemented an educational reformation in 2018, from then on, high school students could choose any three courses from six selective courses (history, politics, geography, chemistry, biology, and physics) as the subjects they learned in high school stage. By contrast, students in some provinces in China have to choose either three art courses or three science courses. The difference in education policies may influence students' attitudes to science. In addition, the economic developments of different provinces are also different. For example, comparing the data of B-S-J-G from the PISA2015 project and the data in the current study, students' parental educational level from B-S-J-G is higher than that in the current study, which implies the economic difference between Hebei province and B-S-J-G provinces. Families' social economic status may influence students' family science capital. Hence, considering those differences discussed before, the results of the current study may have the limitation to explain students' development of science career intentions in other provinces in China.

Furthermore, in order to make the data in the current study reflect the high school students' responses in Hebei province, the current study has conducted many measures. For example, the current study recruited high school students from both rural high schools and urban high schools. In addition, to decrease the influence of irrelevant factors of school on students' responses, the current study has recruited participants from 8 high schools. However, considering some beyond-controlled factors, the responses of participants in the current study may not strictly simulate the responses of high school students in Hebei. For example, since all the participants voluntarily attended the current study, it is legitimate to speculate that the students who were interested in the topic of science were more likely to join in the current study. In addition, although the current study has recruited participants from both rural and urban high schools, given the unknown rate between the number of rural and urban high school students in Hebei province, the current study could not simulate the demographic distribution of high school students in Hebei province.

6.3 Implications for science education policy

At the level of nations, the shortage of qualified professionals in the science area has been argued to significantly influence the development of countries (e. g. Bosworth et al, 2013; Rice, 2007). Many countries have enhanced their investment in science-related research and implemented educational policies aimed at boosting students' aspirations in science (Smith, 2010). Although scientific endeavours are very important for the development of a country, the present study is more inclined to emphasise the value of science-related careers for each individual. This study proposes neither that science-related jobs are better than other jobs nor that stakeholders should stimulate students' aspirations in science for the sake of national development. Instead, the present study just proposes that science-related careers can be a kind option for careers for students. However, many conditions may inhibit students from choosing this option. For example, Archer et al. (2013) found that students with high family science capital were more likely to have science aspirations. It should be mentioned here that family science capital tends to be a privileged resource for middle or upper-class families. Those people who are equipped with family science capital are more likely to generate science capital themselves (Archer et al., 2015). In this sense, the influence of family science capital on science career intentions may make science capital increasingly clustered in some social classes, which exacerbates social inequality.

The present study demonstrates a series of paths to explain how family science capital influences students' science career intentions. The results indicate that family science capital can be translated into learning experiences, which further contribute to students' self-efficacy/self-concept in science. Hence, interventions in learning experiences could be the key points that mitigate the influences of the lack of family science capital on science career intentions. Specifically, there are three kinds of positive learning experiences discussed in the present study: mastery experiences, vicarious learning, and verbal persuasion.

Specifically, school science curriculum content and pedagogical activities which are likely to contribute to students' sense of achievement in science are recommended – these represent mastery experiences. Corresponding to the importance of vicarious learning, role models from school, family, or society inspire students' aspirations. Insofar as that, content related to role models in scientific careers is recommended, in the form of experiences that should permeate through science courses, careers education, and extra-curricular provisions. Finally, the importance of verbal persuasion suggests that more encouragement to students can indeed make effects on engagement. It should be a matter of concern that according to

Pajares and Usher (2009), the destructive effects of negative verbal persuasion may be stronger than the constructive effects of positive verbal persuasion. Students probably are more sensitive to depreciating and negatively critical words. Hence, it is recommended that teachers should be cautious about negative verbal communication with students. In addition, the current study has found that encouragement could enhance students' anxiety and pressure levels, when students regarded the encouragement, which was especially from their admirable people, as a kind of high expectation. Hence, the possible "side effect" of encouragement should also be taken into consideration for teachers.

These interventions to enhance students' positive experiences in science learning may complement the "science capital teaching approach" from Godec, King, and Archer (2017). Compared with the suggested interventions from the current study, Godec et al., (2017) provided school teaching approaches that directly addressed the issues of students' lack of science capital. Godec et al. (2017) have depicted a teaching system with "one foundation" and "three pillars" related to enhancing students' science capital.

> The science capital teaching approach is based on the foundation of broadening what counts and the three pillars: personalising and localising, eliciting, valuing and linking, and building the science capital dimensions. (Godec et al., 2017, p. 17)

Many teachers’ feedback on this approach has been very positive (Godec et al., 2017). The aim of the “science capital teaching approach” was to address social inequality and improve students’ science engagement.

The current study may complement the “science capital teaching approach” by providing a translation mechanism from science capital to students’ science engagement, which implies that Godec et al. (2017) build students’ science capital ‘bag’, and the current study unblocks the pipeline that translates the resources from the science capital bag to science engagement and careers intentions.

Furthermore, it should be noticed that a large percentage of students in the present study had not attained a mature academic/vocational plan. They did not have a clear inclination of whether to engage in science or not in their next life stages. The participants in the current study are second and third-year high school students, which means that they are about to face academic/vocational decisions, in one year’s time. The lack of awareness of future trajectories may detrimentally influence students’ decisions. Furthermore, it should be noticed that a large percentage of students in the present study had not attained a mature academic/vocational plan. They did not have a clear inclination of whether to engage in science or not in their next life stages. The participants in the current study are second and third-year high school students, which means that they are about to face academic/vocational decisions, in one year’s time. The lack of awareness of future trajectories may detrimentally influence students’ decisions. In 2022, the Chinese government has implemented a new vocational education law in nationwide that vocational high schools will be considered as an important component in Chinese education system (moe.gov.cn). From 2022, about half of secondary school students now go to vocational high schools when they graduate from secondary school. From then on, some students – those who either cannot reach academic requirements to enter a (so-called) normal high school or who voluntarily choose vocational high school - have to make their trajectory decisions in the secondary school stage. Curriculum in vocational high schools mainly aims at training students' technical skills rather than cultivating student in whole perspectives. Students who have chosen their majors in vocational school have less flexibility to change their majors. Hence, for those students, relevant guidance on academic/vocational trajectories is even more urgently needed than it previously was. The current study suggests that relevant guidance on academic/vocational trajectories embedded in school education may contribute to students' future decisions. PISA2018 project also suggested that vocational guidance should be added to school education, to mitigate the lack of vocational guidance from family education for some students from disadvantaged backgrounds (OECD, 2019)

6.4 Implications for future studies

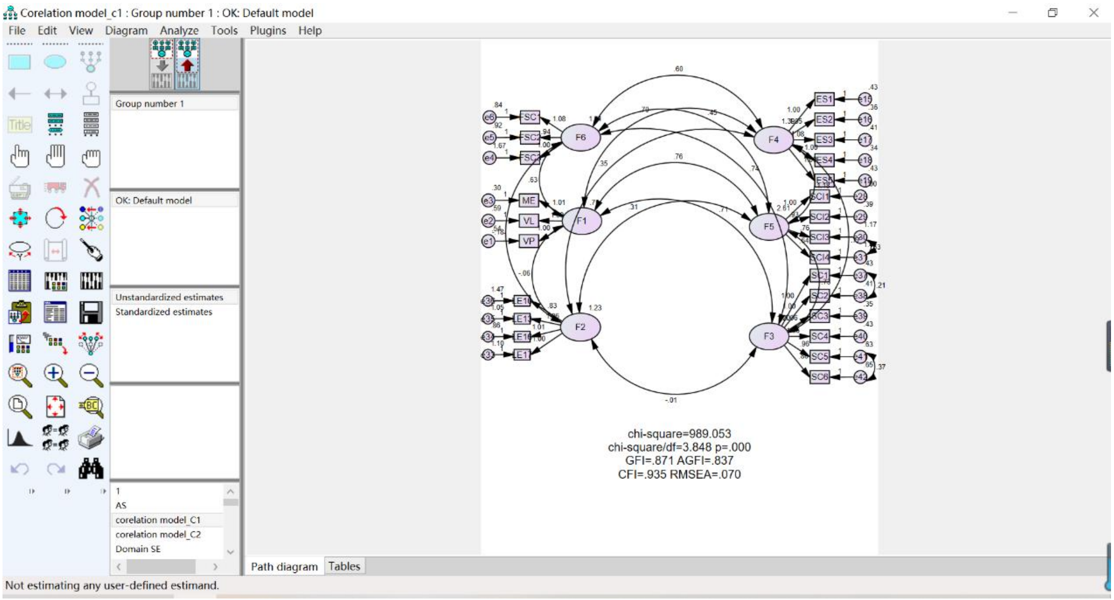
Experimental studies to support model I* and model II* would be expected to compensate for the shortcoming of structural equation modelling that it cannot prove the causality of relationships. Especially, the well-designed "science capital teaching approach" from Godec et al. (2017) provides an intervention method to enhance students' science capital through school education. Experimentally-designed investigations on whether intervention in science capital could influence students' personal agency and science career intentions may provide solid empirical evidence for model I* and model II*. However, it should be noticed that intervention in science capital is not a task that can be instantly completed. The choice of a duration for the intervention period that is neither too short to have any effectiveness nor too long to be a challenge for conducting the study may be an issue to concern.

In addition, the role of family science capital as a possible barrier that hinders the translational pathway from interest to science career intentions needs further empirical evidence, to support or refute the hypothesis. The current study found that communications with science-related practitioners can detrimentally influence the interest-intention translation pathway. The current study proposes a different proposition from other studies (e.g. Cleaves, 2005). Cleaves (2005) proposed that the lack of awareness of science-related jobs may detrimentally influence students' science career intentions. By contrast, the current study proposes that the awareness of the real life of science-related practitioners may also not have the expected positive impact on students' science career intentions. This hypothesis needs further investigation.

To summarise, the current study designs and supports two models which explain Chinese high school students' formation process of science career intentions. These two models explain how variables family science capital, learning experiences, self-efficacy/self-concept, and interest act individually as potential factors influencing Chinese high school students' science career intentions. Hence, Research Question 1 is answered. In addition, not only what potential factors but also how these factors interact with each other to contribute to Chinese high school students' science career intentions are also shown in the present study, which correspondingly answer the Research Question 2. Those two models contribute to peoples' understanding of students' intentions (or lack of intentions) in science careers. At the theoretical level, the current study complements SCCT and science capital theory. Furthermore, the current study provides empirical evidence of the overall applicability of SCCT and science capital theory in the Chinese context and also provides adjustment suggestions to refine these two theories in the Chinese context. Research Question 2a is also answered. Based on the results of the current study, implications on school education policy that may contribute to social equality have been suggested. Future relevant studies on students' science career intentions may carry on the proposed and unsolved questions discussed in the present study, to further enrich the understanding of students' engagement and intentions in science.

Appendices

The screen shot of Amos24 software



Questionnaires

Learning experience questionnaire (Schaub, 2004)

Instruction: Please read the following questions and think about to what extent you agree with them. Answers will be from 1“strongly disagree” to 7 “strongly agree”.

1: strongly disagree; 2: disagree; 3: a little bit disagree; 4 neutral;

5: a little bit agree; 6: agree; 7: strongly agree.

(In the following statement, science courses refers to subjects: chemistry, biology and physics. “science” refers to natural science.)

1.Overall, I performed well in science courses in school.

2. People whom I respect have encouraged me to work hard in science courses.

3. Generally, I have become nervous while solving science problems.

4. Overall, I was successful performing scientific practical work in school.

5. In school, I saw teachers whom I admired working on science projects.

6. I remember my family telling me that it is important to be able to solve science problems.

7. People whom I looked up to told me that it is important to read scholarly articles.

8. On average, I received high scores on the science section of my last term final examination.

9. While growing up, I saw people I respected using science to solve problems.

10.Overall, I have felt anxious while taking science courses in school.

11 I have seen people whom I respect participating in activities that require science abilities.

12. I recall seeing adults whom I admire working in a research laboratory.

13. Generally speaking, I have felt uneasy while learning new topics in science courses.

14. Generally, I have easily understood new science concepts after learning about them in class.

15. I have demonstrated skill at conducting research for my experiment reports.

16. Reading articles about science has made me feel uneasy.

17. I would feel dread about using science in my future job

18. While growing up, I recall seeing people I respected reading articles about science.

19. My friends have encouraged me to use my research abilities.

20. Teachers whom I admire have encouraged me to take science courses.

Mastery Experiences=1, 4, 8 14, and 15

Vicarious Learning=5, 9 11, 12, and 18

Verbal Persuasion=2, 6, 7, 19, and 20

Affective State=3, 10, 13, 16, and 17

The index of self-concept in science (PISA, 2015)

Instruction: Please read the following questions and think about to what extent you agree with them. Answers will be from 1"strongly disagree" to 7 "strongly agree". (In the following questions, school science courses refers to the subjects: chemistry, biology and physics.)

1: strongly disagree; 2: disagree; 3: a little bit disagree; 4 neutral;

5: a little bit agree; 6: agree; 7: strongly agree.

1. school science topics are easy for me;

2. I can usually give good answers to test questions on school science topics;

3. I can learn school science topics quickly;
4. learning advanced school science topics would be easy for me;
5. when I am being taught school science, I can understand the concepts very well;
6. I can easily understand new ideas in school science.

The index of self-efficacy in science (PISA, 2015)

Instruction: Please read the following tasks and think about your ability to perform the following tasks on your own. Answers will be from 1"strongly disagree" to 7 "strongly agree". (In the following questions, "science" refers to natural science, such as chemistry, biology and physics.)

1: strongly disagree; 2: disagree; 3: a little bit disagree; 4 neutral;

5: a little bit agree; 6: agree; 7: strongly agree.

1. I can recognise some science questions that underlie newspaper report on a health issue;
2. I can explain why earthquakes occur more frequently in some areas than in others;
3. I can describe the role of antibiotics in the treatment of disease;
4. I can identify some of the science issues associated with the disposal of garbage;
5. I can predict how changes to an environment will affect the survival of certain

species;

6. I can interpret the scientific information provided on the labeling of food items;
7. I can discuss how new evidence can lead you to change your understanding about the possibility of life on Mars;
8. I can identify the better of two explanations for the formation of acid rain.

The index of broad interest in science topics (INTBRSCI) (PISA, 2015)

Instructions: Please read the following topics and think about whether you are interested in them. Answers will be from 1 “strongly disagree” to 7 “strongly agree”. (“Science” in the following questions refers to natural science, such as chemistry, biology, physics.)

1: strongly disagree; 2: disagree; 3: a little bit disagree; 4 neutral;

5: a little bit agree; 6: agree; 7: strongly agree.

1. I am interested in biosphere (e.g. ecosystem services, sustainability);
2. I am interested in motion and forces (e.g. velocity, friction, magnetic and gravitational forces);
3. I am interested in energy and its transformation (e.g. conservation, chemical reactions);

4. I am interested in the Universe and its history;

5. I am interested in how science can help us prevent disease.

The index of enjoyment of science (JOYSCIE) (PISA, 2015)

Instruction: Please read the following questions and think about to what extent you agree with them. Answers will be from 1 "strongly disagree" to 7 "strongly agree". ("science" in the following questions refers to natural science, such as chemistry, biology, physics.)

1: strongly disagree; 2: disagree; 3: a little bit disagree; 4 neutral;

5: a little bit agree; 6: agree; 7: strongly agree.

1. I generally have fun when I am learning science topics;

2. I like reading about science;

3. I am happy working on science topics;

4. I enjoy acquiring new knowledge in science;

5. I am interested in learning about science.

Science Career Intentions (MSIGS; Smith & Fouad, 1999).

Instruction: Please read the following questions and think about to what extent you agree with them. Answers will be from 1“strongly disagree” to 7 “strongly agree”.

(In the following statement, “science-related job” refers to the careers which work with science topics and also the careers in which scientific knowledge or skills are used as tools.)

1. I already have taken science courses in high school
2. I am committed to study hard in my science classes
3. I intend to find a science-related job
4. I am determined to use my science knowledge in my future career

Family science capital (Hamlyn et al., 2017)

Instruction: Please read the following questions and think about to what extend you agree with them. Answers will be from 1“strongly disagree” to 7 “strongly agree”.

1: strongly disagree; 2: disagree; 3: a little bit disagree; 4 neutral;

5: a little bit agree; 6: agree; 7: strongly agree.

1. Apart from doctors in hospital, I still know some people with medical or science-related jobs that I could talk to about health, medicine or other scientific issues outside of school.

2. I would say my parents are interested in science.

3. There are some people in my family working as scientists or in jobs using science or medicine.

An Example of Thematic Coding on the Translated Transcript(the interview is in Chinese)

R: researcher

P: participant

R: “What grade are you in?”

P: “ I am in the second year of high school”

R: “what selective subjects have you chosen? ”

P: “Physics, chemistry, biology”

R: “Is the major you want to choose in your university science related? Have you ever thought about what major to choose?”

P: “It's not scientific. I haven't decided on my major, but I should choose one that is better for employment”

R: “The reason why you don't want to choose a science related major is that you don't think it is good to get a job?”

P: “Actually, no. I think science is too boring”

R: “do you imply that high school science is boring to you?”

P: “indeed it is.”

R: “Then, do you think high school science is difficult? ”

P: “not really, I can got the model and theory taught in the class, but sometimes, I do not know how to apply them in the exam.”

R: “do you identify yourself as good student in science?”

P: “not really, I guess I am just at he medium level.”

Kernal
Background information

R: “Do you feel anxiety about science?”

P: “well. I guess I do not feel anxiety when I learn science at class, but sometimes, I would feel anxiety about science examination”

R: “ Do you have experiences that you are too anxious to keep on doing science?”

P: “yes, I had those experiences during science examination. The questions were too hard for me, I felt really panic and helpless”

Kernal
Deductive Code 1.1
Science anxiety was stimulated by bad performance in examination

R: “Did this kind of experiences have negative impact on your following science-related learning? ,such as remembering that very flustered experience, and suddenly afraid of exams or learning science”

P: “ Not really. I have ability to adjust myself.”

Kernal
Inductive code 1.2
Coping strategy for threatening situation

R: “how could you cope with this anxiety feeling”

P: “I could adjust myself. I could make up for the missing knowledge that I should grasp. I could study hard every day which made me feel like that I was not in a muddle. I could try my best to learn more.”

Kernal
Inductive code 1.2
Coping strategy for threatening situation

R: “Can I understand your feeling as that your anxiety for science examination is derived from the lack of confidence of science knowledge. Hence, after grasping more science knowledge, you will feel more confidence and less anxiety. ”

P: “Indeed. When I feel I have the capability to get a high score in science examination, I won’t feel too anxious.”

Kernal
Deductive Code 0.1:
Self-efficacy reduced student's science anxiety

R: “Do you think your performance of a science-related task is related to your anxiety

R: “Do you think your performance of a science-related task is related to your anxiety level to that?”

P: “indeed. I think if I could calm down, I would be better”.

Kernal
Deductive Code 1.1
Mastery experiences were negative associated with affective state (anxiety).

R: “Did you have experiences that even if your were really anxious, you still got a good result?”

P: “yes, I have. When I was preparing for Zhongkao (the high school entrance national examination), I was really afraid of failing in this exalt's not scientific. I haven't decided on my major, but I should choose one that is better for employmentmination. So I was very anxious, which influenced my digesting function. I felt sick when I ate food. I did not want to study everyday, but I still persisted in preparing for the examination. And the result for this examination is not bad. ”

Kernal
Inductive code 1.2
Coping strategy for threatening situation

R: “According to your words, do you imply that if you could keep working, no matter you have anxiety or not, you can make it in the end? ”

P: “Indeed, actually, I think if I can keep working, the modest level of anxiety may make me more focused on the task. But if the anxiety is too strong, I could not handle this feeling. I just want to give up and run.”

R: “Did you have experiences that others’ encouragement reduce your science anxiety”

P: “There was one time that I got a bad score for science examination. One of my friends who also failed in that exam came to comfort and encourage me. And I felt better by his words.”

Kernal
Deductive Code 2.1
Verbal persuasion reduced affecitve state (anxiety)

R:“Why did his words made you feel less anxiety?”

P:“I felt psychologically balanced. It is like someone is with me and I was not the only one who did bad.”

R: “Did you have the experience that others’ encouragement could enhance your anxiety for science?”

P: “No, if others said that I am good at science, I would be very happy.”

R:“Did you have experiences that observing others doing science-related activities could mitigate your own science anxiety?”

P: “Yes, I had. I had been told that a new science knowledge was very very hard to learn. So I had been anxious to learn it. However, I accidentally watched someone teaching others to solve a problem about it. It looked like that it was not hard like I imagined before. So my anxiety of learning that knowledge was reduced. I guess that observation of others doing science can let me know how hard it really is, instead of just being terrified by my imaginary fear. ”

Kernal
Deductive Code 3.1
Vicarious learning reduced affecitve state (anxiety)

R:“Did you have experiences that observing others doing science-related activities

Ethic Approval Form

UNIVERSITY of York

Education Ethics Committee

<u>Ethical Issues Audit Form for Research Students</u>

This questionnaire should be completed for each research study that you carry out as part of your degree.

Surname / Family Name:	Li
First Name/ Given Name:	Mengyao
Programme:	Education
Supervisor (of this research study):	Jeremy Airey
Topic (or area) of the proposed research study:	
Investigation on Chinese students' scientific career development process.	
Where the research will be conducted:	
China	
Methods that will be used to collect data:	
Questionnaire interview	
If you will be using human participants, how will you recruit them?	
My targeted participants are first and second year high school students. To get in touch with them, I will firstly get in touch with the headmasters of the high schools. After getting the headmaster's permission, I will further get in touch with students with the headmasters' help and enquire students' willingness to join in my research. Finally, I will recruit those students who will voluntarily be my participants.	

Supervisors, please read *Ethical Approval Procedures: Students*.

The application is a joint one by the research student and supervisor(s). It should be submitted to the TAP member for initial approval and then to the Higher Degrees Administrator who will seek a second opinion from a designated member of Education Ethics Committee. Forms may also require review by the full Ethics Committee (see below).

<u>First approval:</u> by the TAP member (after reviewing the form):

Please select one of the following options.

I believe that this study, as planned, meets normal ethical standards. I have checked that any informed consent form a) addresses the points as listed in this document, and b) uses appropriate language for the intended audience(s).	☒
I am unsure if this study, as planned, meets normal ethical standards	☐

I believe that this study, as planned, does not meet normal ethical standards and requires some modification	☐

TAP member's name (please type):	Constantino Dumangane Jr
Date:	11 December 2019

<u>Second approval:</u> by a designated Ethics Committee member:

Please select one of the following options:

I believe that this study, as planned, meets normal ethical standards. I have checked that any informed consent form a) addresses the points as listed in this document, and b) uses appropriate language for the intended audience(s).	☒
I am unsure if this study, as planned, meets normal ethical standards	☐
I believe that this study, as planned, does not meet normal ethical standards and requires some modification	☐

Name of Ethics Committee member (please type):	Dusana Dorjee
Date:	19 December 2019

The Ethics Committee member should now <u>email</u> this completed form to the Programme Administrator, unless approval is required by the full Ethics Committee (see below).

<u>Approval required by the full Education Ethics Committee</u>

If the application requires review by the full Education Ethics Committee, please select one of the following options then forward the application to (education-research-admin@york.ac.uk).

The study involves deception	☐
The study involves an intervention and procedures could cause concerns	☐
The topic is sensitive or potentially distressing	☐
The study involves vulnerable subjects	☐
Other reason:	

Name of person making referral (please type):	
Date:	Click here to enter a date.

<u>FOR COMPLETION BY THE STUDENT</u>

Data sources

1 If your research involves collecting secondary data only **go to SECTION 2**.

2 If your research involves collecting data from people (e.g. by observing, testing, or teaching them, or from interviews or questionnaires) **go to SECTION 1.**

SECTION 1: For studies involving people

3 a) Have you screened your study for risk using the Data Protection Impact Assessment (DPIA) screening questions? YES
Yes
b) Did you have to undertake the Data Protection Impact Assessment? NO
No

4 a) Is the amount of time you are asking research participants to give reasonable? YES
Yes
b) Is any disruption to their normal routines at an acceptable level? YES
Yes

5 Are any of the questions to be asked, or areas to be probed, likely to cause anxiety or distress to research participants? NO
No

6 a) Are all the data collection methods used necessary and appropriate to the context and participants? YES
Yes
b) Do you need to gather personally identifiable data? YES
Yes
c) Are you capturing the minimum amount of personal data/special category data necessary for your research project? YES
Yes **NA if no personal data is to be collected*

7 Could you anonymise data or pseudonymise data at any point during the project to minimise data protection risk? YES
yes **NA e.g. if only anonymous data is to be collected*
If NO, please explain:

8 Will the research involve deception? NO
No

9 Will the research involve sensitive or potentially distressing topics? (The latter might include abuse, bereavement, bullying, drugs, ethnicity, gender, personal relationships, political views, religion, sex, violence. If there is lack of certainty about whether a topic is sensitive, advice should be sought from the Ethics Committee.) NO
No

If YES, what steps will you take to ensure that the methods and procedures are appropriate, not burdensome, and are sensitive to ethical considerations?

10 Does your research involve collecting data from vulnerable or high risk groups? (The latter might include participants who are asylum seekers, unemployed, homeless, looked after children, victims or perpetrators of abuse, or those who have special educational needs. If there is a lack of certainty about whether participants are vulnerable or high risk, advice should be sought from the Ethics Committee. Please note, children with none of the above characteristics are not necessarily vulnerable, though approval for your project must be given by at least two members of staff; see above). NO

No

If YES, what steps will you take to ensure that the methods and procedures are appropriate, not burdensome, and are sensitive to ethical considerations?

11 Are the research participants under 16 years of age? NO

If NO, go to question 12.

NO

If YES, and you intend to interact with the children, do you intend to ensure that another adult is present during all such interactions? Choose an item.

If NO, please explain, for example:

i) This would seriously compromise the validity of the research because [***provide reason***]

ii) I have/will have a full Disclosure and Barring Service check (formerly Criminal Records Bureau check). Choose an item.

iii) Other reasons:

<u>Payment to participants</u>

12 If research participants are to receive reimbursement of expenses or any other incentives, including financial, before or after the study, please give details. You should indicate what they will receive and, briefly, the basis on which this was decided.

No financial payment. Refreshments will be offered during interviews (e.g. a cup of tea and a biscuit).

It is often considered good practice to consider what the researcher might offer the participants, in the spirit of reciprocity. Some ideas of what this might be include: materials at the end of the study, a workshop summarising the results of the study, a delayed treatment/intervention at the end of the study, an indication about where the findings might be accessed at a later date, a letter or token of thanks. Please ensure that you have considered the potential for reciprocity in your research.

<u>**If your study involves an INTERVENTION i.e. a change to normal practice made for the purposes of the research, go to question 13**</u> (this does not include 'laboratory style' studies i.e. where ALL participation is voluntary):_

<u>**If your study does not involve an intervention, go to question 20.**</u>

13 Is the extent of the change within the range of changes that teachers (or equivalent) would normally be able to make within their own discretion? Choose an item.

14 Will the change be fully discussed with those directly involved (teachers, senior school managers, pupils, parents – as appropriate)? Choose an item.

15 Are you confident that *all* treatments (including comparison groups in multiple intervention studies) will potentially provide some educational benefit that is compatible with current educational aims in that particular context? (Note: This is *not* asking you to justify a non-active control i.e. continued normal practice) Choose an item.

Please **briefly** describe this / these benefit(s):

16 If you intend to have two or more groups, are you offering the control / comparison group an opportunity to have the experimental / innovative treatment at some later point (this can include making the materials available to the school or learners)? Choose an item.

If NO, please explain:

17 If you intend to have two or more groups of participants receiving different treatment, do the informed consent forms give this information? Choose an item.

18 If you are randomly assigning participants to different treatments, have you considered the ethical implications of this? Choose an item.

19 If you are randomly assigning participants to different treatments (including non-active controls), will the institution and participants (or parents where participants are under 16) be informed of this in advance of agreeing to participate? Choose an item.

If NO, please explain:

General protocol for working in institutions

20 Do you intend to conduct yourself, and advise your team to conduct themselves, in a professional manner as a representative of the University of York, respectful of the rules, demands and systems within the institution you are visiting? YES

Yes

21 If you intend to carry out research with children under 16, have you read and understood the Education Ethics Committee's *Guidance for Ethical Approval for Research in Schools*? Choose an item.

22 If you are conducting research overseas, have you checked whether local ethics approval is needed? YES

Yes

23 If local ethics approval is needed, have you obtained it? NO

If NO, please explain:

Local ethics approval is not required in China.

Informed consent

24 Have you prepared Informed Consent Form(s) which participants in the study will be asked to sign, or agree to, and which are appropriate for different kinds of participants? YES

Yes

If YES, **please attach the informed consent form(s).**

If NO, please explain:

25 Please check the details on the informed consent form(s) match each one of your answers below. Does this informed consent form:

a) inform participants in advance about what their involvement in the research study will entail? Yes YES

b) if there is a risk that participants may disclose information to you which you may feel morally or legally bound to pass on to relevant external bodies, have you included this within a confidentiality clause in your informed consent form? YES

Yes

c) inform participants of the purpose of the research? YES

Yes

d) inform participants of what will happen to the data they provide (how this will be stored, who will have access to it, whether and how individuals' identities will be protected during this process)? YES

Yes

e) if there is a possibility that you may use some of the data publicly (e.g. in presentations or online), inform the participants how identifiable such data will be **and** give them the opportunity to decline such use of data? YES

Yes

f) give the names and contact details (e.g. email) of at least two people to whom queries, concerns or complaints should be directed? One of these people should be on the Education Ethics Committee (please use education-research-admin@york.ac.uk) and not involved with the research. YES

Yes

g) in studies involving interviews or focus groups, inform participants that they will be given an opportunity to comment on your *written record* of the event? YES

Yes

If NO, have you made this clear this on your consent form? Choose an item.

If NO, please explain why not:

h) inform participants how long the data is likely to be kept for? YES

Yes

i) inform participants if any data will be kept indefinitely? YES

Yes

j) inform participants if the data could be used for future analysis and/or other purposes? YES

Yes

k) inform participants they may withdraw from the study during data collection? YES

Yes

l) provide a date/timescale by which participants will be able to withdraw their data and tell the participants how to do this? (NB. If your data is going to be completely anonymised, any withdrawal of data needs to happen before this.) YES

Yes

**NA if your data will be anonymous at point of collection*

If your answer was NO to any of the above, please explain here, indicating which item(s) you are referring to (a-j):

26 Who will be asked to sign an Informed Consent Form? Please <u>select all</u> that apply:

CATEGORY	
Adult research participants	☒
Research participants under 16	☐
Teachers	☐
Parents (of U16s)	☐
Head/Senior leadership team member	☒
Other (please explain)	☐

27 In studies involving an **intervention** with under 16s, will you seek informed consent from parents? N/A

If NO, please explain:

SECTION 2

Data Storage, Analysis, Management and Protection

28 I am accessing data from a non-publicly available source (regardless of whether the data is identifiable) e.g. pupil data held by a school or local authority, learners' work. YES

Yes

If YES, I have obtained written permission from a figure of authority who is responsible for holding the data. This informed consent a) acknowledges the purposes for which the data will be used, b) acknowledges responsibility for releasing the data, and c) confirms that releasing the data does not violate any informed consents or implicit agreements at the point the data was initially gathered. YES

29 a) I have read and understood the Education Ethics Committee's *Guidance on Data Storage and Protection.* YES

Yes

b) Are you working collaboratively with 3rd parties or sharing data with non-University personnel?

No NO

c) If YES have you consulted the Information Governance Office and/or IP and Legal to ensure appropriate contract and/or data sharing arrangements are in place? Choose an item.

30 What technical and organisational measures have you put in place to safeguard data (e.g. storage arrangements, folder and file encryption, safe handling practices etc.)?

Please give details:

Data will be stored in secure (locked) filing cabinets, on a password protected computer and on the Google drive with my University of York account.

a) Have you completed a Data Management Plan? YES
Yes

If NO, please explain:

31 If any anonymised data is to be kept indefinitely it will be stored with the University's Research Data York service, as I am practising Open Science. YES
Yes

32 If your data can be traced to identifiable participants:

a) who will be able to access your data?

Mengyao Li

b) approximately how long will you need to keep it in this identifiable format?

Approximately one month

33 If working in collaboration with other colleagues, students, or if under someone's supervision, please discuss and complete the following:

We have agreed:

a) [Mengyao Li] will be responsible for keeping and storing the data
b) [Jeremy Airey and Mengyao Li] will have access to the anonymised data
c) [Jeremy Airey and Mengyao Li] will have the rights to publish using the data

Reporting your research

34 In any reports that you write about your research, will you do everything possible to ensure that the identity of any individual research participant, or the institution which they attend or work for, cannot be deduced by a reader? YES
Yes

If NO please explain:

Conflict of interests

35 If the Principal Investigator or any other key investigators or collaborators have any direct personal involvement in the organisation sponsoring or funding the research that may give rise to a possible conflict of interest, please give details:

Potential ethical problems as your research progresses

36 If you see any potential problems arising during the course of the research, please give details here and describe how you plan to deal with them:

Student's Name (please type):	Mengyao Li
Date:	09 December 2019

Please email this form to your supervisor who will send it to the TAP member

NOTE ON IMPLEMENTING THE PROCEDURES APPROVED HERE:

If your plans change as you carry out the research study, you should discuss any changes you make with your supervisor. If the changes are significant, your supervisor may advise you to complete a new 'Ethical issues audit' form.

For Research Students (MA by Research, MPhil, PhD), once your data collection is over, you must write an email to your supervisor to confirm that your research did not deviate significantly from the procedures you have outlined above.

Information Sheet for headteachers

Investigation the formation process of Chinese students' science career intentions

Dear Headmaster

Mengyao Li is currently carrying out a research project which is an investigation on Chinese students' science career development processes. I would like to invite your school to take part in this research project. Before agreeing to take part, please read this information sheet carefully and let me know if anything is unclear or you would like further information.

For information about General Data Protection Regulation (GDPR) please follow the link
https://www.york.ac.uk/education/research/gdpr_information/

The study is designed to investigate students' scientific career development processes. Specifically, it will try to find the effects of students' family factors, learning experience, self-efficacy in science and interest in science on their science-related career choices. The results of this study could help students and their parents and teachers to know more about their science learning behaviours and their science-related career development processes.

In this study, there are two stages. In the first stage, about 120 students from your school will be recruited separately from high, middle and low academic level classes based on their average science examination score in last term. These students will complete a questionnaire that may take approximately 20 minutes. Additional students may need to be recruited to complete the same questionnaire, depending on initial analysis of the data. In the second stage, 6 students from stage 1 will be invited to an interview that will take about 30 minutes for each student. During the interviews, the conversation will be audio-recorded.

Participation is optional. If students do decide to take part, they will be given a copy of an information sheet for their records and will be asked to complete a consent form. If they change their mind at any point during the study, they will be able to withdraw their participation without having to provide a reason. Your students will be given the opportunity to comment on a written record of their interview.

The data that your students provide (e.g. audio recordings of the interview and questionnaire results) will be stored by code number. Any information that identifies your school or your students will be stored separately from the data. Your students are free to withdraw from the study at any time during data collection and up to two weeks after the collection of data in each stage of the study. Data will be stored in secure filing cabinets and also on a password protected computer. I am practising Open Science and anonymised data will be managed professionally and stored indefinitely with the University's Research Data York service. The data that I collect (audio recordings, transcripts, questionnaire result) may be used in anonymous format in different ways –

neither the school nor any student will be identifiable. Please indicate on the consent form if you are happy for these anonymised data to be used in the ways listed. You will have the right to withdraw your school from Stage 1 of this study during and up to two weeks after data collection, and similarly for Stage 2. Please be informed that the confidentiality protocols will not include the information which may cross moral or legal bound.

If you have any questions about this participant information sheet or concerns about how your data is being processed, please feel free to contact Mengyao Li by email (ml2052@york.ac.uk), or the Chair of Ethics Committee via email education-research-admin@york.ac.uk. If you are still dissatisfied, please contact the University's Data Protection Officer at dataprotection@york.ac.uk

I hope that you will agree to your students taking part. If you are happy for your students to participate, please complete the consent form. Please keep this information sheet for your own records. Thank you for taking the time to read this information.

Yours sincerely

Mengyao Li

Consent Form for headteachers

Please tick/click each box if you are happy to take part in this research.

I confirm that I have read and understood the information given to me about the above named research project and I understand that this will involve my students taking part as described above.	
I understand that participation in this study is voluntary.	
I understand that my school and my students' data will not be identifiable and the data may be used in publications, presentations and online.	
I confirm that I have read the information about GDPR	

NAME____

SIGNATURE_____________________________________

DATE____

Information Sheet for students

Investigation the formation process of Chinese students' science career intentions

Dear student

Mengyao Li is currently carrying out a research project which is an investigation of family factors on Chinese students' science career development processes. I would like to invite you to take part in this research project. Before agreeing to take part, please read this information sheet carefully and let me know if anything is unclear or you would like further information.

For information about General Data Protection Regulation (GDPR) please follow the link

https://www.york.ac.uk/education/research/gdpr_information/

The study is designed to investigate students' scientific career development processes. Specifically, it will try to find the effects of students' family factors, learning experience, self-efficacy in science and interest in science on their science-related career choices. The results of this study could help students and their parents and teachers to know more about their science learning behaviours and their science-related career development processes.

In this study, there are two stages. In Stage 1, you will be firstly invited to complete a questionnaire that may cost approximately 20 minutes. In Stage 2, you will be invited to an interview which will approximately cost 30 minutes. During the interviews, the conversation will be audio-recorded. After filling the questionnaires, students will be asked their willingness to join the second stage. If you are willing, I will ask you to complete another consent form for the interview.

Participation is optional. If you do decide to take part, you will be given a copy of an information sheet for your records and will be asked to complete a consent form. If you change your mind at any point during the study, you will be able to withdraw your participation without having to provide a reason.

The data that you provide (e.g. audio recordings of the interview and questionnaire results) will be stored by code number. Any information that identifies you will be stored separately from the data. Data will be stored in secure filing cabinets and also on a password protected computer. I am practising Open Science and anonymised data will be managed professionally and stored indefinitely with the University's Research Data York service. The data that I collect (audio recordings, transcripts, questionnaire results) may be used in anonymous format in different ways. Please indicate on the consent form if you are happy for these anonymised data to be used in the ways listed. You will be given the opportunity to comment on a written record of your interview. You will have the right to withdraw your data from Stage 1 of this study during and up to two weeks after data collection, and similarly for Stage 2.

Please be informed that the confidentiality protocols will not cover the information which may cross moral or legal bound.

If you have any questions about this participant information sheet or concerns about how your data is being processed, please feel free to contact Mengyao Li by email (ml2052@york.ac.uk), or the Chair of Ethics Committee via email education-research-admin@york.ac.uk. If you are still dissatisfied, please contact the University's Data Protection Officer at dataprotection@york.ac.uk

I hope that you will agree to take part. If you are happy to participate, please complete the consent form. Please keep this information sheet for your own records.

Thank you for taking the time to read this information.

Yours sincerely

Mengyao Li

Consent Form for students (Stage 1)

Please tick/click each box if you are happy to take part in this research.

I confirm that I have read and understood the information given to me about the above named research project and I understand that this will involve myself taking part as described above.	
I understand that participation in this study is voluntary.	
I understand that my data will not be identifiable and the data may be used in publications, presentations and online.	
I confirm that I have read the information about GDPR	

NAME____

SIGNATURE_____________________________________

DATE____

Consent Form for students (Stage 2)

Please tick/click each box if you are happy to take part in this research.

	I confirm that I have read and understood the information given to me about the above-named research project and I understand that this will involve myself taking part as described above.	
	I understand that participation in this study is voluntary.	
	I understand that my data will not be identifiable and the data may be used in publications, presentations and online.	
	I confirm that I have read the information about GDPR	

NAME____

SIGNATURE______________________________________

DATE____

Glossary

Abbreviation	Term Name
FSC	Family Science Capital
ME	Mastery Experiences
VL	Vicarious Learning
VP	Verbal Persuasion
AS	Affective State
LE	Learning Experiences
PLE	Positive Learning Experiences
SE	Self-efficacy
SC	Self-concept
IST	Interest in Broad Science Topics
ES	Enjoyment of Science
SCI	Science Career Intentions
SI	Science Interest

References

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