Relationships Among Students' Perceptions of Science Class,

Science Identification, and Career Goals

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ABSTRACT

This dissertation examined the extent to which pre-high school students' motivation-related perceptions of their science class affected their science identification, which sequentially affected their future science-related career goals. The MUSIC® Model of Motivation (Jones, 2009, 2018) includes five components (i.e., eMpowerment, Usefulness, Success, Interest, and Caring) and is designed to help teachers design instruction to promote students' motivation. Domain identification (Osborne & Jones, 2011) is a concept closely related to students' motivation and academic outcomes. In this study, data was collected from 311 pre-high school students and Structural Equation Modeling (SEM) analysis was conducted to test the structure pattern among the MUSIC model components, science identification, and science-related career goals. Results indicate that with three of the MUSIC model components (i.e., usefulness, success, and interest) significantly related to students' science identification, students' science identification was highly correlated to their science career goals.

Moreover, this study demonstrated the structure patterns among the MUSIC model components and science identification varied by gender by conducting multi-group SEM analyses for a separate female sample (N = 161) and male sample (N = 150). Consistently, students' science identification was a strong predictor of their science career goals in both female and male groups.

These findings are important for STEM educators because they indicate that it may be

possible for teachers to impact students' science identification and career goals by focusing on students' perceptions of the MUSIC model components in science class. Moreover, these results contribute to the study of the large gender gap in STEM careers. Teachers can focus on specific teaching strategies and help female students develop their science identification in ways that lead to their long-term science-related career goals.

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GENERAL AUDIENCE ABSTRACT

This dissertation examined the extent to which pre-high school students' motivation-related perceptions of their science class affected their science identification, which sequentially affected their future science-related career goals. Science identification is a concept that describes the extent to which a student values science as an important part of his or her self (Osborne & Jones, 2011). One goal of this study examined how students' perceptions of their science class affected students' science identification. Specifically, this study focused on students' perceptions of the five components of the MUSIC® Model of Motivation (Jones, 2009, 2018): eMpowerment, Usefulness, Success, Interest, and Caring. The MUSIC model was developed to help teachers design instruction to promote students' motivation. In this study, results indicate that with three of the MUSIC model components (i.e., usefulness, success, and interest) significantly related to students' science identification, students' science identification was highly correlated to their science career goals. Moreover, this study reveals that the structure patterns among the MUSIC model components and science identification varied by gender. Consistently, students' science identification was a strong predictor of their science career goals in both female and male groups.

These findings are important for STEM educators because they indicate that it may be possible for teachers to impact students' science identification and career goals by focusing on students' perceptions of the MUSIC model components in science class. Moreover, these results

contribute to the study of the large gender gap in STEM careers, in which females are underrepresented. Teachers can focus on specific teaching strategies and help female students develop their science identification in ways that lead to their long-term science-related career goals.

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Chapter 1: Introduction

Overview

There is a growing awareness of the importance of a Science, Technology, Engineering and Mathematics (STEM) workforce in the rapidly developing technology society. As the world becomes more technologically developed, people with STEM degrees will be a driving force for increasing economic competition and national security in the United States (Atkinson & Mayo, 2010; National Science and Technology Council [NSTC], 2013; President's Council of Advisors on Science and Technology [PCAST], 2012).

According to the report from U.S. Bureau of Labor Statistics (2017), there is high demand in STEM occupations. In 2013, there were 5.7 million job openings in STEM fields. Moreover, from 2012 to 2022, about 9 million jobs are expected to assign to people with STEM degrees (Vilorio, 2014). Therefore, a STEM degree may provide a good way for people to get a job in the years to come in addition to enhancing the competitiveness of the U. S. economy in the world market.

However, the lower student retention rate in college STEM education has become a threat to the effort of expanding the workforce pool in engineering. According to the result from longitudinal STEM attrition research carried by the U. S. Department of Education, only 42% of students who started with a STEM major in 2003-2004 completed their degrees within six years by 2009. The college STEM major switch out rate is as high as 58% (U.S. Department of Education, 2013; Watkins & Mazur, 2013). Duderstadt (2009) indicated that there was a noticeable decline in student graduates with STEM degrees over the past 30 years, for instance the number of engineering students who graduated with a bachelor's degree dropped from 85,000 per year in 1985 to 74,186 per year in 2006.

To reduce the drain of college STEM graduates, much effort has been made to increase the number of students earning STEM degrees in the United States. National Academies, federal agencies, and professional organizations have emphasized the need for developing technological literacy for the workforce in the 21st century. Importance of STEM education for the U.S. society has attracted nationwide attention and much research has been conducted and many theories have been proposed. Engineering students' persistence rates has been monitored and addressed by college administrators (Kahn & Nauta, 2001; Pascarella & Terenzini, 2005). Additionally, the growth of K-12 and college STEM engineering programs provides large numbers of K-12 students chances to have exposure to STEM education. The practice of engineering and its relationship with science inquiry has been emphasized in the Next Generation Science Standards [NGSS] (2013).

The nationwide efforts focus on enhancing STEM education has increased students' interest and retention in STEM programs in some ways. According to a recent report from Bidwell (2015), compared with social sciences and psychology majors, STEM majors become more popular and students are willing to get a STEM career after graduation. Prospectively, the increasing number of individuals with STEM degrees will strengthen the economy, power, and leadership of the U.S. in the more technologically driven world.

In general, more students earning STEM degrees seems to solve and fulfill the shortage of STEM workforce. However, there are other problems that arise in STEM fields. First, "International STEM workers" becomes a noticeable phenomenon. Students from foreign countries concentrate on STEM majors and majority of them earn STEM degrees. STEM companies in the U.S. rely more and more on students from overseas (Ung, 2015). On the other hand, there is a five percent decrease in the number of U.S. citizens and permanent residents earning STEM degrees in 2014 compare to 2008 (Neuhauser, 2016).

Second, there is a large gender gap in STEM graduates. Females earn fewer STEM degrees, especially in Bachelor's level. In 2014, females earned 19% of the engineering degrees at the Bachelor level, 24% at the master's level, and 23% at the doctoral level. Even though women are gaining more STEM degrees at the advanced level, men still dominate STEM field (Smith, Lewis, Hawthorne & Hodges, 2013; U. S. Department of Commerce, 2011).

The "international STEM workers" phenomenon and the larger gender gap in STEM fields demonstrate a need of further research in STEM education. Numerous articles and research focusing on college students' persistence and experience in STEM fields may not be able to fully explain how to increase U.S. citizens and permanent residents students' interest in STEM area. As more and more international students join in the United State's undergraduate education with overseas education background, conducting research at college level may not really represent the U.S. citizens or permanent residents students' interest or persistence in STEM area. Also, it is not meaningful or needed to distinguish college students according to their current or previous nationalities. The better way to capturing the U.S. citizens or permanent residents students' interest in STEM area is to focus more on studying K-12 student' STEM education. Compared with college education, there is smaller portion of international students in K-12 schools (Cavanagh, 2017; Zhao, Kuh & Carini, 2005). Moreover, engaging students in STEM content at K-12 education could foster motivation for students to pursue STEM degrees and careers after (National Research Council, 2009; Rockland et al., 2010).

Paying attention to K-12 STEM education could be an effective way to improve the gender differences in STEM fields. STEM majors and careers, such as engineering and computer science, are considered masculine and fully related with science and math abilities (Quinn & Spencer, 2001). Females are traditionally stereotyped as having less aptitude and lower performance in science or math than male (Quinn & Spencer, 2001; Sekaquaptewa & Thompson, 2003). Cheryan (2012) argued that different gender roles between male and female will explain why fewer women choose science or math related careers. Indeed, gender related stereotypes highly influence female's interest and performance in science or math related courses or careers, especially in STEM area (Davies, Spencer, Quinn, & Gerhardstein, 2002; Jacobs & Eccles, 1992; Quinn & Spencer, 2001; Sekaquaptewa & Thompson, 2003; Shih, Pittinsky, & Ambady, 1999; Spencer, Steele, & Quinn, 1999). Enhancing K-12 STEM education, engaging female students in learning science and math, is perhaps a good way to address the issue of gender stereotypes and encourage female students to pursue STEM majors and careers in the future (Adya & Kaiser, 2005; Farrington et al., 2012).

STEM in K-12 education. The importance of enhancing STEM education can be found in many research articles (Clough, 2004; Keller & Pearson, 2012; DeJanrnette, 2012; Stohlmann, Moore & Roehrig, 2012). The *National Science Education Standards* (National Research Council [NRC], 1996) included design and technology topics in elementary schools science standards and indicated how students' understanding of science related to their understanding of design and technology. *Science for All Americans* (American Association for the Advancement of Science [AAAS], 1989) and *Benchmarks for Science Literacy* (AAAS, 1993) emphasized the relationship between science literacy and engineering design. Engineering design in turn would enhance students' understanding of science by applying their science knowledge to solve real-world engineering problems.

The quality and diversity of STEM education programs in K-12 and college education have been discussed in many research reports (NAE, 2005; NRC, 1996; International Technology Education Association [ITEA], 2002). Building Engineering and Science Talent [BEST] (2004) explained the importance of highly qualified STEM teachers in developing STEM talent and provided approaches on how to build teacher's capacity through STEM education programs. STEM education programs should provide professional development and classroom science and math activities to in-service teachers to help them incorporate STEM in K-12 classrooms. The NAE annual report (2005) emphasized the relationship between science and engineering practice and indicated that STEM education programs should provide hands-on science and engineering activities to K-12 students to practice and understand the engineering design process. Douglas, Iversen, and Kalyandurg (2004) discussed that K-12 STEM education programs should emphasize the social relevance of science and engineering discipline to engage both students and teachers in learning and teaching STEM concepts, respectively.

Furthermore, the U.S. government has invested a substantial amount of money and effort to increase the number of STEM programs nationwide to promote STEM education. Gordon and Shea (2013) reported that the government has spent nearly $3 billion annually on STEM education. However, American students' performance in science and mathematics consistently ranked lower in international comparisons (President's Council of Advisors on Science and Technology, 2010). According to the U.S. Congress Joint Economic Committee (2012), American 15-year-olds rank 25th in math and 17th in science in the Program for International Student Assessment (PISA) among 34 Organization for Economic Co-operation and Development (OECD) countries. Low performance in science and math indicate that the K-12

STEM education needs to be further strengthened. How to motivate K-12 students in science and math, therefore, is an important and urgent problem.

Factors influence K-12 students' motivation in science. Lots of research has been conducted to explain how to motivate K-12 students in learning science. Practically, providing an inquiry-based science learning environment has been considered an effective way to motive students in science learning (Geier et al., 2005; Hofstein & Lunetta, 2004). From a science perspective, inquiry-based learning engages students in the investigative nature of science (Haury, 1993). According to constructivist learning models, students construct their knowledge through their own learning experiences (Osborne & Freyberg, 1985). In inquiry-based classrooms, students are encouraged to develop and restructure their own knowledge schemes through posing their own questions, designing investigations, analyzing, and presenting their findings. With the help and intervention from teachers, students construct their own understanding by taking an active role in their learning (Drive, 1994).

According to the theory of inquiry-based science learning, Songer, Lee and Kam (2002) emphasized the relationship between classroom science and the real world. Solving real world problems by applying science knowledge will encourage students to learn science. Furthermore, students' GPA, classroom engagement, school and family environment all have effects on students' motivation in learning science (Fraser & Khale, 2007; Songer & Linn, 1991).

In addition to inquiry-based learning theory, several motivation theories have been applied to students in science classroom learning: Self-efficacy theory (Bandura, 1977; Linnenbrink & Pintrich, 2003), expectancy-value theory (Wigfield & Eccles, 2000), social cognitive career theory (Lent, Brown, & Hackett, 1994, 2000), and domain identification theory (Osborne & Jones, 2011).

Linnenbrink and Pintrich (2003) argued that self-efficacy is a significant predictor of students’ engagement and learning science. Zimmerman (2000) demonstrated student’s self-efficacy positively related to students’ learning process and academic success. Bleicher and Lindgren (2005) found that self-efficacy has effects not only on students’ science learning but also on teachers’ classroom teaching. Teachers with high self-efficacy in science tend to be highly engaged in teaching. In addition, they tend to provide a more positive and conductive learning environment. All these behaviors of teachers with high self-efficacy in science promote students’ science learning. Self-efficacy theory from Bandura (1977) is considered as a key point in the research of students’ motivation in learning.

Wigfield and Eccles (2000) provided the expectancy-value model explained the relationship between expectancies-values and achievement choices. Students’ expectancies and values in learning science/math strongly related to their success and achievement in learning. Hulleman and Harackiewicz (2009) indicated that expectancy-related beliefs would promote students’ interest in learning and positively related to students’ performance in high school science classes.

Social cognitive career theory (SCCT; Lent, Brown & Hackett, 1994, 2000) emphasized a career development process beginning from the young age and continuing throughout adulthood. Building a career goal helps students to stay motivated in learning and persist in their choices. Fouad and Smith (1996) explained that middle school students’ future career plans were reflective of students’ science/math self-efficacy beliefs and outcome expectations.

Osborne and Jones (2011) defined domain identification as “the extent to which an individual defines the self through a role or performance in a particular domain” (p. 132). In other words, the individual relates his or her characteristics to a particular domain, and believes this particular domain is a valuable part of his or her self. Osborne and Jones (2011) explained that the concept of domain identification can be linked with academic subjects and it's closely related to students' motivation and academic outcomes. Students with high domain identification in science are more likely to have the long-term individual interest and high motivation in learning science (Jones, Ruff & Osborne, 2015). Domain identification has been applied to investigation of how engineering students' engineering identification relates to their motivational belief, course effort, academic outcomes, engineering major, and career goals (Jones, Osborne, Paretti, & Matusovich, 2014; Jones, Tendhar, & Paretti, 2015; Tendhar, 2015; Tendhar, Sing, & Jones, 2018). In a longitudinal study where Hierarchical Linear Modeling (HLM) was used, domain identification was found to be a significant predictor of engineering career intentions controlling for engineering program expectancy (conceptually similar to self-efficacy), while engineering program expectancy was found to be statistically insignificant in predicting engineering career intentions controlling for domain identification (Tendhar, Paretti, & Jones, 2017).

Study Rationale

Domain identification is an important factor that influences students' long-term interest and motivation in a domain. However, very limited research has been conducted on students' science identification in the pre-high school context. For secondary school students, especially middle school students with a high level of uncertainty, motivating in STEM concepts would influence their identification and future progress in STEM fields (Tan, Calabrese, Kang & O'Neill, 2013). Finding the relationship between K-12 school students' motivation and identification in science and their future career goal is certainly necessary. Jones, Tendhar, and Paretti (2015) and Tendhar, Singh and Jones (2018) explored the relationship between college students' engineering identification and career goals. Their research explained that engineering students' engineering identification closely related to their motivational beliefs, course efforts, outcomes, and career goals.

This present study extends the research and application of domain identification by focusing on pre-high school students' science identification. This study investigates the relationship among middle school students' perceptions of their science class, science identification, and career goals. The gender gap in STEM education is also discussed in this research. Quinn and Spencer (2001) explained that STEM majors and careers are closely related to science and math and traditionally dominated by men. Adya and Kaise (2005) demonstrated that engaging K-12 female students in learning science and math and encourage them to pursue STEM careers will decrease gender stereotypes. In this study, I will compare male and female students' motivational beliefs, science identification and career goals. The findings of this study should help people get new perspectives of whether there is gender difference in science identification and career goals at pre-high school level.

Research Questions

The following research question was formed for this study, as depicted in Figure 1.1.

RQ1: To what extent do pre-high school students' motivation-related perceptions of the science classroom affect their science identification, which sequentially affects their science-related career goals?

RQ2: Does the relationship among students' motivation-related science classroom perceptions, science identification, and their science-related career goals vary by gender?

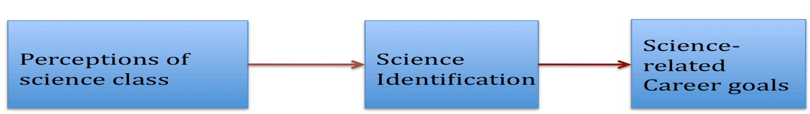

Figure 1.1 Depiction of the research questions

Outline of the Dissertation

There are five chapters in this dissertation. In the first chapter, I have introduced the research background, the rationale for the study, and presented the research questions. The second chapter includes the literature review related to the research questions and explains all of the variables in this study. In Chapter 3, I present the methodology of the study, which includes the research sample and instruments, the data collection, and the data analysis procedures. I provide the results of my data analysis in Chapter 4 and draw conclusions in Chapter 5 with a discussion of the limitations and directions for future research.

Chapter 2: Literature Review

The purpose of this literature review is to provide a background and theoretical framework for this study. The literature review has three sections corresponding to the three major components of my research questions: Domain identification, MUSIC® Model of Motivation, and career goals in science.

Domain Identification

The theory of domain identification is rooted in William James' (1842-1910) clarification of multiple selves. James (1890) discussed that an individual' self is actually comprised of "self as known" and "self as knower." "Self as known" is phenomenal, and it includes three aspects of self: The material self (all the materials over which we feel a sense of ownership like body, clothes, family, possessions, etc.), the social self (our social relations), and the spiritual self (the feeling of our own subjectivity). James (1890) addressed "Self as knower" to the feeling of self-identity, he reviewed theories of personal identity and concluded the implications of multiple selves.

From William James's view of multiple selves, two different perceptions of the concept of identification have developed: Identification with school and domain identification. Finn (1989) and Voelkl (1996, 1997) discussed identification through the perspective of identification with the institution of school and included belonging and value in their model to describe students' engagement in the school. Steele (1992, 1997) and Osborne (1995, 1997) explored identification through another angle of stereotype threat and linked identification to academic domain which leads to academic achievement and performance. Subsequently, Osborn and Jones (2011) provided a domain identification model and clarified the relationship among academic domain identification, perceptions of motivation and academic outcomes.

Identification with school. Finn (1989) explained that students' success links to the development of a sense of identification with school. Students who identify with the school have a feeling of belongingness and positively participated in and value school-related tasks or projects. Students' commitment to the school leads to their academic success in the school. Finn (1989) discussed the identification with school has two components, "belonging" and "valuing" (p. 127). These two components are related to concepts such as attachment, commitment, bonding, emotional engagement, and involvement (Finn, 1989; Finn & Voelkl, 1993).

Identification can be developed through participation of academic activities in school and "active participation is the minimal essential condition for formal learning to occur" (Finn, 1989, p. 127). Students' withdraw from school was related to low identification with school and lack of participation in school-related activities and projects (Finn, 1989).

Derived from Finn's explanation of identification with school, Voelkl (1997) grouped school participation and achievement as school experience and directly related it to identification with school which has comprised of belonging and valuing. Voelkl (1997) explained that students' identification with school has positive correlation with school experience. Higher identification with school relates to positive school experience, lower identification with school associates with negative school experience. Voelkl (1997) developed the *Identification with School Questionnaire* and found that race and gender highly affected students' identification with school. Analyzing data from a large sample of 1335 African American and White eighth-grade students, Voelkl (1997) found that academic achievement and classroom participation could predict students' identification with school.

Finn and Frone (2004) conducted a research to measure the relationship among identification with school, academic performance, academic self-efficacy and cheating. Their research results showed that lower academic performance, lower identification with school, and lower self-efficacy all related to cheating. Students' with lower identification with school usually had weaker bonding or attachment to school, they didn't pay enough efforts to make academic progress, which leads to cheating. Finn and Frone (2004) pointed out that developing students' identification with school shall prevent cheating and could help students to build up academic self-efficacy of learning.

In Finn and Voelkl's definition of identification with school, school is considered as the institution of school. Students' experience in the school influenced students' belonging and valuing, which in return predicted students' identification with school. From a different angle, Steele (1997) provided another definition of identification that explains the relationship between an individual and the "domains of schooling" (p.616).

Academic domain identification. Steele's (1992) definition of domain emerged from Walter Lipmann's theory of stereotype. Lipmann (1922) defined stereotype as "a distorted picture or image in a person's mind, not based on personal experience, but derived culturally" (p. 115). Lippmann discussed that stereotypes always formed or organized by social, political, or economic motivations and passed from one generation to the next. Steele (1997) illustrated that stereotype threat influences an individual's performance if he or she belongs to a stereotyped group. For example, there is a stereotype that short boys are not good at basketball. When a short boy plays basketball with a group of tall boys, he will be anxious that he will be the worst on the team. In this case, he is experiencing stereotype threat, which will increase his anxiety. His increase anxiety will decrease his confidence while playing basketball and eventually negatively influence his performance, which confirm the stereotype.

Stereotype threat has been found in academic performances as well. Steele and Aronson (1995) found that stereotype influenced African-American students' academic performance. Among many follow up researches, Spencer, Steele, and Quinn (1999) and Keller (2007) focused their studies on the stereotype of females' math performance. Croizet and Claire (1998) and Harrison, Stevens, Monty, and Coakley (2006) explored the impact of stereotype on academic performance of students from low-income families. Schmader (2002) discussed gender stereotype, in detail the author found that females who believe in gender differences get lower score in a math test. The gender stereotype that females are not good at math influences their effort and confidence of learning math and taking math tests.

Stereotype threat negatively influences an individual's performance because of the anxiety of confirming the stereotype. The individual's identity of certain stereotype groups helps to produce the anxiety and cause a negative influence on performance. For instance, if the basketball player identified himself as a short boy, such identification would led him to group himself with poor performing basketball players. This will make him feel anxiety and lead to negative influence on his performance.

Steele (1992, 1997) connected academic identification to the theory of stereotype threat and concluded that identification is a central element of stereotype threat theory. In schooling context, as students develop an identification with an academic domain (i.e., math, science, music or sports), their achievement in this academic domain will largely affect their self-esteem or self-regard. For example, an Asian girl may identify herself as a good math learner because there is a stereotype that Asians are good at math. Her self-esteem and confidence in math will help the girl to gain better achievement in math class, which in return, boost her self-esteem and confidence in math. This Asian girl's example demonstrates that her motivation in learning science can be positively influenced by her academic identification.

Model of domain identification. Osborne and Jones (2011) built upon the definition of identification with academic to provide a definition of domain identification as "the extent to which an individual defines the self through a role or performance in a particular domain" (p.132). That is, when an individual is identified with a domain, the individual links his or her self to the particular domain and values that domain as an important part of his or her self. Osborne and Jones (2011) emphasized that an individual can link his or her self with multiple domains and value these domains differently. Therefore, compared to domains with less value, the domains with greater value will have higher impact on an individual's self-esteem and motivation. The commitment of oneself to several domains at the same time will benefit the individual because it helps to build a healthy and stable self-esteem. If it becomes too difficult to achieve desirable outcome in one's most value domain, he or she will have the opportunity to switch to other domains instead of suffering from the decrease of self-esteem due to setbacks in a particular domain.

Because academic identification has a high impact on one's academic motivation, it is positively related to academic and behavioral outcomes. Osborne and Rausch (2001) showed that students' academic identification is positively correlated to their learning goals and performance goals, self-regulation, and both deep and shallow cognitive process. Osborne and Walker (2006) further examined the relationship between academic identification and high GPAs of high school students. Jones, Osborne, Paretti and Matusovich (2014) demonstrated the significant relationship between engineering students' domain identification and motivational beliefs, course effort, and academic outcomes. Jones, Tendhar and Paretti (2015) examined the positive relationship among students' motivation-related perceptions, engineering identification, and engineering major and career goals.

Lower academic identification leads to negative outcomes. Osborne (1997) explained how lower academic identification linked to lower GPAs. Elliot and Voss (1974) and Osborne (1997) examined and found that lower academic identification of students resulted in more school withdraw.

Osborne and Jones (2011) developed a model of domain identification to explain how the factors of social and academic background impact domain identification and how domain identification related to motivation constructions, which further influence behavioral and academic outcomes (Figure. 2.1).

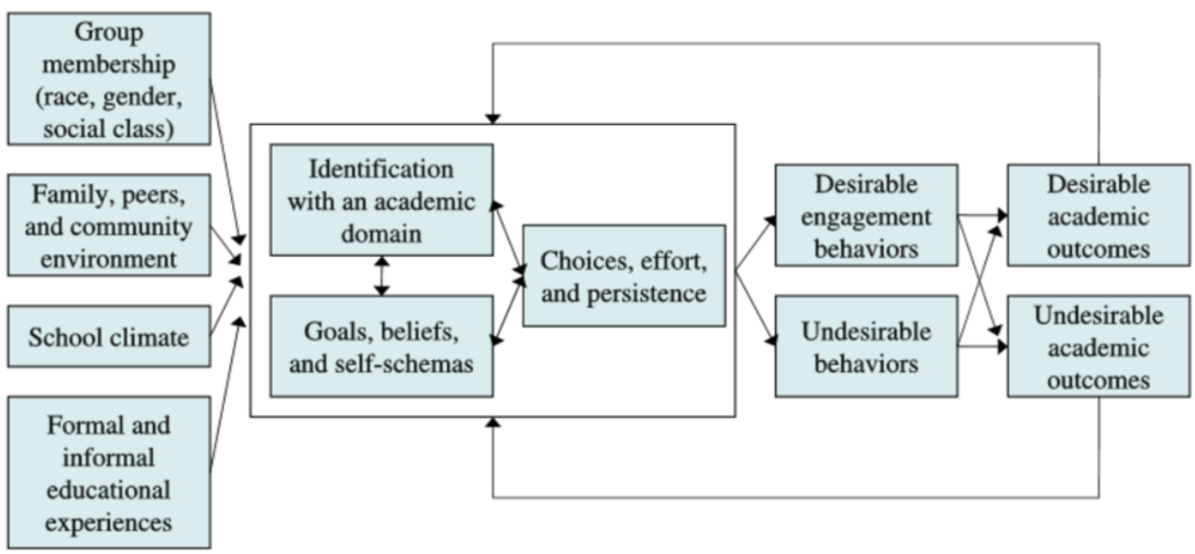

Figure. 2.1 Precursors and consequences of identification with an academic domain

Note. From "Identification with Academic and Motivation to Achieve in School: How the Structure of the Self Influences Academic Outcomes" by J. W. Osborne and B. D. Jones, 2011,Educational Psychology Review 23 (1) p. 138. Copyright 2018 by Springer Natural. Reprinted with permission.

The precursors in this model include group membership (e.g., gender, race, ethnicity, class); family, peer, and community environment; school climate; and, both formal and informal educational experiences. The domain identification model links these precursors to academic outcomes. This model shows the inter-related factors of domain identification: Identification with an academic domain, goals, beliefs, self-schemas, choices, effort and persistence. These factors influence engagement behaviors and academic outcomes.

Domain identification is closely related to student' academic motivation. In the following section, I shall discuss the MUSIC® Model of Motivation.

MUSIC® Model of Motivation

The MUSIC® Model of Motivation (Jones, 2009, 2018) was developed to help instructors to apply motivation theory and research to their classroom teaching in practice. The MUSIC model has five motivation components: (a) eMpowerment, (b) Usefulness, (c) Success, (d) Interest, and (e) Caring. These five components help instructors to design their instructions within an organized framework of motivation principles. In order to represent the core idea of motivation principles, these components are distilled based upon the analysis, evaluation and synthesis of a variety of motivation research and theories (Jones, 2009). Researchers have documented relationships among the MUSIC Model components and students' domain identification and career goals. Therefore, I will briefly review the five MUSIC components in this section.

eMpowerment. The empowerment component of the MUSIC models refers to the amount of control on learning that students have in their classroom. The research of empowerment relates back to the study of self-determination theory (Deci & Ryan, 1985; Rayn & Deci, 2000). Self-determination theory demonstrates that students are more engaged in the classroom activities if they feel the control over these activities. Instructors can therefore motivate students by providing learning choices and allowing students to make their own decisions about learning. With more choices and management in their learning environment, students will be more engaged in the learning. Vice versa, few or no choice and management will lead to less or no engagement in the learning. Empowerment in the MUSIC model emphasizes that letting students make their own choices and decisions in learning is a good way to motivate them in classroom learning. Empowerment also plays well if the instructor has active interaction with students. The active interaction will help instructors to monitor the learning process of students and adjust their teaching pace or method accordingly. Through this way, students feel their empowerment in the learning environment from their teachers' adjustment, which enhance their motivation in learning.

Usefulness. The usefulness component of MUSIC model refers to how students believe what they are learning (e.g., readings, writings, classroom activities) is relevant to their short- or long-term goals. The research of usefulness related to the study from theorists of future time perspective who examined the instrumentality construct (De Volder & Lens, 1982; Kauffaman & Husman, 2004; Tabachnick, Miller & Relyea, 2008). In addition, the studies of expectancy-value model of motivation also tied to the research of usefulness (Eccles, 1983; Eccles & Wigfield, 1995; Wigfield & Eccles, 2000). To promote usefulness, instructors ought to help student to build the connection between their classroom learning and their learning goals (Jones, 2009, 2018). Students who feel what they are learning is closely related to their goals will more likely be engaged in learning. Otherwise, the students can hardly be motivated in learning if they feel that the classroom activities have little or no alignment with their future goals. For example, a student may be less motivated in the calculus class if he feels he will never use this knowledge in his future career as a musician.

Success. The Success component of MUSIC model refers to the extent to which students believe they can attain success if they put forth the necessary effort in learning (Jones, 2009, 2018). The study of success relates to a variety of theories including self-concept theory (Marsh, 1990; Marsh & Yeung, 1997; Schavelson & Bolus, 1982), self-efficacy theory (Bandura, 1986), self-worth theory (Covington, 1992), goal orientation theory (Ames, 1992) and expectancy-value theory (Wigfield & Eccles, 2000). An individual's self-perception of potential capability is the central element of these motivation theories. When students feel they will be able to succeed in a task or field, they will grow confidence that they can have long-term success through the study and are willing to invest more time and effort to make progress in learning. To foster students' perception of success in learning, Jones (2009) illustrated several ways that instructor can use in their classroom: Clearly explain the course expectations to students, set up appropriate level challenge, and regularly provide feedback to students.

Interest. There are two types of interest: Situational interest and individual interest. Situational interest can be defined as "focused attention and the affective reaction that is triggered in the moment by environment stimuli, which may or may not last over time" (Hidi & Renninger, 2006, p.103). This definition featured with two characters of situational interest: Trigged by a moment and may or may not last for a longer time. Therefore, situational interest is a short-term interest because they related to specific environment and context (Jones, 2009). Differently, individual interest refers to a long-term interest that an individual has, which characterized with enduring internal motivation on a specific topic (Schraw & Lehman, 2001; Hidi & Renninger, 2006). Individual interest can be related to a specific academic domain which further links to academic domain identification. The differences and comparison between individual interest and academic domain identification are discussed in Jones, Ruff and Osborne (2015). Instructors can trigger students' interest in learning by linking it to their prior knowledge, social interaction, games, humor, and/or emotional content (Jones, 2009). If the students transferred the trigged situational interest to an internal motivation and continuously putting efforts in learning the subject, that will help in turning the temporal situational interest to long-lasting individual interest (Jones, 2009).

Caring. Caring includes academic caring and personal caring. Academic caring refers to the extent of the instructor and other students' care that an individual can feel in regard of his or her academic success. Personal caring refers to the extent of care about his or her wellbeing that an individual can feel from the instructor and other students (Jones, 2009). The study of caring is related to the research of belongingness, relatedness, connectedness, affiliation, involvement, Commitment, bonding, and sense of community (Baumeister & Leary, 1995; Nodding, 1992; Ryan & Deci, 2000). Instructors can show their caring to students by making reasonable accommodations to students' academic or living status (Jones, 2009).

Relationships among MUSIC components and domain identification. The MUSIC model provides a framework that help instructors apply motivation principles into classroom teaching. In addition, the MUSIC Model components are strong related to students' domain identification, which predict students' major and career goals. The MUSIC model components statistically related to college engineering students' engineering identification (Jones, Osborne, Paretti, & Matusovich, 2014; Jones, Tendhar & Paretti, 2015). Consistently, Jones, Sahbaz, Schram and Chittum (2017) confirmed that all the five components of the MUSIC model (eMpowerment, Usefulness, Success, Interest, and Caring) were positively related to pre-high school students' science identification for both the U.S. and Icelandic samples.

Persistence

Career goals is the third component I investigate because ultimately, it is important to understand how students' MUSIC perceptions of science relate to their science identification and career goals. Middle school student's future career goals represent their perception of persistence in learning science, especially the persistence in a science-related college degree. Numerous studies have been conduct related to students' degree or persistence. I provide a literature review of these persistence studies in this section.

Definition and models of persistence. Fishbein and Ajzen (1975) indicated that people's persistence was strongly related to previous behavior and attitudes. Quigley (1998) explained that persistence in education could be defined as the length of time a people continuously attending classes. In Rovai (2003), persistence was defined in terms of "the behavior of continuing action despite the presence of obstacles" (p. 1). Martin and Barresi (2003) explained persistence as "how much students keep trying to work out an answer or to understand a problem even when that problem is difficult of is challenging" (p. 3). Based on theoretical models of college persistence, Hagedorn (2005) distinguished the words "persistence" and "retention". In most research articles, these two words were often interchangeably used. The National Center for Education Statistics differentiated the two words by taking different measurement. "Persistence" is referred as a student measure, and "retention" is referred as an institutional measure. In other words, "Institutions retain and students persist" (Hagedorn, 2005, p. 7).

In the research of persistence, very few research has been conducted to explain pre-high schools students' persistence. Gallagher (1994) demonstrated that parent education, gender, student perceptions of classroom practices and teachers' instructional method were key predictor of middle school students' science persistence. Lavigne, Vallerand and Miquelon (2007) tested a motivational model of science persistence. In their motivational model, teachers' autonomy support affects students' perceptions of competence and autonomy which lead to students' science motivation. Students' science motivation will affect students' science persistence. Lavigne, Vallerand and Miquelon's model (2007) linked students' science motivation to persistence without explaining the reason how did motivation change to long-term persistence. Compared with this motivational model, Osborne and Jones's domain identification model (2011) added domain identification as the bridge between students' motivation and academic persistence. They well explained the relationship among domain identification and motivation constructions, which further influence students' behavioral and academic outcomes (2011).

In my search for the literature review of this study, Gallagher (1994) and Lavigne, Vallerand and Miquelon (2007) are the only two research articles focusing on middle school students' persistence. Almost all the other persistence models are applied to higher education because persistence closely related to a student's stay within a program and degree completion (Hagedorn, 2005). To better understand variables that influence persistence, in this section, I will explain three foundational persistence models: Astin's Input-Environment-Outcomes Model (1985, 1993), Tinto's student departure model (1975, 1988) and Bean and Metzener's student persistence model (1985). Although these models are applied to higher education, variables in these persistence models can be found in the domain identification model (Osborne & Jones, 2011) which will be used in this study.

Astin's Input-Environment-Outcome model. Astin (1993) explained his model as "to assess the impact of various environmental experiences by determining whether students grow or change differently under varying environmental conditions" (p. 7). In his model, there were three main components: input, environment, and outcome. Input was referred to as the student precollege characteristics that influence their success in college. There were 146 input variables explained in Astin (1993) including age, gender, race, ethnicity, marital status, religious preference, income, parental level of education, high school grades, admission test scores, and reasons for attending college.

The environment component explained the environmental variables that might influence students' success in their college study. In Astin (1993), the environment component had eight classifications, 192 environment variables, which include institutional characteristics, students' peer group characteristics, faculty characteristics, curriculum, financial aid, major field of choice, place of residence, and student involvement.

The third component in this model was outcomes. Outcomes referred to the college final results with influence from environment and students' precollege characteristics and experience. There were 82 outcome variables discussed in Astin (1993) including academic cognition, career development, academic achievement and retention.

Astin's Input-Environment-Outcome Model provided very detailed variables that might influence students' persistence in college study. However, the interrelationship between these variables was not well explained. In listing a large number of variables and without exploring the relationships between them, Astin's model was not practically used in students' persistence measurement.

Tinto's student departure model. Consistent with the variables from Astin's model, Tinto explained there were two major factors that influence students persistence in college learning: (a) students' individual characteristics and their life and study experience before entering college and (b) student' experience during their college learning. Compared with

Astin's model, Tinto explained the interrelationship between the variables that influence student persistence. Tinto emphasized that the first factor, students' characteristics and precollege experiences, was not affected by college. Students got into college with their individual characteristics and precollege experience. The second factor, students' college experience, was largely affected by their college life. Students' college experience includes their formal and informal social life in college as well as their experience with curriculum and academic assessment. Tinto's model paid more attention on students' college experience. Tinto explained that "the more central one's membership is to the mainstream of institutional life the more likely, other things being equal, is one to persist" (Tinto, 1987, p.123).

Tinto's model explored the active role of school that influenced student persistence. From Tinto's model, schools were encouraged to take more responsibility in respect to student persistence. Students' persistence directly related to their social and academic life in college. Constructing appropriate curriculum, building reasonable assessment system, and providing adequate social life would help students persist in learning. Tinto's model provided a good example for the research on the persistence model and how to balance the relationship between persistence factors.

Bean and Metzener's student persistence model. Because Tinto's model was so focused on students' school experience, it was not as applicable for the research of non-traditional students. Based upon Tinto's model, Bean and Metzener (1985) proposed a persistence model that is more applicable for non-traditional students. The non-traditional students was defined as "older than 24, does not live in a campus residence (i.e., is a commuter), or is part-time student, or some combination of these three factors; is not greatly influenced by the social environment of the institution, and is chiefly concerned with the institution's academic offering (especially course, certification and degrees)" (p.489). Bean and Metzener (1985) emphasized that their model was not targeting students who have been influenced a lot by college practice, and they were trying to balance the influence between student college life and individual social life.

In Bean and Metzener's model, there were five factors influencing student persistence: Academic variables (study habits, advising, course availability and program fit); Background & defining variables (age, residence status, educational goals, ethnicity and prior GPA); Environmental variables (finances, hours of employment, family responsibilities, outside encouragement, and opportunity to transfer); Academic outcome (current GPA); and Psychological outcomes (utility, stress, goal commitment and institutional commitment).

Bean and Metzern's model was highly recognized by non-traditional student persistence researchers. For non-traditional students, the social environment should be considered as an important factor influencing students' persistence. Bean and Metzern's model emphasized the social environment factor as well as the school environment factor. The effects of students' college life and social life on their persistence in college were successfully incorporated in Bean and Metzern's model (Cabrera, Castaneda, Nora & Hengstler, 1992).

Factors influencing college students' persistence. According to the persistence models discussed above and my literature review on student persistence, I have identified five main factors relating to college students' persistence and I will explain these in this section.

The first factor is pre-college individual experience. Pre-college individual experience refers to student's social background before entering college. Student's social background includes gender, race and financial need, which are related to college students' persistence. For example, engineering students from underrepresented minority groups might lack a feeling of belonging in an engineering major, and lack motivation to persist in learning (Tate & Linn, 2005;

Walton & Cohen, 2007). Financial need relates to student family income and their parent educational level. Finance-related factors have a big influence on students' persistence in learning (Saint John, Cabrera, Nora & Asker, 2000). Compared with students who have financial problems, students without financial difficulties are more confident in their college learning and more likely persisted in their major.

The second factor is K-12 academic experience. K-12 academic experience includes students' high school GPA and experience with science education. Students with a higher GPA were more willing to choose science related majors and had higher opportunity to be accepted by the science related department (Zhang, Anderson, Ohland & Thorndyke, 2004). Salzman, Ricco, and Ohland (2013) found that 89% of first-year engineering students had engineering experience prior to college. Students' K-12 learning experience have strong influence on students' persistence in college learning (NRC, 2011).

The third factor is college academic performance. In the first two college years, students can face some basic, but difficult courses. Academic results from these courses can play an important role in student persistence (Burtner, 2005; French, Immekus & Oakes, 2005). Students with higher GPA in the first two years were more willing to persist in their majors (Reichert & Absher, 1997; Seymour & Hewitt, 1997). Seymour and Hewitt (1997) indicated that better college academic performance would enhance students' self-efficacy in learning, which is a predictor of future major persistence. Therefore, it is possible that students' perceptions of success in the MUSIC model could predict future persistence in students' college major.

The fourth factor is academic and social integration. Academic interaction and both formal and in-formal social life on campus help students persist in learning (Tinto, 1987). Academic interactions could affect students' perceptions of the caring component of the MUSIC

Model and may also help improve their perceptions of success. For example, students who had active learning interactions with faculty members and classmates were more engaged in learning and had better grades (Marra, Rodgers, Shen & Bogue, 2012). In particular, having the opportunity to talk or work with a faculty member helped a student build self-efficacy in learning and develop a sense of belonging in the major. Cole and Espinoza (2008) indicated that students who had an academic relationship with their professor had higher satisfaction in their college study and had a higher graduation rate. Moreover, compared with non-minority students, minority students had less interaction with faculty members, which also influenced their persistence in college programs (May & Chubin, 2003). Similarly, social life on campus helped students adapt to college life. Positive social interactions with friends and classmates would create a friendly peer environment that encourages a student to persist in learning.

The fifth factor is perceptions of the college degree. Students' perceptions of the college degree are similarly related to the useful components of the MUSIC® Model. According to Shavers, Jackson and Sheppard (2010), students who were worried about their future achievement and not sure they could get a good job when they graduated with the college degree, may show less persistence in their major. Not surprisingly, students who were confident that they would get a satisfying job in the future would be more likely to remain in the college majors (Seymour & Hewitt, 1997). In other words, students who feel their major will be useful for finding a satisfying job will have high persistence in their major and vice versa.

In general, college student persistence is closely related to their pre-college individual experience, K-12 academic experience, college academic performance, college academic and social integration and perceptions of the college degree. Although these five factors are summarized from higher education persistence models, they can be used as the source of reference when we explore pre-high school students' academic persistence and career goals.

The aforementioned variables (i.e., Perceptions of the degree, Academic performance, and academic and social integration) are closely related to three components of MUSIC Model: Usefulness, Success, and Caring. Students who believe that what they are learning is useful and that they would get a satisfying job after graduation are more engaged and persist in learning. Students who believe they can attain success and achieve good academic performance have enhanced self-efficacy which leads to motivation and persistence in learning. Students who have positive academic and social integration with teachers and peers help improve their perceptions of success. Figure 2.2 shows three persistence factors are embedded in the MUSIC® Motivation Model.

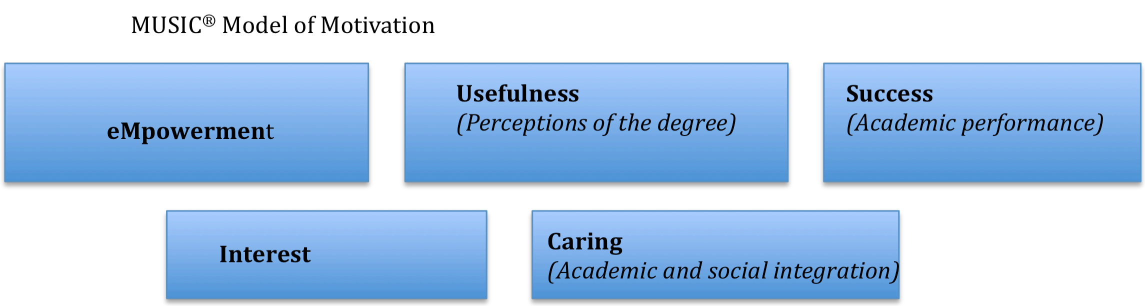

Figure 2.2 MUSIC® Model components and three factors of persistence (adapted from Jones, 2009, 2017). MUSIC® Model components are in bold. Persistence factors are in parenthesis and in italic type.

Two other factors of persistence are included in the domain identification model (Jones & Osborne, 2011). Figure 2.3 shows that Pre-college individual experience factor is included in the two variables of the domain identification model: (1) group membership and (2) family, peers, and community environment. The school climate variable can represent a students' academic and social integration in school. The formal and informal educational experience includes students' previous K-12 academic experience.

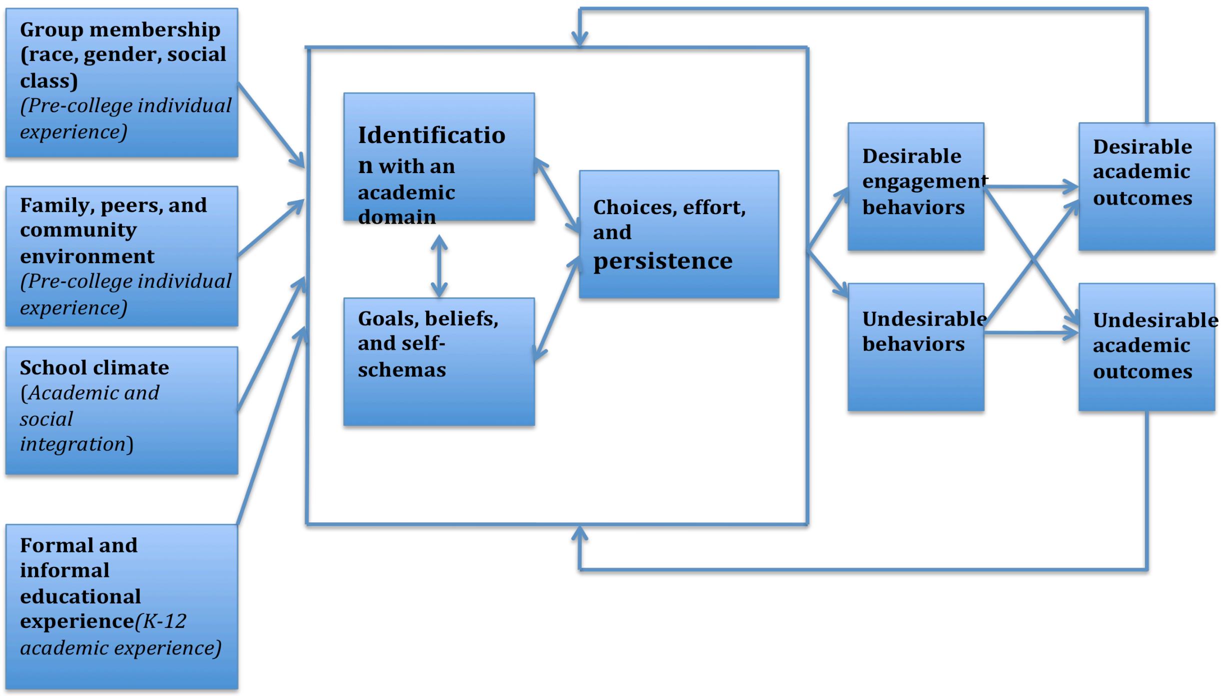

Figure. 2.3 Three persistence factors embedded in the Domain Identification model (adapted from Osborne & Jones, 2011). Domain identification model variables are in bold. Persistence factors are in parenthesis and in italic type.

Research variables in this study

In this present study, I will use the MUSIC® Model of Motivation (Jones, 2009, 2018) and the theory of domain identification (Osborne & Jones, 2011) to test the relationship among components of the MUSIC® Model, students' science identification and their future career goals. Figure 2.4 shows the relationships among the variables in this present study.

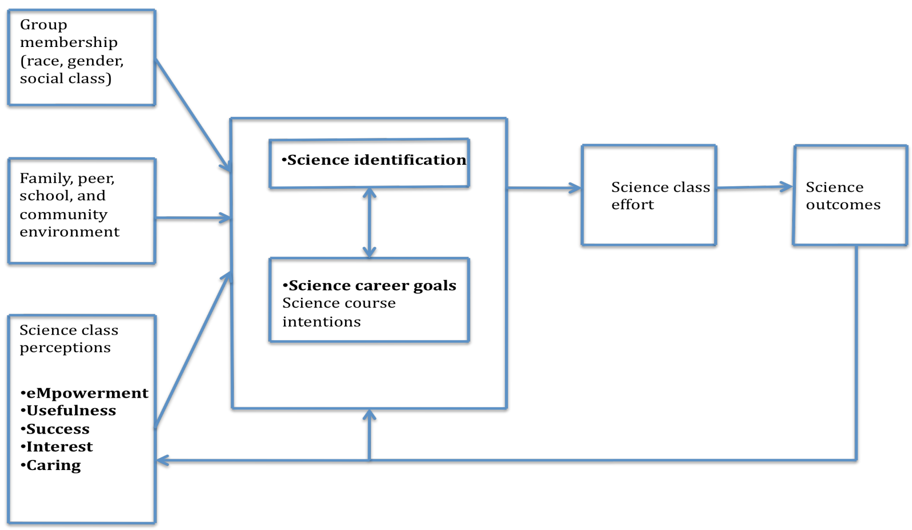

Figure 2.4 Relationships among the research variables. Variables measured in this study are bulleted and bolded.

A simplified model that includes only the variables I will examine in this study is presented in Figure 2.5. This structural model is important to test because if the data fits the model, it will provide evidence that students' science class perceptions are related to their science career goals.

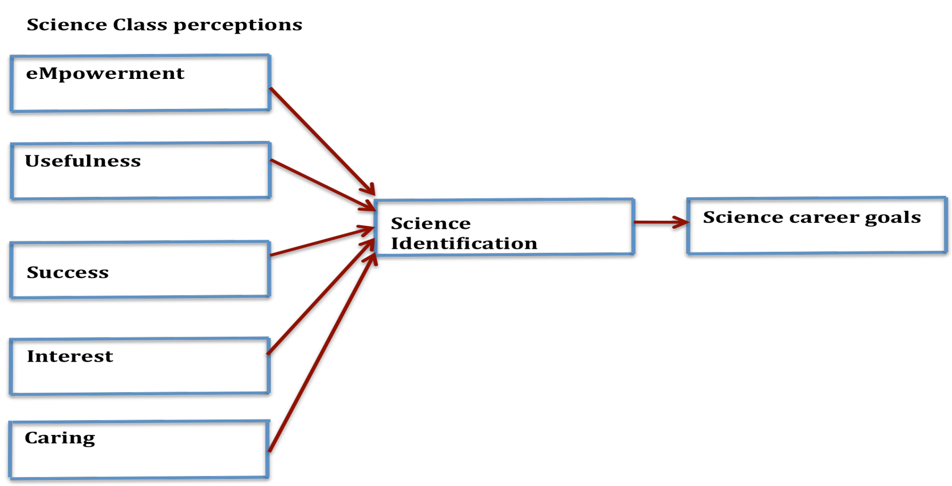

Figure 2.5 The structural model

Chapter 3: Methodology

There are two major purposes in this present study. The first purpose is to examine the structural patterns of students' MUSIC perceptions, science identification, and future career goals. I presented the structure model to be tested in this study in Figure 2.5, including seven latent variables: five exogenous variables and two endogenous variables. Five exogenous variables are the five components of the MUSIC model: eMpowerment, Usefulness, Success, Interest, and Caring. These five components were hypothesized to predict one mediating endogenous variable: science identification. Students' science identification was hypothesized to predict the other endogenous variable: students' future science-related career goals. In general, the structural model hypothesizes that students' MUSIC perceptions in their science classroom predict their science identification and that their science identification in turn predicts their career goals related to science.

The second purpose is to test the gender differences between the structural patterns of the MUSIC model, science identification, and science career goals. By separating male and female student's data, I examine whether there are gender differences when MUSIC model components are used to predict science identification, and science identification is used to predict science career goals.

Therefore, this study addressed the following research questions:

RQ1: To what extent do pre-high school students' motivation-related perceptions of the science classroom affect their science identification, which sequentially affects their science-related career goals?

RQ2: Do the relationships among students' motivation-related science classroom perceptions, science identification, and science related career goals vary by gender?

Participants

Participants in this study included 311 students (150 male and 161 female) from three grade levels (101 fifth graders, 91 sixth graders, and 119 seventh graders) in two rural public schools in Southwest Virginia (155 students from one school and 156 from the other) from one school district. Females (52%) represented slightly over half of the participants. According to the state guidelines, both schools were eligible for federal TITLE I funds because they had a high proportion of low-income students (Virginia Department of Education [VDOE], 2012; VDOE Office of School Nutrition Programs, 2014). In the fifth- and seventh- grades, the science curriculum comprised earth/space, life, and physical science. In the sixth- grade, the science curriculum comprised earth/space science and physics science.

Data Collection

Students completed a paper-and-pencil, self-report questionnaire near the end of the school year that was part of a larger project to investigate students' motivation-related science beliefs. The data was collected by Brett Jones in 2013 and was used in a prior study (Chittum & Jones, 2017) for a different type of analysis (i.e., cluster analysis). Therefore, my use of the data is for another purpose and involves another type of analysis (i.e., structural equation modeling).

Measures

As Figure 2.5 in the previous chapter shows, there are seven latent variables tested in this study: (1) students' perceptions of the five components of the MUSIC® Model of Motivation (eMpowerment, Usefulness, Success, Interest, and Caring), (2) students' science identification and (3) students' science related career goals. All seven variables in this study were scaled using a 6-point Likert-type format with the following descriptions: 1 = *strongly disagree*, 2 = *disagree*, 3 = *mostly disagree*, 4 = *mostly agree*, 5 = *agree*, and 6 = *strongly agree*.

MUSIC® model components. I used the MUSIC® Model of Motivation Inventory, middle/high school version (Jones, 2017) to assess students' perceptions of eMpowerment, Usefulness, Success, Interest, and Caring. Table 3.1 shows the definitions of the MUSIC model components and their related constructs.

Table 3.1

The MUSIC® Model Components, Definitions, and related constructs

MUSIC® Model components	The degree to which a student perceives that:	Related constructs
Empowerment	he or she has control of his or her course learning environment	autonomy
Usefulness	the coursework is useful to his or her future	Utility value
Success	he or she can succeed at the coursework	Expectancy for success
Interest	the instructional methods and coursework are interesting or enjoyable	Situational interest
Caring	the teacher cares about whether the student succeeds in the coursework and cares about the student's well-being	Caring

Note. From "User Guide for Assessing The Components of the MUSIC® Model of Motivation" by B. D. Jones, 2017, p. 5. Copyright 2017 by Brett D. Jones. Reprinted with permission.

An example item from each of the latent variables is provided in Table 3.2. Cronbach's alpha values for the middle/high school version of the MUSIC Model Inventory scales have been shown to be acceptable for fifth- to twelfth-grade student in music and band ensemble classes (Parkes, Jones, & Wilkins, 2017; empowerment $\alpha = .73$, usefulness $\alpha = .86$, success $\alpha = .92$, interest $\alpha = .91$, caring $\alpha = .92$). Chittum and Jones (2017) examined the Cronbach's alpha values for the MUSIC Inventory in a study of pre-high school students' science class motivation profiles and found them to be acceptable (in 2012 data, empowerment α = .72, usefulness α = .78, success α = .83, interest α = .77, caring α = .84; in 2013 data, empowerment α = .72, usefulness α = .83, success α = .77, interest α = .76, caring α = .79; in 2014 data, empowerment α = .78, usefulness α = .82, success α = .85, interest α = .78, caring α = .83).

Table 3.2

An example item of each measure

Construct	Example item	No. item
Empowerment	I have choices in what I am allowed to do in science class.	4
Usefulness	The knowledge I gain in science class is important for my future.	3
Success	I am capable of getting a high grade in science class.	4
Interest	The science class work is interest to me.	3
Caring	My science teacher is friendly	4
Science Identification	Doing well in science is very important to me.	4
Science related career goals	My future career will involve science	2

Science identification. I measured science identification using a four-item Identification measure based on Schmader, Major, and Gramzonw (2001, α = .78). See Table 3.2 for an example item. Jones, Paretti, Hein and Knott (2010) and Jones, Osborne, Paretti and Matusovich (2014) examined college students' engineering identification using this scale (α = .84 and 0.89 in the 2010 study; α = .92 in the 2014 study). In a study of pre-high school students, researchers found the Cronbach's alpha values to be acceptable (Chittum & Jones, 2017; α = .82; .83).

Science career goals. I measured science career goals using a two-item measure of science career goals similar to students' engineering career goals measurement (Jones, Osborne, Paretti & Matusovich , 2014; Jones, Tendhar, & Paretti, 2016; Tendhar, Singh, & Jones, 2017). A sample item is presented in Table 3.2. Chittum and Jones (2017) showed the Cronbach's alpha values are acceptable for pre-high school science class (α = .83; .82).

Data Analysis

The first step of the data analysis was to perform preliminary analyses, including descriptive statistics, correlations among the latent variables, and reliabilities for all of the seven latent variables in this study. I used Statistical Package of the Social Sciences (SPSS) version 22.0 to conduct the preliminary analyses.

The second step of the data analysis was Structural Equation Modeling (SEM) analyses. Referring back to my research question of testing the model structure of the MUSIC model components, science identification, and career goals, SEM is considered an appropriate data analytic strategy for this study. SEM can be used to test a theoretical model that hypothesizes how certain indicators define factors and the relationships among the factors (Schumacker & Lomax, 2010). I conducted SEM to examine the factor structure of 24 observed variables and relationships among seven latent variables. I tested the research question by estimating the measurement model and structural patterns using variance-covariance matrix and the Maximum Likelihood (ML) estimation method in LISREL 9.3 (Jöreskog & Sörbom, 1993). Initially, I conducted SEM using the entire sample (N=311) to examine my first research question: To examine the structural patterns among the components of the MUSIC Model, students' science identification, and their future career goals. Next, I conducted multi-group SEM analyses to compare the female and male group samples (N = 161 for female group; N = 150 for male group). The three steps that were involved in multiple group analysis were: (1) assessing the data-model fit of the hypothesized model for each group separately, (2) assessing the tenability of the hypothesized model simultaneously for the two groups, and (3) testing group differences between individual parameters. All theoretically interesting parameters need to be constrained to be equal across groups. Then, the constraints need to be sequentially released if the model fit indices indicate a significant improvement in data-model fit. Parameters, whose constraints are released, are inferred to differ across groups. The constraints that are not released are inferred to be invariant across groups. Regarding the sample size, Wolf et al. (2013) recommended that SEM samples range from 30 (Simple CFA with four indicators) up to 450 cases (mediation models). Boomsma (1982, 1985) suggested a minimum sample size of 100 for conducting SEM. Sideridis et Al. (2014) suggested sample size of 50-70 would be enough for a SEM model with 15 observed variables and four latent variables. Thus, both the female group sample (N=161) and the male group sample (N = 150) fulfill the minimum sample size requirements of conducting SEM.

Chapter 4: Results

Introduction

In this chapter, I present the results of data analysis in three sections. In the first section, I show the descriptive statistics for the observed and latent variables, along with the correlations among the latent variables. In the second section, I present the results of structural equation modeling (SEM) analyses and show the measurement and construct structural model for the entire sample group. In the third section, I compare and explain the results of multi-group SEM analyses by using the female sample group and the male sample group. At the end of the third section, I separately present the results of the SEM analyses for the female sample group and the male sample group.

Descriptive Statistics

This section includes the descriptive statistics for the entire sample and two sub-groups (i.e., the female sample and male sample). For each sample, I calculate the mean and standard deviation for the observed variables and latent variables. Table 4.1 shows the 24 observed variables and their related survey items. The seven latent variables are: five components of MUSIC model (i.e., eMpowerment, Usefulnees, Success, Interest, and Caring), science identification, and career goals. In this section, I also present Cronbach's alpha values for each latent variable and the correlations among them.

Table 4.1

Observed variables and its related survey item

Observed Variable	Survey Item
SI1	Doing well in science is very important to me.
SI2	Success in science is very valuable to me.
SI3	Being good at science is an important part of who I am.
SI4	It matters to me how well I do in science.
Career1	My future career will involve science.
Career2	In the future, I will have a career that requires me to understand science.
M1	I have choices in what I am allowed to do in science class.
M2	I have control over how I learn the content in science class.
M3	I have options in how to achieve the goals in science class.
M4	I have freedom to complete my science class work in my own way.
U1	The knowledge I gain in science class is important for my future.
U2	In general, science class work is useful to me.
U3	I find science class work to be relevant to my future.
S1	I am capable of getting a high grade in science class.
S2	During science class, I feel that I can be successful on the class work.
S3	I feel that I can be successful in meeting the academic challenges in science class.
S4	I am confident that I can succeed in science class work.
I1	The science class work is interesting to me.

I2	I enjoy completing science class work.
I3	The science class work holds my attention.
C1	My science teacher is friendly.
C2	My science teacher is respectful of me.
C3	My science teacher is willing to assist me if I need help in science class.
C4	My science teacher cares about how well I do in science class.

Entire sample descriptive statistics. Table 4.2 shows means and standard deviations of all observed variables. This dataset includes 311 students with no missing data. Out of a maximum score of six for each observed variable, mean scores for the 24 observed variables are within the range of 3.03 and 5.06. Their standard deviations are between 1.22 and 1.74. Table 4.3 presents mean, standard deviation, and Cronbach's alpha for seven latent variables. Out of a maximum score of six for each latent variable, mean scores are in the range between 3.22 and 4.90. Their standard deviations range between 1.11 and 1.57 and scale reliabilities range between .75 and .84. The correlation matrix of the latent variable is presented in Table 4.4.

Table 4.2

Descriptive Statistics of *Observed Variables for Entire Sample*

Observed Variables	N	Mean	Standard Deviation
SI1	311	4.68	1.22
SI2	311	4.31	1.52
SI3	311	3.74	1.64
SI4	311	4.58	1.40
Career1	311	3.03	1.74
Career2	311	3.42	1.70
M1	311	3.68	1.61
M2	311	4.13	1.58
M3	311	4.33	1.42
M4	311	4.19	1.61
U1	311	3.94	1.62
U2	311	4.14	1.54
U3	311	3.77	1.68
S1	311	5.09	1.29
S2	311	4.66	1.42
S3	311	4.54	1.41
S4	311	4.83	1.34
I1	311	4.13	1.55
I2	311	4.27	1.53
I3	311	4.11	1.61
I4	311	4.95	1.52
C1	311	4.91	1.40
C2	311	4.84	1.43
C3	311	5.06	1.32

Table 4.3

Descriptive Statistics and Reliabilities of Latent Variables for Entire Sample

Latent Variables	N	Mean	Standard deviation	Cronbach's Alpha
SI	311	4.35	1.21	.84
Career	311	3.22	1.57	.77
M	311	4.07	1.18	.74
U	311	3.98	1.41	.84
S	311	4.76	1.11	.80
I	311	4.23	1.30	.78
C	311	4.90	1.16	.80

Note: SI=Science Identification; Career=Career goals; M=Empowerment; U=Usefulness; S=Success; I=Interest; C=Caring

Table 4.4

Correlation Matrix of Latent Variables

	SI	Career	M	U	S	I	C
SI	1						
Career	.70**	1					
M	.66**	.46**	1				
U	.76**	.86**	.64**	1.			
S	.83**	.51**	.70**	.59**	1		
I	.88**	.67**	.78**	.86**	.78**	1	
C	.57**	.33**	.56**	.39**	.78**	.54**	1

*Note. SI=Science Identification; Career=Career goals; M=Empowerment; U=Usefulness; S=Success; I=Interest; C=Caring; *p< .05; **p< .01*

Female sample descriptive statistics. The means and standard deviations of the observed variables for the female group are shown in Table 4.5. There are 161 students with no missing data in female group. Out of a maximum score of six for each observed variable, mean scores for the 24 observed variables range between 3.26 and 5.29. Their standard deviation ranged between 1.11 and 1.77.

Table 4.5

Descriptive Statistics of *Observed Variables for Female Sample*

Observed Variables	N	Mean	Standard Deviation
SI1	161	4.85	1.11
SI2	161	4.37	1.49
SI3	161	3.81	1.61
SI4	161	4.76	1.34
Career1	161	3.26	1.77
Career2	161	3.65	1.72
M1	161	3.58	1.56
M2	161	4.17	1.57
M3	161	4.42	1.38
M4	161	4.20	1.59
U1	161	4.06	1.58
U2	161	4.24	1.45
U3	161	3.91	1.68

S1	161	5.18	1.28
S2	161	4.78	1.39
S3	161	4.59	1.35
S4	161	4.96	1.30
I1	161	4.19	1.45
I2	161	4.35	1.47
I3	161	4.09	1.60
I4	161	5.24	1.30
C1	161	5.09	1.25
C2	161	5.10	1.31
C3	161	5.29	1.14

In Table 4.6 are the means, standard deviations, and the Cronbach's alpha values for the latent variables. Out of a maximum score of six for each latent variable, the mean scores range from 3.48 to 5.16. Their standard deviations are between 1.02 and 1.65 and scale reliabilities range between .75 and .88. The correlation matrix of the latent variables is presented in Table 4.7.

Table 4.6

Descriptive Statistics and Reliabilities for Female Sample Latent Variables

Latent Variables	N	Mean	Standard deviation	Cronbach's Alpha
SI	161	4.50	1.20	.88
Career	161	3.48	1.65	.82
M	161	4.07	1.16	.75
U	161	4.12	1.42	.87
S	161	4.90	1.13	.86
I	161	4.28	1.29	.83
C	161	5.16	1.022	.80

Note: SI=Science Identification; Career=Career goals; M=Empowerment; U=Usefulness; S=Success; I=Interest; C=Caring

Table 4.7

Correlation Matrix of Latent Variables for Female Sample

	SI	Career	M	U	S	I	C
SI	1						
Career	.71**	1					
M	.67**	.38**	1				
U	.81**	.93**	.57**	1.			
S	.79**	.53**	.62**	.61**	1		
I	.89**	.67**	.77**	.85**	.76**	1	
C	.53**	.25**	.58**	.37**	.66**	.57**	1

*Note. SI=Science Identification; Career=Career goals; M=Empowerment; U=Usefulness; S=Success; I=Interest; C=Caring; *p< .05; **p< .01*

Male sample descriptive statistics. Table 4.8 shows the means and standard deviations of the observed variables for male group sample. The male group has 150 students with no missing data. Out of a maximum score of six for each observed variable, mean scores for the 24 observed variables range between 2.77 and 4.99, with standard deviations range between 1.32 and 1.68.

Table 4.8

Descriptive Statistics for Male Sample Observed Variables

Observed Variables	N	Mean	Standard Deviation
SI1	150	4.51	1.32
SI2	150	4.25	1.55
SI3	150	3.65	1.66
SI4	150	4.38	1.44
Career1	150	2.77	1.68
Career2	150	3.17	1.64
M1	150	3.78	1.66
M2	150	4.09	1.58
M3	150	4.23	1.45
M4	150	4.17	1.64
U1	150	3.81	1.66
U2	150	4.03	1.62
U3	150	3.62	1.67
S1	150	4.99	1.30
S2	150	4.53	1.44
S3	150	4.49	1.48

S4	150	4.70	1.38
I1	150	4.05	1.65
I2	150	4.18	1.59
I3	150	4.13	1.61
I4	150	4.65	1.68
C1	150	4.72	1.52
C2	150	4.57	1.51
C3	150	4.81	1.45

In Table 4.9 are the means, standard deviations, and values of Cronbach's alpha of latent variables. Out of a maximum score of six for each latent variable, mean scores range between 2.94 and 4.61. Their standard deviations are in range of 1.072 and 1.426 and scale reliabilities in the range of .678 and .797. The correlation matrix of the latent variables is shown in Table 4.10.

Table 4.9

Descriptive Statistics and Reliabilities for Male Sample Latent Variables

Latent Variables	N	Mean	Standard deviation	Cronbach's Alpha
SI	150	4.19	1.21	.80
Career	150	2.94	1.43	.69
M	150	4.08	1.20	.73
U	150	3.83	1.40	.80
S	150	4.60	1.07	.73
I	150	4.17	1.31	.72
C	150	4.61	1.24	.79

Note: SI=Science Identification; Career=Career goals; M=Empowerment; U=Usefulness; S=Success; I=Interest; C=Caring

Table 4.10

Correlation Matrix of Latent Variables for Male Sample

	SI	Career	M	U	S	I	C
SI	1						
Career	.68**	1					
M	.67**	.57**	1				
U	.69**	.77**	.72**	1.			
S	.89**	.48**	.78**	.56**	1		
I	.88**	.68**	.81**	.87**	.79**	1	
C	.59**	.36**	.56**	.38**	.90**	.53**	1

*Note. SI=Science Identification; Career=Career goals; M=Empowerment; U=Usefulness; S=Success; I=Interest; C=Caring; *p< .05; **p< .01*

SEM Results for the Entire Sample

I conducted the SEM analyses in two steps. First, I tested the measurement model to ensure that all the seven latent variables are distinct. Second, I conducted and modified the structural model to examine the relationships among latent variables.

Measurement model. The measurement model analysis is also known as confirmatory factor analysis (CFA), which is used to test the factor structure and factor loading of a set of observed variables (Schumacker & Lomax, 2012). In this measurement model, I tested whether the data fit the hypothesis factor structure of seven latent variables: empowerment, usefulness, success, interest, carefulness, science identification, and career goals. The results for the entire sample measurement model produced an overall chi-square (χ^2) value of 689.51, degree of freedom (*df)* = 231, root-mean-square error of approximation (RMSEA) = .08, comparative fit index (CFI) = .89, and standardized Root Mean Square residual (SRMR) = .06. MacCllum, Vrowne, and Sugawara (1996) indicated the value of RMSEA range from 0 to .01 was excellent, .05 to .07 was good, and .06 to .08 was a mediocre fit. The value of SRMR less than .08 is generally considered a good fit. The value of CFI greater than .90 or .95 represented fair or satisfactory fit (Bentler, 1990; Hu & Bentler, 1999). According to the recommendations of model fit indices, the entire sample measurement model presents mediocre model fit with mediocre fit RMSEA value (RMSEA = .08), good fit SRMR value (SRMR = .06) and fair CFI value (CFI = .89).

Table 4.11 presents the properties of the entire sample measurement model including the standardized item loading, error variances of indicators, and the squared multiple correlation coefficients. Squared multiple correlation coefficients (R squared) measures the proportion of the total variation in the observed variable that is explained by the latent variable. In this measurement model, the standardized loadings vary from .51 to .85 with error variances within the range from .27 to .74, and squared multiple correlation coefficients vary between .26 and .73.

Table 4.11

Properties of The Entire sample Measurement Model

Variable	Standardized loading	Error variances	R^2
SI1	.71	.50	.51
SI2	.77	.41	.60
SI3	.75	.44	.56
SI4	.81	.34	.66
Career1	.73	.47	.53
Career2	.85	.27	.73
M1	.51	.74	.26
M2	.72	.48	.52
M3	.75	.44	.56
M4	.62	.61	.39
U1	.83	.31	.69
U2	.70	.51	.50
U3	.85	.28	.72
S1	.59	.66	.34
S2	.78	.40	.60
S3	.73	.47	.53
S4	.76	.43	.57
I1	.71	.50	.50
I2	.72	.48	.52
I3	.77	.41	.59
C1	.72	.48	.52
C2	.71	.49	.51
C3	.68	.54	.46
C4	.70	.50	.50

Structural equation model. In this section, I explained the results of the entire sample structure model to address my first research question as presented in Chapter 1: To what extent do pre-high school students' motivation-related perceptions of the science classroom affect their science identification, which sequentially affects their future science-related career goals? In the structural models, the measurement part of the model was established based upon the entire sample measurement model, as described previously. For the structural part, I examined the structure model in which the five components of the MUSIC model correlated with students' science identification, and in turn, science identification correlated with students' future career goals.

Figure 4.1 shows the entire sample structural equation model. Three of five components of the MUSIC model (Usefulness [β = .26], Success [β = .52], and Interest [β = .40]) are significantly related to science identification positively while eMpowerment [β = -.19] is significantly related to science identification negatively. Caring [β = - .07]) doesn't have significant relationship with science identification. Furthermore, science identification has a significantly positive relationship with science career (β = .82).

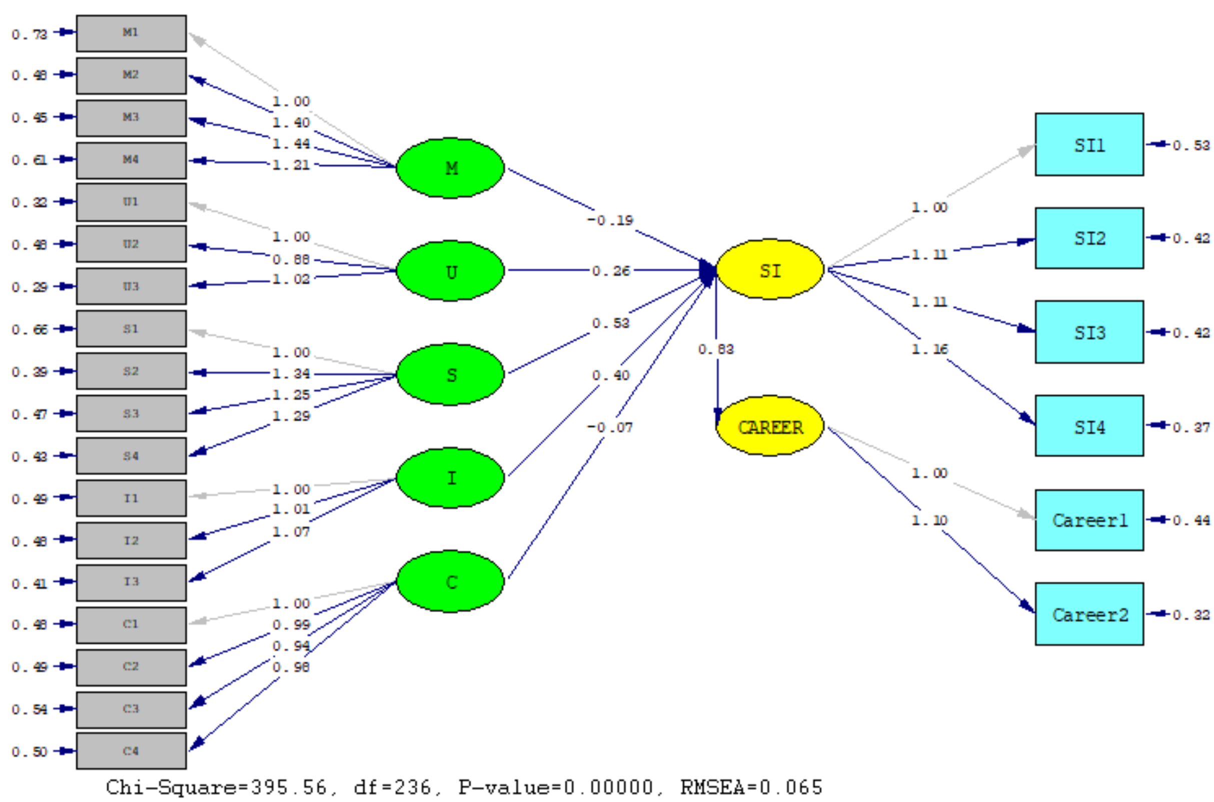

Figure 4.1 Structure Equation Model for Entire Sample

Table 4.12 presents the goodness-of-fit indices of the measurement model and SEM model of the entire sample group. Overall, the entire sample SEM model presents mediocre model fit, with a mediocre fit RMSEA value (RMSEA = .08), good fit SRMR value (SRMR = .06), and fair fit CFI value (CFI = .87).

Table 4.12

Goodness-of-fit Indices of Measurement and SEM Model of Entire Sample

Models	χ^2	*df*	RMSEA	CFI	SRMR
Measurement model	689.51	231	.08	.89	.06
SEM model	764.09	236	.08	.87	.06

Results for Multi-group SEM Analyses

In this section, I present the SEM results associated with gender difference to address my second research question as presented in Chapter 1: Do the relationships among students' motivation-related science classroom perceptions, science identification, and their future science-related career goals vary by gender? I conducted multi-group SEM analyses for the female sample (N = 161) and male sample (N = 150). Generally, there are two parts in multi-group SEM analyses: the measurement part and the structural part. For the measurement part, the group differences on the number of factors, factor loading, and error variance are compared step by step. If the two groups are very similar with same number of factors and factor loadings, the structural patterns among latent variables can be compared by establishing and examining the unconstrained model (structural patterns among latent variables were different across groups) and the constrained model (structural patterns among latent variables kept the same for the two groups).

For the measurement part, I first established the basic model without any invariance. Then, I hypothesized that the number of factors would be the same for the two groups and tested in model two: the invariance of number of factors. Table 4.19 shows the results of the two-group sample comparison for measurement part.

Table 4.13

Goodness-of-fit Indices of Multi-group Sample SEM in Measurement Part

Models	χ^2	*df*	RMSEA	CFI	SRMR	Decision
Basic model	637.83	300	.085	.97	.067	Accept
Model one: number of factors invariant	1113.57	462	.095	.95	.073	Reject

According to the model fit indices, I rejected the first hypothesis, which was model one (number of factors invariant). Compared to the basic model, model one's degree of freedom increases by 162 and the value of chi-square increases by 475.74, which is considered as a significant increase according to the chi-square critical values table. The values of RMSEA and SRMR became larger by .01 and .06, and value of CFI reduced by .02, which indicated a poorer fit to data. Therefore, for the SEM measurement part, I concluded that the female and male groups had a different number of factors.

Female sample SEM analyses. Similar to the SEM analyses for the entire sample, I conducted the female group SEM analyses in two steps. First, I tested the measurement model to ensure that all the seven latent variables were distinct. Second, I conducted the structural model to examine the relationships among latent variables.

The results for the entire sample measurement model indicated an overall model with a χ^2 value of 588.28 (*df* = 231) and fit indices for the model as follows: RMSEA = .09, CFI = .86, and SRMR = .07. The goodness-of-fit indices indicated a mediocre or poor model fit to the data according to the recommendations of model fit indices. Table 4.14 presents the properties of the female sample measurement model including the standardized item loading, error variances of indicators, and the squared multiple correlations. In this measurement model, the standardized loadings vary from .51 to .85 with error variances within the range from .22 to .80, and squared multiple correlation coefficients vary between .20 to .78.

Table 4.14

Properties of the Female Group Measurement Model

Variable	Standardized loading	Error variances	R^2
SI1	.78	.40	.60
SI2	.80	.37	.63
SI3	.80	.36	.64
SI4	.86	.26	.74
Career1	.78	.39	.61
Career2	.88	.22	.78
M1	.44	.80	.20
M2	.70	.50	.50
M3	.82	.33	.69
M4	.65	.58	.42
U1	.86	.26	.74
U2	.76	.43	.57
U3	.87	.24	.76
S1	.60	.65	.35
S2	.85	.28	.72
S3	.82	.33	.67
S4	.87	.25	.75
I1	.76	.42	.58
I2	.76	.42	.58
I3	.83	.31	.70
C1	.76	.42	.58
C2	.70	.51	.49
C3	.67	.55	.45
C4	.70	.51	.49

Figure 4.2 shows the female sample structural equation model. Consistent with the entire sample model, three of five components of the MUSIC model (Usefulness [β = .39], Success [β = .34], and Interest [β = .32]) are significantly positively related to science identification, while the other two components (eMpowerment [β = -.01] and Caring [β = - .03]) are not significantly related to science identification. Furthermore, science identification has a significant positive relationship with science career (β = .81).

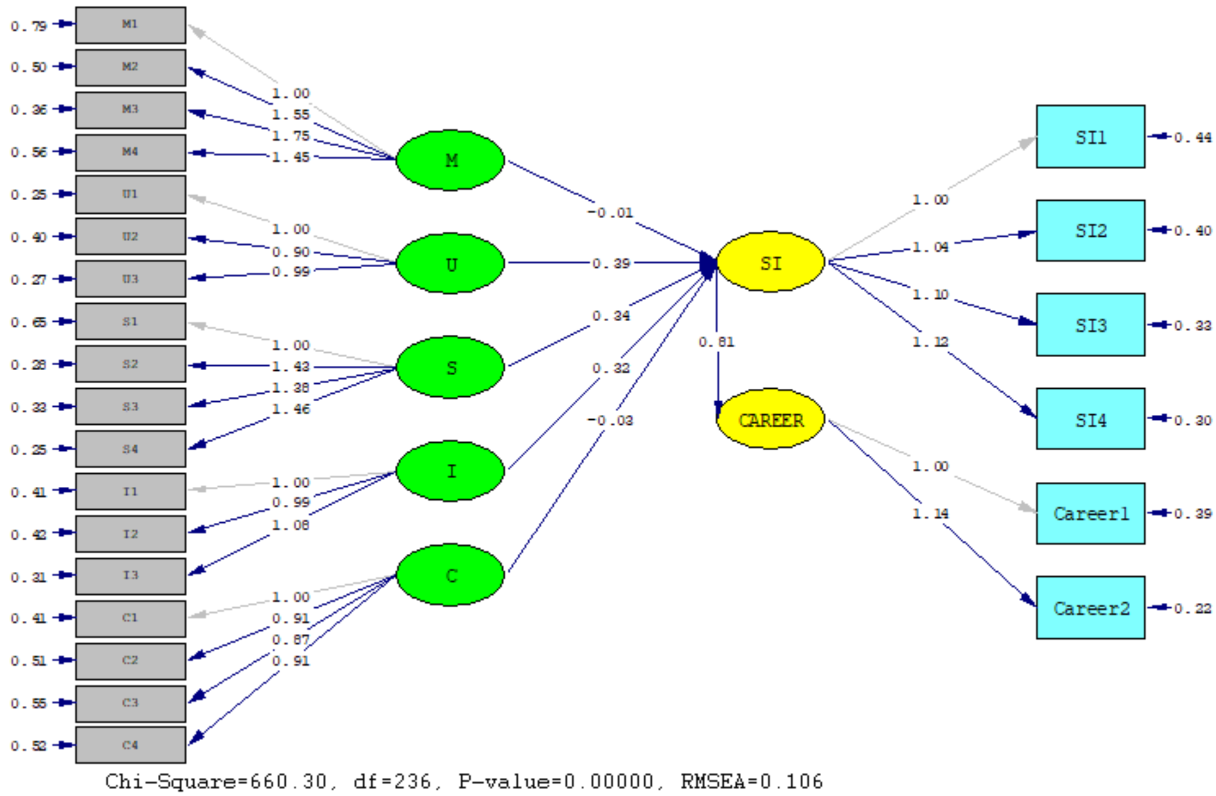

Figure 4.2 Structure Equation Model for Female Group Sample

Table 4.15 presents the goodness-of-fit indices of the measurement model and SEM model of the female sample group. Overall, the female sample SEM model presents poor model fit with low value of CFI (CFI = .84).

Table 4.15

Goodness-of-fit Indices of Measurement and SEM Model of Female Sample

Models	χ^2	*df*	RMSEA	CFI	SRMR
Measurement model	588.28	231	.09	.86	.07
SEM model	660.30	236	.10	.84	.08

Male sample SEM analyses. Similar to the female sample, I tested the male sample measurement model first and then conducted the structural model to examine the relationships among latent variables. The results for the male sample measurement model indicated an overall model with a χ^2 value of 528.87 (*df* = 231) and RMSEA = .093, CFI = .82, and SRMR = .073. Table 4.16 presents the properties of the male sample measurement model including the standardized item loading, error variances of indicators, and the squared multiple correlations. In this measurement model, the standardized loadings vary from .51 to .85 with error variances within the range from .22 to .80, and squared multiple correlation coefficients vary between .20 and .78.

According to the results of male group measurement model, although all seven latent variables are distinct as different factors, Success and Caring are highly correlated shown in the latent variable correlation matrix (Table 4.10). The correlation between Success and Caring is .90 in the male group measurement model.

Table 4.16

Properties of the Male sample Measurement Model

Variable	Standardized loading	Error variances	R^2
SI1	.65	.58	.42
SI2	.76	.43	.57
SI3	.69	.53	.47
SI4	.76	.42	.58
Career1	.65	.58	.42
Career2	.80	.36	.64
M1	.57	.68	.33
M2	.72	.49	.51
M3	.70	.52	.48
M4	.60	.65	.35
U1	.80	.35	.65
U2	.65	.58	.42
U3	.82	.33	.68
S1	.54	.70	.29
S2	.70	.51	.49
S3	.64	.59	.41
S4	.65	.58	.42
I1	.66	.56	.44
I2	.69	.55	.45
I3	.71	.50	.50
C1	.70	.52	.49

C2	.73	.47	.53
C3	.65	.58	.42
C4	.68	.53	.47

Figure 4.3 presents the initial male sample structural equation model. The results for the SEM model show the path coefficient between Success and Science Identification is 4.71 which is much bigger than 1.0 and indicates that there is multicollinearity in this initial model which may be caused by high correlations among the latent variables (Grewal, Cote & Baumgartner, 2004). Referring to the latent variable correlation matrix (Table 4.10), two latent variables, Success and Caring, are highly correlated. Thus, I combined Success and Caring as one single variable, SuCa, and updated the male group SEM model including six latent variables. Figure 4.4 shows the update male group SEM model. Consistent with the entire sample and female sample model, Interest (β = .86) is statistically significant positively correlated with science identification, which is a strong predictor of career goals (β = .82). Beside Interest, the new combined variable, SuCa, has significant correlation with science identification. Meanwhile, one another components of the MUSIC model, eMpowerment [β = -.25], is significantly negatively related to science identification. There is no significant correlation between Usefulness [β = -.02] and science identification.

Table 4.17 presents the goodness-of-fit indices of the measurement model and the initial and the updated SEM model of the male sample. Both of the initial model and the updated model present poor model fit with low values of CFI (CFI = .81 for the initial model; CFI = .80 for the updated model). Compared to the initial model, the updated male SEM model has no multicollinearity. Also, there are six latent variables in the updated male SEM model different from the number of latent variables in the female SEM model (Figure 4.2) that is consistent with the results of multi-group SEM analyses indicating female and male samples have a different number of factors. Thus, the updated male SEM model does not exhibit multicollinearity, but is still poor fit.

Table 4.17

Goodness-of-fit Indices of Measurement and SEM Models of Male Sample

Models	χ^2	*df*	RMSEA	CFI	SRMR
Measurement model	528.87	231	.09	.82	.07
SEM model	550.61	237	.09	.81	.08
Updated Model	578.26	242	.09	.80	.08

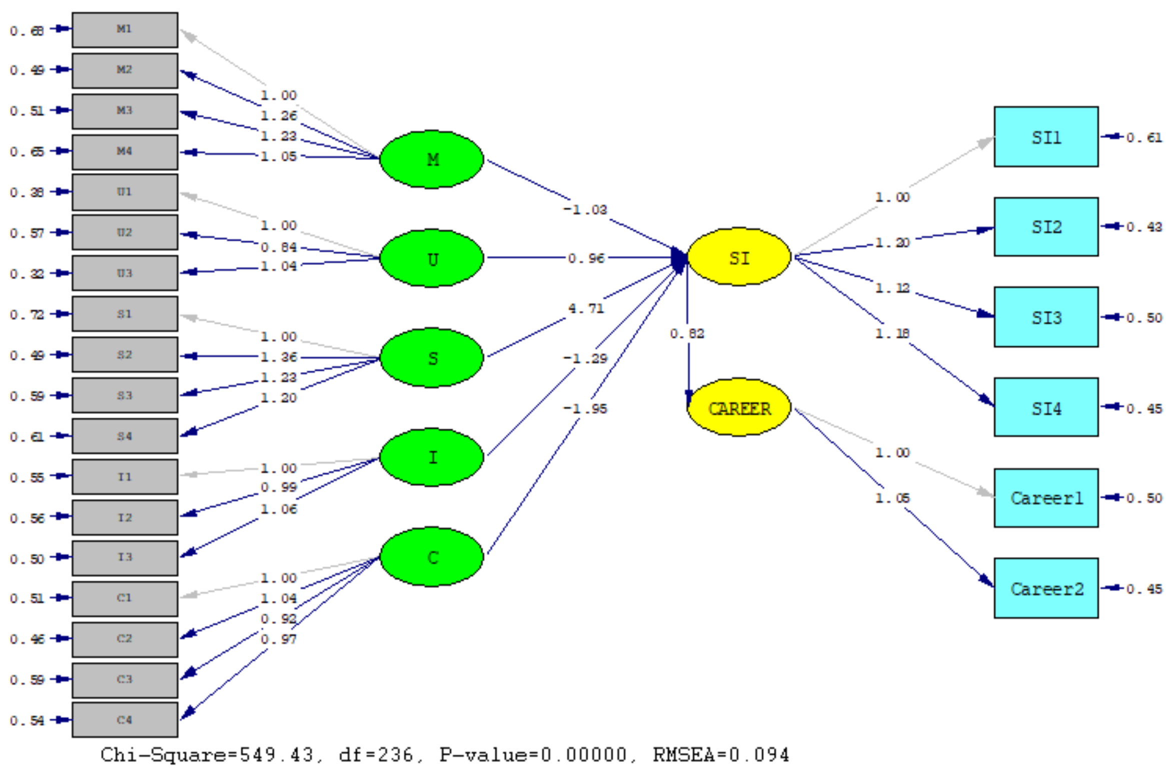

Figure 4.3 Initial SEM Model for Male Sample

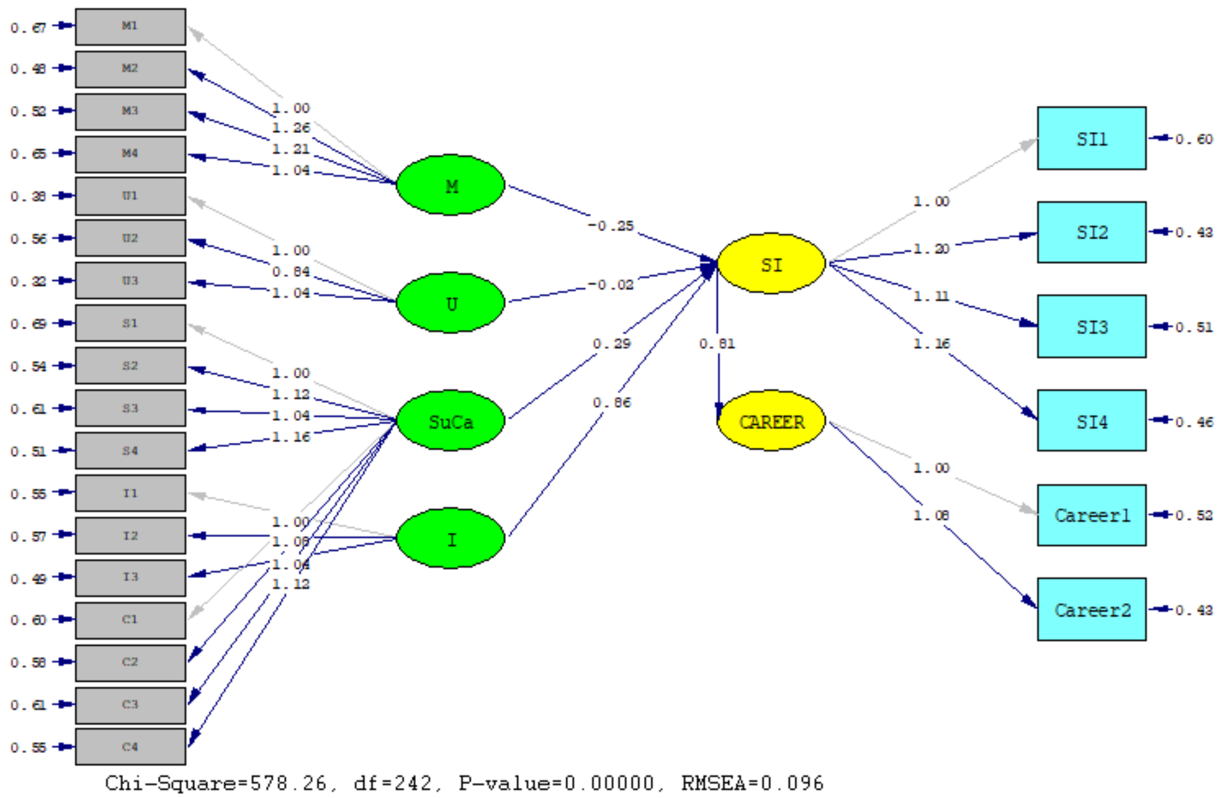

Figure 4.4 Updated SEM Model for Male Sample

Chapter 5: Discussion and Conclusion

In this final chapter, I present the findings, the theoretical and practical teaching implications, the limitations of this study and future research directions, and final conclusions.

Summary of the Findings

The purpose of this study was to explain (1) to what extent do pre-high school students' motivation-related perceptions of the science classroom affect their science identification, which sequentially affects their future science-related career goals and (2) to examine gender differences among the structure patterns. I conducted SEM analyses to explore the relationships among the five components of the MUSIC motivation model (i.e., eMpowerment, Usefulness, Success, Interest, and Caring), science identification, and career goals. The results of the entire group analysis demonstrated that the model fit to the data is mediocre and indicates that students' MUSIC perceptions in their science classes predicted their science identification, which then predicted their science career goals. Furthermore, three components of the MUSIC model (i.e., Interest, Success, and Usefulness) are positively related to students' science identification, which is a strong predictor of students' science career goals.

To examine the gender differences, I split my sample data into female and male groups and conducted the multi-group SEM analyses to test the model fit. According to the results of goodness-of-fit indices, I rejected my hypothesis model that both the female and male samples have the same number of factors in the measurement model part. My final accepted model indicated that the female and male groups have different factor structures. To better understand the differences between the female and male samples, I conducted SEM analyses for these two groups.

For the female sample, the final SEM model is consistent with the results of entire sample in that three MUSIC model components (i.e., Interest, Usefulness, and Success) are positively related to students' science identification, which then highly correlate with students' career goals. For the male sample, I combined Success and Caring as one latent variable because they were highly correlated to each other and produced multicollinearity in the SEM model. After variable combination, the male sample SEM model still presented poor model fit; therefore, I will not attempt to interpret the findings of the male sample.

Overall, the SEM results from the entire sample and female sample demonstrated that students' MUSIC perceptions in their science class (Usefulness, Success, and Interest) are positively correlated with their science identification. Moreover, students' science identification is significantly correlated with students' future science-related career goals in both groups.

Theoretical implications

The findings of this study contribute to theory in at least three ways, as I describe in this section. First, this research provided evidence that, for fifth, sixth, and seventh grade students, students' MUSIC perceptions of their science classes are related to their science identification; additionally, their science identification is a strong predictor of their science career goals. Second, the findings show strong evidence that the relationships among the MUSIC model components, science identification, and career goals vary by gender. Third, the research findings provided evidence that helping students to understand the usefulness of science to their goals, helping students feel that they can succeed in science class, and promoting situational interest in science classes is critical for pre-high school students because these three variables are correlated with their science identification and career goals.

MUSIC perceptions predict domain identification. The results of this study, which show positive relationships among the MUSIC model components, science identification and career goals, are consistent with other reported studies targeting different research participants, such as first-year college engineering students (Jones et al., 2014; Jones, Tendhar, & Paretti, 2016) and pre-high school students in the U.S. and Iceland (Jones et al., 2017). The positive relationship between students' domain identification and their career goals is consistently strong in all these studies, providing convincing validity evidence for the relationship between these variables in the domain identification model (Osborne & Jones, 2011). Thus, it appears that the relationship between domain identification and career goals in that domain can be applied to students in different age groups and domains. Among these studies with different research participants, there are some differences regarding which components from the MUSIC model significantly positively related to domain identification. For the first-year college engineering students, one study documented that all five MUSIC model components predicted students' engineering identification (Jones et al., 2014). In another study, Jones, Tendhar, and Paretti (2016) documented that four of the five MUSIC model components (i.e., eMpowerment, Usefulness, Success, Caring) were positively related to students' engineering identification. For different groups of fifth, sixth, and seventh grade students from the U.S. and Iceland, only Usefulness (and Success in the U.S. sample) predicted students' science identification. In the present study, three of the five MUSIC model components (i.e., Usefulness, Success, and Interest) positively influenced students' science identification for both females and the full sample group.

Theoretically, different participants with different domain identification predictors demonstrated the usability of the MUSIC motivation model. For pre-high school students, their science curriculum has to follow educational standards (e.g., common core, Standards of Learning). Instructors have to design science teaching content and activities according to these educational standards, which may decrease students' empowerment in the learning because they may have limited control of the content or teaching methods. Thus, for fifth, sixth, and seventh grade students they may not be able to make the connection between eMpowerment and science identification. For pre-high school students, they may require more specific guidance and detailed explanations from teachers to succeed in the class.

For college engineering students, the components of the MUSIC model that predicted identification in prior studies were different from the components with pre-high school students in science classes. One reason may be that empowerment is more important for the college students. For example, college students may have more freedom to choose different course subjects they want to take, to participate in the classroom in different ways (e.g., online, face-to-face), to finish their course work in different ways, or to work individually or in groups. Thus, the empowerment component may also have a more positive relationship with college engineering students' domain identification.

Gender differences exist. The second theoretical implication of this study relates to gender differences. Numerous researchers have explained that there is a stereotype that females have less aptitude and are more likely to perform lower in science or math than males (Quinn & Spencer, 2001; Sekaquaptewa & Thompson, 2003). These gender stereotypes in return highly influence female's interest and performance in science or math related courses or careers (Davies, Spencer, Quinn, & Gerhardstein, 2002; Jacobs & Eccles, 1992; Quinn & Spencer, 2001; Sekaquaptewa & Thompson, 2003; Shih, Pittinsky, & Ambady, 1999; Spencer, Steele, & Quinn, 1999). The present study clarified that the relationships among MUSIC components, science identification, and careers do vary by gender at pre-high school level. With almost an equal sample size (female N=161, male N=150), the female groups' final results are similar to the results for whole group sample. Three components, Usefulness, Success, and Interest, were statistically related to science identification. Differently, the male group sample, the MUSIC variables were more highly correlated causing multicollinearity, and when I combined the Success and Caring variables, Usefulness didn't have a positive relationship with Science Identification. Therefore, the models are different in terms of the relationships between the MUSIC components and science identification. For both groups, science identification is strongly related to future career goals.

Because the model fit was poor for the male sample, it is difficult to interpret the results of the gender comparison precisely. Further research is needed to confirm that these differences exist and to create a model that fits the male data more closely. Therefore, I can only conclude that there appear to be differences by gender in how students' science class perceptions relate to their science identification.

Situational interest is important. Another implication of this study involves the relationship between situational interest and science identification. The results indicated that situational interest has significant positive relationship with science identification. Interest was assessed using a measure of situational interest, which captures the extent to which students perceive that the instructional methods and coursework are interesting or enjoyable. Situational interest is different from *individual* interest for which the interest is more enduring and a student demonstrates greater value for and knowledge of the object, content, or topic (Hidi & Renninger, 2006).

The fact that situational interest predicted science identification is consistent with the theoretical framework of domain identification provided by Jones, Ruff, and Osborne (2015) who clarified that "domain identification begins to occur during the transition from situational to individual interest" (p. 338). This study results clarify that situational interest is positively related to science identification in the pre-high school context and provided statistical support for the theoretical framework of domain identification.

Perception of success is critical. Another theoretical implication of this study relates to success because there was a positive relationship between success and science identification. The perception of success indicates that students are confident that they can have long-term success by studying in the class, which may then lead them invest more time and effort to make progress in learning, which could ultimately lead to increases in students' science identification. These results are consistent with the expectancy-value model in which students' expectancies and values are theoretically related to their long-term success and achievement (Wigfield & Eccles, 2000; Hulleman & Harackiewicz, 2009). Thus, these study results demonstrate the positive relationship between success and science identification for the fifth, sixth, and seventh grade students and provide statistical support for the expectancy-value model.

Practical Teaching Implications

The present research results answered the proposed research question by showing the positive relationships among the MUSIC model components, science identification, and science career goals of pre-high school students. It's worth considering what it means that not all the MUSIC components were positively correlated with science identification. As a practical motivation model, the MUSIC model is designed to help teachers to understand the principles of motivation and guide them to design instruction to promote students' motivation (Jones, 2009, 2018). The five MUSIC model components represent different motivational teaching strategies for instructors, meanwhile, they are correlated to and support each other, and work together to engage students in learning. Therefore, although empowerment wasn't positively related with science identification, I still kept empowerment as a factor in the final model because empowerment may support one or more of the other MUSIC model components, such as interest (which was a predictor of science identification). Generally speaking, the MUSIC model components can be distinguished in theory, but in practice, all five components often work together as a whole model. The results indicate that, as a whole, the MUSIC model is correlated to students' science identification. However, a more detailed look at the critical difference among the five components indicates that they may affect students' science identification differentially.

With all five MUSIC components in the overall and female model, usefulness, situational interest, and perceptions of success were positively related to science identification. This finding suggests that in order to develop students' science identification, pre-high school teachers should intentionally help students understand the usefulness of the content, trigger students' interest, and foster their perceptions of success. For example, teachers could create an inquiry-based science learning environment, which has been considered as an effective way to motivate and engage students in science learning (Geier et al., 2005; Hofstein & Lunetta, 2004). In inquiry-based classrooms, students are encouraged to develop and reconstruct their own knowledge schemes through posing their own questions, designing investigations, analyzing and presenting their findings. With the help and intervention from teachers, students construct their own understanding by taking an active role in their learning (Drive et al., 1994). Another way to develop students' situational interest in science is connecting students' prior knowledge, or using social interaction, games, humor, and/or emotional content (Jones, 2009). Making these connections can trigger students' situational interest, which can eventually become a longer-term individual interest if the students continue to develop the knowledge, value, and affect for the subject (Hidi & Renninger, 2006).

Besides triggering students' interest, it is also important to help students feel successful in learning science to promote their science identification. For example, teachers can provide clear and easy-to-follow project guidance to make students' feel that they can succeed in science if they follow the instruction well. Setting-up appropriate challenges and regularly providing feedback to students can also be beneficial to students' feeling of success (Jones, 2009).

The results also suggest that instructors should consider different teaching strategies for female and male students in their teaching practice. For example, feeling success may protect female students against the stereotype that females have less aptitude and perform lower in science or math than males (Quinn & Spencer, 2001; Sekaquaptewa & Thompson, 2003). Female students' identification also relates to how they perceive the usefulness of science to their life goals. Applying science knowledge to students' daily lives could be a good way for students to find the usefulness in learning science. Students may feel the usefulness of science when they find what they are learning are relevant to their daily life or future study goals. In summary, pre-high school teachers should trigger students' interest in learning, help them to see the usefulness of science in their lives, and ensure that they can feel successful in science.

Limitation and Future Research

One of the biggest limitations in this study is the sample size of the female and male group. Although the sample size of 331 for the overall sample is considered a medium sample size for SEM analyses, the female group (N = 161) and male group (N = 150) sizes were small, which may have caused the poor model fit in this study.

Another research limitation is that several grade levels of students were included. The 311 participants came from three different grade levels (101 fifth graders, 91 sixth graders, and 119 seventh graders). For pre-high school students, they are on their way to developing from a child to a teenager, which means there may be difference in their attitudes towards science class. For future studies, it will be good to increase the sample size and use SEM analyses for each grade to determine the structure pattern among students' motivation-related perceptions, science identification, and career goals.

Also, for future studies, more variables from the domain identification model could be selected (e.g., students' effort, academic outcomes, school or family educational experiences). It would be an interesting topic to explore the relationships among students' learning experiences, motivational perceptions, domain identification, learning effort, and academic outcomes.

Conclusion

I found positive relationships among the MUSIC model components, science identification, and career goals from a survey of 331 pre-high school students. Students' science identification strongly related to their science career goals, but its correlation to MUSIC model components varied. Such variation was dependent upon the gender of students. Girls' science identification was associated with their perceptions of Interest, Usefulness, and Success in science class, while the model did not fit well for the boys. This finding suggests that situational interest in science class (i.e., their interest and enjoyment in science class), the usefulness of science class, and perception of success are the most important factors in terms of predicting pre-high school students' levels of science identification.

This study results are meaningful because they provide practical solutions to engage students in learning science and develop their science identification. Pre-high school students' science-related career goals are highly influenced by their science identification that is positively related to the MUSIC model components. This result is consistent with other motivation-related theories such as expectancy-value theory (Wigfield & Eccles, 2000) and social cognitive career theory (SCCT; Lent, Brown & Hackett, 1994, 2000), which indicates that building a career goal at a young age helps students to stay motivated in learning and persist in their choices. Developing students' science identification at fifth, sixth, and seventh grade may help students engage and persist in learning science and pursue science related career in the future.

Additionally, this study results demonstrate that there are gender differences exist at pre-high school levels regarding to the relationships among students' motivation-related perceptions of science class, science identification, and career goals. Moreover, an effective way to encourage female students to pursue STEM related career in the future is help them develop science identification at per-high school level. Based upon the positive relationships among the MUSIC model components and science identification, the teacher can focus on specific teaching strategies and help female students develop their science identification and science related career goals.

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