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Outreach Program, Cognitive Variables and STEM Identity: Mediation and Longitudinal Mediation Study of Middle and High-School Students’ Career Aspirations

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Abstract

The purpose of the study was to investigate cross-sectionally and longitudinally the direct and indirect effects of a STEM outreach program in Ontario, Canada, on middle and high-school students' STEM career intentions through STEM self-efficacy, outcome expectations, interest and identity. The STEM outreach program provided students with hands-on, investigative and exciting workshops aiming at increasing interest in STEM disciplines and careers. Mediation and longitudinal mediation analysis procedures were employed to analyze a secondary data to answer the following research questions: 1) To what extent did the STEM outreach program influence high-school students' STEM career choice goals directly and indirectly through STEM self-efficacy, outcome expectations, interest and identity? 2) To what extent did the direct and indirect effects of the STEM outreach program on middle-school students' STEM career intentions through STEM self-efficacy, outcome expectations, interest and identity change from Phase II to Phase III? The research questions and analysis were guided by social cognitive career theory's interest-choice model and science identity theory. The findings from the analysis revealed that students' STEM self-efficacy, outcome expectations and identity were found to be significant mediating predictors of the association between the outreach workshops and high-school students' STEM career goals. It was also found that the change from Phase II to Phase III in the indirect effect of STEM outcome expectations on the relationship between outreach workshops and middle-school students' STEM career pursuits was statistically significant. The results presented theoretical and practical implications. The findings not only supported the hypothesis of and prior literature by the interest-choice model and science identity theory but also contributed to the advancement of theoretical understanding of the influences of contextual, cognitive and identity variables on the process of career development. This was done by examining the cross-sectional and longitudinal mediating effects of STEM cognitive and identity variables on the association between STEM outreach workshops and STEM career pursuits that have not been sufficiently addressed in the present studies. The study findings were also believed to present useful insights for teachers, district and school administrators, and stakeholders of overseeing STEM outreach programs to design and implement integrated and inquiry-based learning experiences.

Keywords:

STEM education, integrated and inquiry-based curriculum, social cognitive theory, social cognitive career theory, self-efficacy, outcome expectations, interest, science identity theory, outreach program, career choice goal

Summary for Lay Audience

While China and India are emerging to become world leaders in STEM and advanced technology industries, STEM disciplines have been facing crisis in Canada and other comparable countries in terms of students' lack of interest and poor academic performance. A variety of interventions that emphasize STEM enrichment have been initiated to enhance students' interest in STEM subjects and careers. The context of the study was a STEM outreach program that, facilitated with real scientists and engineers, provided hands-on, investigative and exciting workshops to middle and high-school students in a school district in Ontario, Canada. The study aimed at examining the influence of the STEM outreach workshops on students' self-efficacy and outcome expectations beliefs, interest, identity and intention of choosing a career in STEM. It also investigated whether there was a change in students' perceptions about the influence of the STEM outreach workshops on students' self-efficacy and outcome expectations beliefs, interest, identity and intention of choosing a career in STEM from Phase II to Phase III. The findings of the study showed that participation in the outreach workshops (a) increased students' beliefs in their abilities to perform STEM related duties, (b) enhanced their sense of belonging to STEM community, (c) improved their beliefs about future positive outcomes from participating in STEM activities, and (d) strengthened the likelihood of them remaining in STEM pathways. The study results also revealed that there was a positive change in students' perceptions from Phase II to Phase III that the STEM outreach workshops enhanced their expectation beliefs about the usefulness of choosing a career in STEM for their future, which, in turn, increased the likelihood of their intention to major in STEM. The findings of the study offer insights for teachers, district and school administrators and stakeholders of STEM outreach programs to design and implement hands-on and exciting learning experiences.

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List of Abbreviations

CCA	Council of Canadian Academies
CMEC	Council of Ministers of Education, Canada
GLM	generalized linear model
MEMORE	mediation and moderation analysis for repeated measures
NRC	National Research Council
OECD	Organisation for Economic Co-operation and Development
P2	Phase II
P3	Phase III
SCCT	social cognitive career theory
STEM	science, technology, engineering and mathematics
STEM-CCG	STEM career choice goal
STEM-OP	STEM outreach program
STIC	Science, Technology and Innovation Council

Chapter 1

1 Introduction

The science, technology, engineering and mathematics (STEM) education movement has gained momentum since 2001 globally, despite the fact that the need for literacy in STEM has been highlighted since the early 1980s (Breiner et al., 2012; Moore et al., 2020; Sanders, 2009). For instance, STEM education and skills have been hyped by professional organizations and provincial and federal legislators in Canada. The report, *Science and Technology Strategy: Mobilizing Science and Technology to Canada's Advantage* (Industry Canada, 2007), is considered as the first comprehensive STEM-related document. Published by Canadian federal government, the report detailed STEM and sustainability education and stressed the influence of scientific and technological innovations on economic development and higher standard of living for Canadians (Krug & Shaw, 2016). The document fell short of specifically naming science, technology, engineering, and mathematics reflecting the newness of research on STEM education (DeCoito, 2016).

STEM education has been gradually embraced by Canadian government and businesses (Krug & Shaw, 2016). For example, the Expert Panel on STEM Skills for the Future, commissioned by the Council of Canadian Academies (CCA, 2015), published *Some Assembly Required: STEM Skills and Canada's Economic Productivity Report*. The report, requested by Employment and Social Development Canada to investigate the current state of STEM education and future employment and skill development in Canada, contained a variety of subjects that included:

> the relationships among STEM skills and innovation, productivity, and growth; whether Canada has a shortage or surplus of STEM graduates; what future demand for STEM skills in Canada could be; considerations for developing a STEM-literate society; the role of post-secondary education, and immigration and the global market. (CCA, 2015, para. 3)

In the United States, the release of the report, *Rising Above the Gathering Storm,* that was published in 2007 by the Committee on Prospering in the Global Economy of the 21st Century, was to respond to the lag in student performance in mathematics and science (Breiner et al., 2012; Krug & Shaw, 2016). STEM education has been mainly driven by two rationales: STEM literacy and global competitiveness. In other words, the main goals of STEM education have been to (a) develop STEM literacy in all students including nurturing 21st century skills (critical thinking needed for problem solving; skills for creativity, cooperation and self-directed learning; and environmental, scientific and technological literacy), and (b) prepare them to compete globally (Breiner et al., 2012; DeCoito & Myszkal, 2018; Harlow et al., 2020; Mohr-Schroeder et al., 2020; Owens & Sadler, 2020). According to Zollman (2012), STEM literacy is about improving student proficiency in comprehending and applying contents from STEM disciplines to solving real-world problems. Developing STEM literacy has become essential for all students regardless of whether they opt to pursue postsecondary STEM studies or carriers (DeCoito & Myszkal, 2018; DeCoito, 2016). It has been argued that navigating the present and fully participating in the increasingly technologically and scientifically advanced world have necessitated STEM literacy for all citizens (Bybee, 2010; DeCoito & Myszkal, 2018; Feinstein, 2009; Zollman, 2012).

STEM education has also been embraced for the reason of global competitiveness which, defined as “a set of factors that measure the level of productivity of a country” (Krug, 2016, p. 1858), is considered necessary to sustain competitive economic growth, and hence to achieve the prosperity and high standard of living (DeCoito & Myszkal, 2018; Martin-Paez et al., 2019). This is evidenced by Dodge, the Chair of the Expert Panel on STEM Skills for the Future, who stated that “after 18 months of study, we are convinced that high-quality investments in STEM skills—in both early education and in more advanced training—are critical to Canada’s prosperity” (CCA, 2015, p. vii). In the US, the *American Competitiveness Initiative*, announced in George W. Bush’s State of the Union Address given on January 31, 2006 and renewed into the *America COMPETES Reauthorization Act* of 2010, committed significant increase in federal funding with the objective of raising the amount of the STEM degree graduates (Krug & Shaw, 2016).

1.1 Study Context and Statement of the Problem

As China and India are developing into becoming world leaders in STEM and advanced technology industries (Atkinson & Mayo, 2010), STEM disciplines have been facing crisis in terms of students’ lack of interest and poor academic performance in Western countries such as

Australia (Office of the Chief Scientist, 2013), United Kingdom (Morgan & Kirby, 2016), United States (Krug & Shaw, 2016; Wang et al., 2011), and Canada (DeCoito, 2016; DeCoito & Myszkal, 2018).

According to Council of Ministers of Education, Canada (CMEC) (2020), 22.2% of 2018 postsecondary graduates in Canada were holders of STEM degrees which grew slightly from 18.5% in 2010. By this outcome, Canada, although ranking better than the United States that had 17.9% of graduates from STEM disciplines, fell far behind the percentage of 2018 STEM graduates in comparable major countries including Germany (35.6%) and Singapore (34.9%) (Buchholz, 2020). Additionally, only around 8.1% of Canadians in 2018, aged between 25 and 34, had postsecondary degrees in a science or engineering fields (CMEC, 2020). Whereas Canada ranks high relative to the Organisation for Economic Co-operation and Development (OECD) countries in life science, mathematics and statistics (holding 5th-8th places), it fares very low in engineering and technology fields (occupying 19th and 25th places respectively) (CCA, 2015). Therefore, the Science, Technology and Innovation Council's (STIC) *State of the Nation* report underlined Canada's lag in market innovation performance and stated that "Canada has fallen further behind comparator countries on key business innovation performance indicators, and the gap between Canada and the world's top five performers has widened" (STIC, 2015, p. 2). The report, emphasizing that Canada's poor business innovation performance would endanger its global competitiveness, recommended that educational institutions are advised to work "more closely with industry to develop curricula that better integrate science and technology knowledge with a broader set of business, entrepreneurship and commercialization skills that nurture creativity, intelligent risk taking and ambition" (STIC, 2015, p. 3). The findings of the report directly address the dire need to the advancement of STEM education to raise the knowledge and talent advantages of Canada.

The poor performances have been contributed to lack of interest by students in STEM and structural challenges such as traditional educational systems with established isolated STEM practices. These challenges have been posing substantial barriers to successful enactment of integrated STEM education (Breiner et al., 2012; DeCoito & Myszkal, 2018; Martin-Paez et al., 2019; Nadelson & Seifert, 2017; Sanders, 2009). Considerable number of interventions that have emphasized STEM enrichment programs have been initiated to increase students' interest in

STEM subjects and careers (Bagshaw, 2015; DeCoito, 2016; DeCoito & Myszkal, 2018; Krug & Shaw, 2016).

The context of the study was a STEM enrichment intervention, a STEM outreach program (STEM-OP; STEM outreach workshops and STEM outreach program were used interchangeably), that was implemented as a partnership between industry, a school board, a university and a charitable organization in Ontario, Canada. Facilitated by real scientists and engineers and informed by integrated and inquiry-based learning approaches, the STEM-OP presents students with hands-on and exciting activities in the form of half-day workshops that are associated with Ontario's Science and Technology curriculum (Ontario Ministry of Education, 2007). Integrated and inquiry-based learning (detailed in Chapter 2) in the study refers to a range of scientific experiences that help students make connections between STEM contents and real-life problems through the process of formulating questions and investigating hypothesis (De Jong et al., 2010; Keselman, 2003; Pedaste et al., 2012; Pedaste et al., 2015; Scanlon et al., 2011). The vision of the program has been to improve students' self-efficacy in STEM and increase their interest and love of science and technology. The study focused on examining the impact of the STEM-OP on middle and high-school students' STEM interest, identity and career pursuits.

1.2. Significance of the Study

Using secondary longitudinal data collected by Dr.DeCoito, the current study aimed at cross-sectionally and longitudinally investigating whether participation in the STEM-OP influenced middle and high-school students' interest in and identification with STEM. First of all, my study utilized mediation and longitudinal mediation procedures to examine research questions and test related hypotheses which were different from the generalized linear model (GLM) repeated measure techniques proposed to be used to analyze the original longitudinal data. Furthermore, the successful accomplishment of the study has a theoretical significance for educational researchers and practical relevance for teachers and administrators at schools and district boards.

The theoretical significance lies in the extension of social cognitive career theory (SCCT) (Lent et al., 1994) to science identity theory (Carlone & Johnson, 2007) to study students' STEM career pursuits. STEM-OP have shown to (a) boost interest in STEM, and (b) motivate students to persist in the STEM educational and career pathways which start at the early age and continue through choosing a STEM career (Ashford et al., 2016; Blotnicky et al., 2018; DeCoito, 2014, 2016; DeCoito & Myszkal, 2018; Krug & Shaw, 2016; Thomasian, 2011a; VanIngen-Dunn et al., 2016). The STEM educational and career pathways have been studied either by SCCT (Blanco, 2011; Hui & Lent, 2018; Kelly et al., 2009; Lee et al., 2015; Lent, Paixao, et al., 2010; Thompson & Dahling, 2012) or science identity theory (Dou et al., 2019; Godwin et al., 2016; Hazari et al., 2010; Lock et al., 2015, 2019; Monsalve et al., 2016; Verdin et al., 2018). There is a lack of studies that combine SCCT (Lent et al., 1994) and science identity theory (Hazari et al., 2010) to examine STEM career pursuits. A search for literature revealed that studies (Byars-Winston & Rogers, 2019; Hazari et al., 2010; Lock et al., 2015, 2019; Monsalve et al., 2016; Verdin et al., 2018) that blends SCCT and science identity theory to examine the process of students' career pursuits tend to focus on bivariate and multivariate relationships among contextual, cognitive, identity and career goal variables. Through extending the SCCT to science identity theory, the study intends to fill a research gap by examining both direct and indirect effects of high-school grade 12 (hereafter referred to as "high-school") students' participation in the STEM-OP influenced their STEM career choice goals (STEM-CCGs) through STEM self-efficacy, outcome expectations, interest and identity.

Moreover, SCCT was subsequently upgraded by scholars (Lent et al., 2001, 2018; Lent & Brown, 2019; Sheu et al., 2010) with the inclusion of the indirect effects of proximal contextual variables on career choice goals through self-efficacy and outcome expectations. The indirect pathways were missing from the original version of SCCT (Lent et al., 1994). The original and updated models of SCCT did not include an indirect pathway from contextual variables to career choice goals via interest. My research tried to contribute to the theoretical base of SCCT by investigating an additional pathway, that is, the indirect effect of the STEM-OP on STEM-CCG through STEM interest. Additionally, Lent et al. (2018) report, in their meta-analysis of literature framed by SCCT, a lack of longitudinal studies that assess temporal precedence of SCCT variables. My study aimed at contributing to the advancement of the SCCT by investigating the temporal effects of the direct and indirect association between the STEM-OP, social cognitive constructs, interest, identity and middle-school grades 7 and 8 (hereafter referred to as "middle-school") students' career choices.

Regarding the practical relevance, studies have shown that integrated inquiry-based learning (a) enhances students' problem-solving skills through improving their ability to understand connections among STEM themes and concepts and make them relevant to their everyday lives (Berlin & White, 1994; Froyd & Ohland, 2005; Lonning & DeFranco, 1997; Mason, 1996), and (b) increases student retention in STEM (Crosling et al., 2009). However, there is sustained confusion by teachers about integrated and inquiry-based STEM learning. This has resulted in the lack of classroom implementation of meaningful integration of contents and methods of various disciplines in a unified and efficient manner for students (DeCoito & Myszkal, 2018). Thus, the report by CCA (2015), pinpointing Canada's poor performance in global competitiveness, suggested that educational institutions would work hand in hand with industries to develop integrated STEM curriculum that promotes creativity and innovation. The insights from this study can be beneficial in helping teachers shift from transmission-based instruction to design and implement hands-on, integrated and inquiry-based instructional materials and strategies in a way that enhances students' self-efficacy and outcome expectation beliefs about and identification with STEM and stimulate their interests in STEM careers.

Finally, it is argued by scholars of SCCT (Lent & Brown, 2006; Lent et al., 2001) that studying the influence of environmental influences (i.e., outreach programs) on students' perceived beliefs in their abilities to do better in STEM subjects and their STEM career interests and choices can pinpoint productive ways for enhanced interventions. The STEM-OP in my study provides hands-on learning experiences in the form of a half-day workshops. These workshops are characterized as integrated and inquiry-based curriculum. The integrated inquiry-based curriculum refers to a range of scientific experiences that enable students to make connections between STEM disciplines (Bybee, 2013; Czerniak & Johnson, 2014; Honey et al., 2014; Jackson et al., 2020). In other words, in the workshops, students engage in the process of formulating and investigating questions regarding real-world problems and communicating findings to others (De Jong et al., 2010; Keselman, 2003; Pedaste et al., 2012; Pedaste et al., 2015; Scanlon et al., 2011; Wilhelm & Walters, 2006). Findings from the study can be used by school and district administrators to better develop and implement integrated and inquiry-based STEM curriculum and STEM intervention programs in a form that sparks students' interest in STEM subjects and promotes their scientific investigative abilities necessary to increase their STEM literary and career pathways.

1.3 Research Positionality

Research positionality, based on a fundamental argument that social inquirers cannot escape bringing their prior beliefs and assumptions to their studies (Creswell & Poth, 2018; Greene, 2007), implies a researcher's "role in social location/identity in relationship to the context and setting of the research" (Ravitch & Carl, 2016, p. 6). More specifically, researchers' positionality refers to the issues of insider-outsider regarding how the investigators views themselves in relation to a research and its participants (Berger, 2015; Dwyer & Buckle, 2009; Foote & Bartell, 2011).

The debate on insider-outsider involves concerns around research biases. I am in line with an argument that being a member of a group does not mean complete sameness with that group and absence of biases (Dwyer & Buckle, 2009). According to Dwyer and Buckle (2009), not holding a membership in a group does not indicate complete difference and presence of biases. It is argued that to "be considered the same or different requires reference to another person or group" (Dwyer & Buckle, 2009, p. 60), and, accordingly, there is "no self-understanding without other-understanding" (Fay, 1996, p. 241). Therefore, I agree with Dwyer and Buckle's (2009) argument that "the core ingredient is not insider or outsider status but an ability to be open, authentic, honest, deeply interested in the experience of one's research participants, and committed to accurately and adequately representing their experience" (p. 49).

My interest in this study is rooted in my personal experiences as a student and a teacher. My whole primary learning experience had been one that fully focused on text memorization and standardized tests. The curriculum used to provide no meaningful connection with real world problems that we would face in our daily and future lives. I was one of those fortunate ones who survived their school thanks to my parents' encouragement and dedication to learning themselves. For instance, I spent my schooling days listening to my parents share their reading of reports from science magazines about extracurricular activities in Japanese schools. The reports were about Japanese pupils who had opportunities to participate in out-of-school programs and experience application of integrated STEM subjects to solve real-life problems. My parents had hoped that we could have these types of learning opportunities. Having become a teacher with a strong commitment to the enhancement of student learning, I found myself constrained with a reality of resources and administrative limitations and teaching habitus that were mainly structured around ensuring students pass standardized tests.

As a graduate student, I have been introduced to a wide variety of works of my supervisor, Dr. DeCoito. I have, specifically, been interested in Dr. DeCoito's longitudinal study that has investigated the influence of an outreach program on students' STEM learning and career aspirations. While I was searching for a research topic, I was fortunate that Dr. DeCoito granted me access to the data of the longitudinal study that she has been collecting since 2013 to be used as secondary data for my study. Dr. DeCoito's study fulfilled my yearning as a student for the opportunities offered by the STEM-OP and my dream as a teacher to provide my students with programs that enable them to connect what they learn in classrooms with real-world applications and activate their interest in STEM learning and career pathways. Based on my learning and teaching experiences, I have a vested interest in (a) understanding what sparks students' interest in STEM disciplines and keeps them motivated on the pathways towards a career in STEM, (b) sharing insights from the study with my fellow educators for the betterment of teaching and learning, and (c) committing myself to accurately and authentically interpreting students' responses to the survey questions about the influence of the STEM-OP on their career pursuits.

1.4 Theoretical Framework

The study examined the influence of participation in the STEM-OP on middle and high-school students' self-efficacy and outcome expectation beliefs about, interest in, identification with and choice of STEM subjects and careers, and was guided by SCCT in a way that is extended to include science identity theory.

1.4.1 Social Cognitive Career Theory (SCCT)

SCCT (Lent et al., 1994) adapts and extends Bandura's (1986) social cognitive theory to career spheres and provides a framework of process models that help explain students' educational and career pursuits (Lent, 2013; Lent et al., 2002). SCCT endorses Bandura's (1986) bidirectional, triadic-reciprocal model of causality regarding the causal influences between persons, their behaviour and environment. The triadic-reciprocal system is based on the assumption of a co-determinant of the causal transactions in which each aspect of the personal, behavioral and environmental factors, that affects human functioning, influences the other two and is in turn influenced by them (Bandura, 1986, 1997).

Based on the underlying assumptions of the triadic-reciprocal system, SCCT is subdivided into two levels of reciprocal analysis which provides it with its theoretical constructs (Lent et al., 1994; Lent et al., 2000). The first level embodies cognitive-person variables that are composed of self-efficacy, outcome expectations, interest and personal goals (Lent, 2013; Lent et al., 1994). The second level consists experiential variables (e.g., informational sources of self-efficacy), person inputs (e.g., gender and race) and contextual factors (e.g., sociostructural support and barriers) (Lent et al., 1994, 2002) The two levels work together to influence educational and career-related behaviour (Lent & Brown, 2006; Lent et al., 2001; Lent et al., 2000; Lent et al., 2005).

1.4.2 Science Identity Theory

Scholars, pinpointing the multiple “selves” of individuals and the various contexts in which identity is performed, have used different conceptualization of identity including that of personal identity (Burke & Stets, 2009) and social identity (Tajfel & Turner, 1986). Personal identity is conceived by Burke and Stets (2009) as a set of characteristics that “define the person as a unique individual” (p. 124). Social identity, in Tajfel’ (1981) conceptualization, is defined as a “part of an individual's self-concept which derives from his [or her] knowledge of his [or her] membership in a social group (or groups) together with the value and emotional significance attached to that membership” (p. 255). There are two elements that are fundamental to the development of social identity: marking out boundaries of a group membership where individuals hold a sense of belonging to a particular group (e.g., mathematicians) (Burke & Stets, 2009; Hogg et al., 1995), and identifying an individual as a prototypical member of a group and distinguishing him or her from other groups (Hogg, 2007). Drawing on the social identity perspective, STEM identity in my proposed study refers to the extent to which students identify as a member of a particular STEM field (e.g., mathematics major, mathematicians), and perceive themselves as prototypical members of the STEM field (e.g., mathematicians are nerds).

Three theoretical constructs that include performance, competence and recognition, were identified by Carlone and Johnson (2007) for the study of science identity formation. Advancing Carlone and Johnson's (2007) framework, Hazari et al. (2010) added a fourth construct, interest, to investigate students' STEM-related identities. It is noteworthy to mention that Hazari et al. (2010) factored competence and performance into one construct because of research participants' inability to differentiate between developing a disciplinary content knowledge and attaining grades. Based on Hazari et al's (2010) framework, students' science identity is developed by science-related perceptions which is influenced by (a) the degree of their interest in science, (b) whether they maintain the belief that they have the capability to comprehend science and perform activities necessary to understand its contents and methods, and (c) how their competence as science persons are recognized by themselves and others (e.g., science community).

1.4.3 Social Cognitive Career Theory and Science Identity Theory

There is a similarity between the concept of self-efficacy of social cognitive theory (Bandura, 1986) and competence/performance construct of science identity theory (Carlone & Johnson, 2007). However, although the scholars of science identity theory (Godwin et al., 2016; Mahadeo et al., 2020) recognize that there is an overlap between competence/performance and self-efficacy beliefs, they argue that self-efficacy construct focuses on task-specific performance (Bandura, 1997) which is different from competence/performance construct of identity theory that is more broad and subject-specific. My study follows SCCT's (Lent et al., 1994) conceptualization of self-efficacy as one's belief in their ability to perform a specific task. There is plenty of literature demonstrating a positive relationship between task-specific self-efficacy and positive career interest and choice behaviours (Byars-Winston et al., 2017; Lent & Brown, 2006, 2019; Lent et al., 2018; Sheu et al., 2018).

Despite the above-mentioned difference, Hazari et al.'s (2010) science identity theory aligns with SCCT on constructs including outcome expectations and learning experiences. Hazari et al. (2010) utilized outcome expectations and learning experiences from SCCT (Lent et al., 1994, 2003) to study the impact of the three constructs (i.e., competence/performance, recognition and interest) on the development of science identity. According to Hazari et al.'s (2010) framework, the three influencing components that impact science identity formation are shaped by students' career-related outcome expectations and learning experiences. Additionally, the science identity theory (Hazari et al., 2010) and SCCT (Lent et al., 1994) conceptualize the interest construct in a similar vein. In both theories, interest is defined as an individual's desire to engage in career-related activities and is predicted by career-related outcome expectations and learning experiences. Therefore, the research only used recognition construct, which is defined as recognizing self and recognized by others as belonging to science community (Carlone & Johnson, 2007), to measure students' STEM identity.

The study extended SCCT to include science identity construct to examine the impact of the STEM-OP on middle and high-school students' STEM choice goals and career interest. I chose SCCT as my main theoretical framework for its articulation of the interaction between cognitive variables and environmental influences with the study of educational and occupational pursuits. However, the SCCT does not cover the identity construct that has demonstrated significant effect on the development of a pathway to career goals. Therefore, the extended version of SCCT with a science identity component is better suited for my proposed research to investigate the influence of the association among contextual factors (e.g., participation in the science outreach program), cognitive variables (e.g., self-efficacy, outcome expectation, interest) and science identity on middle and high-school students' STEM career choice goals.

1.4.4 Conceptual Framework

A hybrid conceptual framework that guided the study is composed of six constructs generated from extending SCCT to include science identity theory (Figure 1.1) and operationalized to investigate the role of the STEM-OP in increasing middle and high-school students' interest in and choice of a career in STEM. The six variables are:

(1) self-efficacy which refers to STEM students' perceived beliefs about their ability to perform academic tasks and activities (Bandura, 1986),

(2) contextual support in the form of the STEM-OP that refers to the factors that boost STEM students' academic and career-related interests and choice goals (Lent, 2013; Lent et al., 1994, 2000, 2002; Sheu et al., 2010).

(3) outcome expectations which denotes a belief about the results that STEM students expect from engaging in an academic task or activity (Bandura, 1986),

(4) interest which refers to students' likes and dislikes about a STEM activity or task (Lent et al., 2002),

(5) identity which refers to student's identification as a person of belonging to STEM community (Carlone & Johnson, 2007; Hazari et al., 2010), and

(6) career choice goal that is conceptualized as students' intention to pursue STEM-related academic and occupational paths (Lent et al., 1994; Lent & Brown, 2019).

The hybrid conceptual framework is based on the integrated form of SCCT's choice model (Lent et al., 2001, 1994; Sheu et al., 2010) and science identity theory (Carlone & Johnson, 2007; Hazari et al., 2010). According to the hybrid framework (Figure 1.1), that was proposed by the researcher, self-efficacy and outcome expectations are hypothesized to predict people's choice goals directly (Lent et al., 2002). It is also posited that self-efficacy and outcome expectations influence choice goals indirectly through interests (Sheu et al., 2010). Self-efficacy and outcome expectations influence interests, which then serve to promote academic and occupational choice goals (Lent et al., 1994). In accordance with the general argument in Bandura's (1986) social cognitive theory that the cognitive variables function in concert with environmental factors, the choice model maintains that people's perceptions about their abilities, expectations and interest in academic and career pursuits are either enhanced by the presence of a supportive environment (e.g., economic support, quality education including outreach programs) or deterred by contextual barriers (e.g., lack of quality education and economic support) (Lent, 2013; Lent et al., 1994, 2000, 2002; Sheu et al., 2010). In SCCT, contextual supports and barriers are assumed to predict choice goal behaviour directly and indirectly through self-efficacy and outcome expectations (Lent et al., 1994; Lent et al., 2001; Sheu et al., 2010). Furthermore, the conceptual framework that adds an additional pathway to the SCCT in the form of identity construct, predicts that the effects of contextual and cognitive variables on choice goal are influenced through (a) simple indirect pathway from identity and (b) serial indirect pathways from self-efficacy, outcome expectations, interest and identity. Simple and serial mediating effects are detailed in Chapter 3 in section 3.5.2 on data analysis.

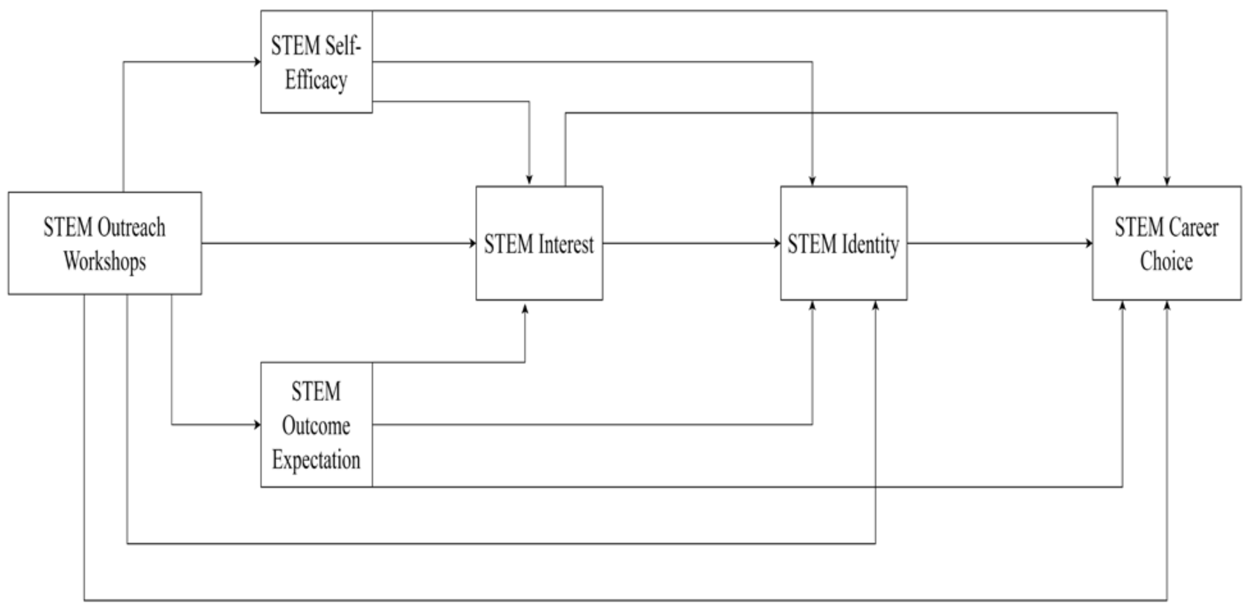

Figure 1.1: Integrated and Expanded Model of SCCT's Interest-Choice with Science Identity Theory

The hybrid conceptual framework was a lens through which the secondary data was analyzed and interpreted to examine the research questions and hypotheses. My study focused on direct and indirect effects of contextual supports on choice goals. The direct pathway included the STEM-OP directly influencing middle and high-school students' STEM-CCGs. In addition to the direct effect, the STEM-OP were proposed to predict STEM-CCG indirectly through self-efficacy, outcome expectations, interest and identity. The quantitative analysis of the secondary data was guided by two separate conceptual models. This was because PROCESS (Hayes, 2022) and mediation and moderation analysis for repeated measures (MEMORE) (Montoya & Hayes, 2017) macros for SPSS (detailed in Chapter 3), that were utilized to examine research questions and test the related hypotheses, did not include a model for testing parallel-serial mediation and longitudinal parallel-serial mediation with more than three mediators. The hybrid conceptual framework of the study was composed of four mediating variables that included self-efficacy, outcome expectations, interest and identity. In the first conceptual model (Figure 1.2), STEM self-efficacy served as first mediating variable of the serial mediators. In the second conceptual model, outcome expectations was treated as first mediator influencing interest and identity sequentially (Figure 1.3). It is noteworthy to mention that, in my research, self-efficacy and outcome expectations were not hypothesized to causally influence each other as proposed by SCCT.

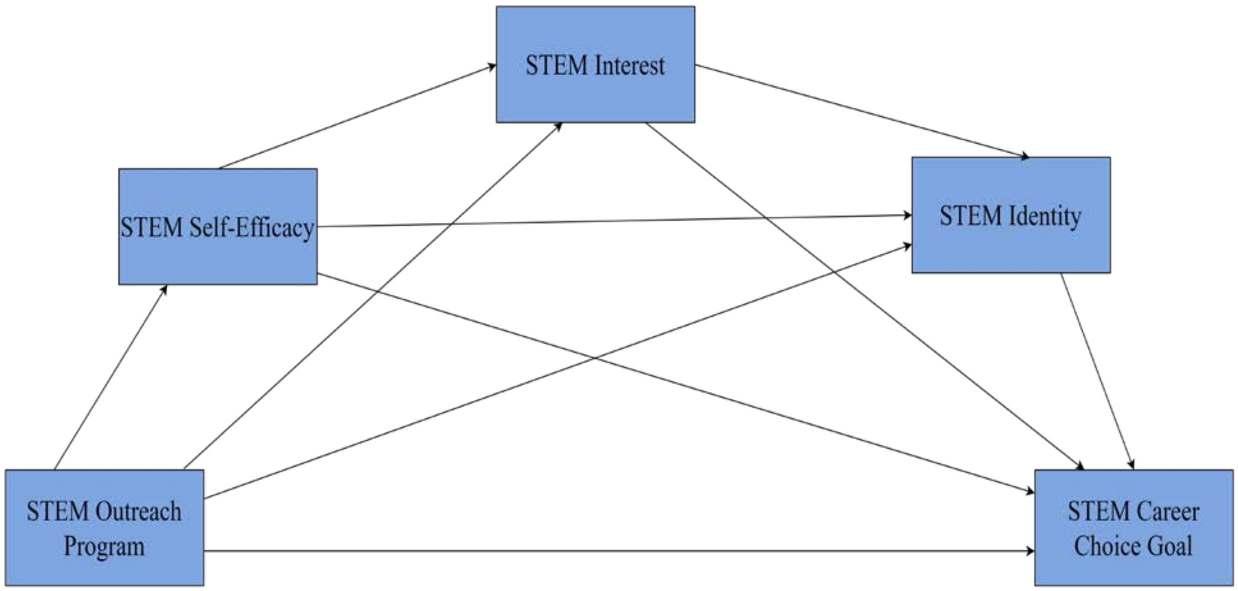

Figure 1.2: Extended Version of SCCT with Science Identity Construct and Self-Efficacy as First Mediator

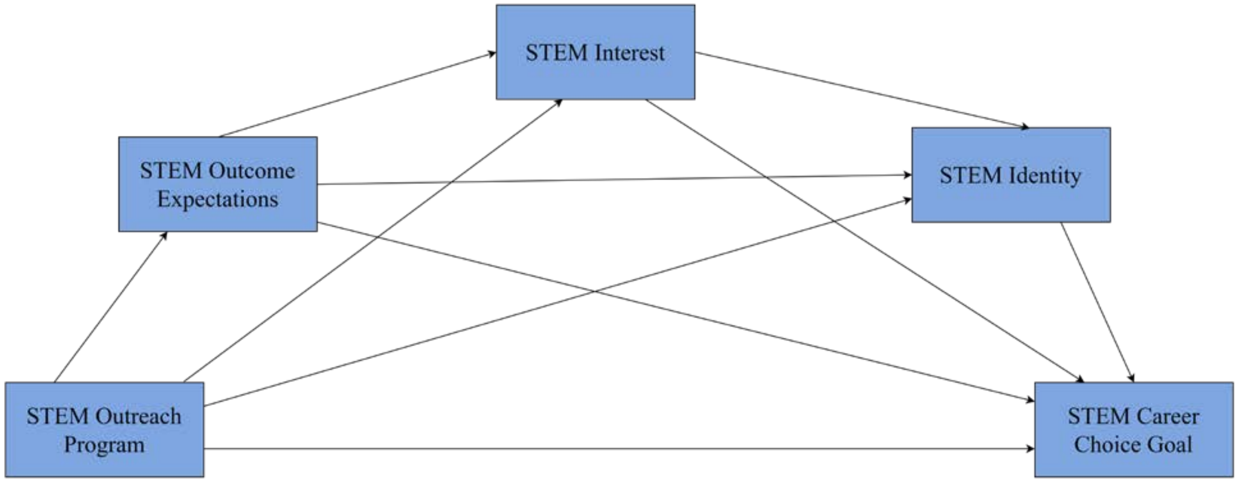

Figure 1.3: Extended version of SCCT with Science Identity Construct and Outcome Expectations as First Mediator

1.5 Research Questions and Hypotheses

The purpose of the cross-sectional and longitudinal study was twofold. First, it sought to examine whether there were direct and indirect effects of the STEM-OP on high-school students' STEM-CCGs via STEM self-efficacy, outcome expectations, interest and identity. Second, it pursued to investigate whether there was a change from Phase II (P2) to Phase III (P3) (detailed in Chapter 3 under section 3.2) in the direct and indirect effects of the STEM-OP on middle-school students' STEM-CCGs via STEM self-efficacy, outcome expectations, interest and identity. The following research questions and hypotheses, drawn from the hybrid conceptual framework, guided the analysis and interpretation of the secondary data:

1. To what extent did the STEM-OP influence high-school students' STEM-CCGs directly and indirectly through STEM self-efficacy, interest, and identity?

    Hypothesis 1A: The STEM-OP directly influences high-school students' STEM-CCGs.

    Hypothesis 1B: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM self-efficacy, interest, and identity.

2. To what extent did the STEM-OP influence high-school students' STEM-CCGs directly and indirectly through STEM outcome expectations, interest, and identity?

    Hypothesis 2A: The STEM-OP directly influences high-school students' STEM-CCGs.

    Hypothesis 2B: The STEM-OP indirectly influences high school students' STEM-CCGs through STEM outcome expectations, interest, and identity.

3. To what extent did the direct and indirect effects of the STEM-OP on middle-school students' STEM-CCGs through STEM self-efficacy, interest, and identity change from P2 to P3?

    Hypothesis 3A: Direct effect of the STEM-OP on middle-school students' STEM-CCGs changes from P2 to P3.

    Hypothesis 3B: Indirect effects of the STEM-OP on middle-school students' STEM-CCGs through STEM self-efficacy, interest, and identity change from P2 to P3.

4. To what extent did the direct and indirect effects of the STEM-OP on middle-school students' STEM-CCGs through STEM outcome expectations, interest, and identity change from P2 to P3?

    Hypothesis 4A: Direct effect of the STEM-OP on middle-school students' STEM-CCGs changes from P2 to P3.

Hypothesis 4B: Indirect effects of the STEM-OP on middle-school students' STEM-CCGs through STEM outcome expectations, interest and identity change from P2 to P3.

1.6 Overview of Chapters

This dissertation is organized into five chapters. The introductory chapter provided a brief overview of STEM education with special reference to Canada and the United States, illustrated the research context and problem, described the theoretical and conceptual framework, and provided research questions and related hypotheses that guided the process of the study. Chapter 2 offers a detailed account of literature on STEM education with a focus on STEM intervention programs. This chapter also included an in-depth discussion of the theoretical foundation of the study in the form of an integrated version of SCCT and science identity theory. Chapter 3 illustrates the dissertation methodology that described research design, secondary data source in the form of S-STEM survey, data analysis procedures, measurement validity and reliability, generalizability and ethical considerations. Chapter 4 reports findings of descriptive statistics and mediation and longitudinal mediation analysis. Chapter 5 provides a discussion of major findings along with implications for theoretical base of the SCCT and practice. Finally, Chapter 6 presents limitations of the study and suggestions for future research, and concluding remarks.

Chapter 2

2 Literature Review

The literature review is intended to examine the impact of the STEM-OP on middle and high-school students' attitudes towards, interest in, and identification with and choice of STEM learning and career. The first section of the literature review focuses on rationale for and definition of STEM education. Next, lack of interest and traditional and compartmentalized educational systems are explained as the main challenges of STEM education. This is followed by illustrating enrichment interventions including outreach programs that have been initiated to increase students' interest in STEM. In the last strand of the section, STEM-OPs are described and situated in curriculum studies through conceptualization of integrated inquiry-based STEM curriculum. After reviewing literature on STEM education and situating the study in curriculum, the theoretical framework of the study in the form of an extended version of SCCT (Lent et al., 1994) to include science identity theory is explained. In the first segment of this section, detailed accounts of SCCT are presented including description of its underlying assumptions, theoretical constructs and models of interest and choice. Finally, science identity theory that was conceptualized by Carlone and Johnson (2007) and advanced by Hazari et al (2010) is described.

2.1 Rationale for STEM Education

Developing STEM literacy in all students including nurturing 21st century skills and preparing them to compete globally have been primary drivers of STEM education (Breiner et al., 2012; DeCoito & Myszkal, 2018; Harlow et al., 2020; Mohr-Schroeder et al., 2020; Owens & Sadler, 2020). Regarding the benefits of STEM education, the literature has revealed that integrated STEM education, through providing a valuable learning context to solve real-world problems, improves the learning of students and increase their interest in STEM subjects (Brown & Bogiages, 2019; Martin-Paez et al., 2019; Stohlmann et al., 2012).

Findings from *WISEngineering*, a web-based scaffolding program that supports engineering design procedures and facilitates STEM integration, showed enhanced math performance of students on the measurement of Common Core math concepts (Chiu et al., 2013). A meta-analysis of 30 studies on the impact of integrated instruction on student learning found that (a) students in integrated curricular classrooms steadily exceeded the performance of students in non-integrated classrooms on both national and state-wide tests, and (b) integrated instruction was effective for science and mathematics teaching and was specifically helpful for low-performing students (Hartzler, 2000). Overall, interdisciplinary STEM education has exhibited potential for enhancing students' content retention and improving their real-world problem-solving skills (Stohlmann et al., 2012).

In a recent synthesis of literature, Martin-Paez et al. (2019) argued that STEM education has benefited students at cognitive, procedural and attitudinal learning levels. Regarding cognitive benefits, studies indicate that integrated STEM education improves students' interdisciplinary STEM knowledge (English et al., 2017; McLurkin et al., 2012), enables them to make connections between the knowledge they have and the STEM disciplines (Lou et al., 2017), and enhances their skills to utilize STEM knowledge to solve problems (Lamb et al., 2015; Lou et al., 2017; Shahali et al., 2017). Concerning procedural benefits, the literature highlighted that integrated STEM education boosts students' technological ability (Duran et al., 2014), cultivates creativity in students (Lamb et al., 2015), and helps students build up their practical experiences in solving real-world problems (Lou et al., 2017; Marle et al., 2014). In terms of attitudinal benefits, scholars have found that STEM education inspires optimistic attitude towards STEM disciplines (Toma & Greca, 2018; Tseng et al., 2013), stimulates dedication to STEM subjects (Kim et al., 2015), and increases student interest in postsecondary STEM degrees (Lamb et al., 2015; Lou et al., 2017; McLurkin et al., 2012; Shahali et al., 2017; Tseng et al., 2013).

2.2 Defining STEM Education

STEM education was pioneered by the National Science Foundation (NSF) that first, in the early 1990s, adopted the acronym of SMET for science, mathematics, engineering and technology (Sanders, 2009). For the issues of similarity between the term SMET and the word "smut", NSF later changed the acronym to STEM (Sanders, 2009). It was Judith A. Ramaley, a former director of the NSF's Education and Human Resources Division, who first introduced the acronym STEM when she used it to specify science, technology, engineering and mathematics curriculum (Breiner et al., 2012).

STEM education is defined in various ways and there are as many definitions as the authors who have written on it (Martin-Paez et al., 2019). For example, Sanders (2009) defines STEM education as “approaches that explore teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects” (p. 21). Merrill (2009) perceives STEM education as a meta-discipline focused on learning standards where teachers follow an integrated teaching and learning approach to design and deliver problem-solving-oriented lesson contents. In a similar vein, Vasquez (2015) described STEM as “a meta-discipline—an integration of formerly separate subjects into a new and coherent field of study” (p. 11). According to DeCoito (2014), STEM education is about the intersection of science, technology, engineering, and mathematics. Emphasizing the problem-based nature of STEM education, Moore et al. (2014) defined STEM education as “an effort to combine some or all of the four disciplines of science, technology, engineering, and mathematics into one class, unit, or lesson that is based on connections between the subjects and real-world problems” (p. 38).

For the purpose of my study, I rely on the conception given by Kelley and Knowles (2016) who attempt to address the three main areas of STEM education: curriculum, teaching and learning. They define STEM education as “the approach to teaching the STEM content of two or more STEM domains, bound by STEM practices within an authentic context for the purpose of connecting these subjects to enhance student learning” (Kelley & Knowles, 2016).

The main reason behind the lack of a precise definition lies in the broad range of concepts employed by researchers to clarify STEM education such as STEM curriculum (Lou et al., 2017), STEM literacy (Abdullah et al., 2014; Marle et al., 2014), STEM identity (Hughes et al., 2013), STEM learning (Lamb et al., 2015), and STEM teaching (Lou et al., 2017). Although various conceptualizations exist, all the above definitions share one thing in common, that is, the “integration” aspect of STEM education (Breiner et al., 2012; Vasquez, 2015). STEM education refers to exploring alternative approaches to traditional compartmentalized teaching and learning to STEM through integrating theses disciplines into one “meta-discipline” (DeCoito & Myszkal, 2018; Sanders, 2009; Vasquez, 2015). Referring to the integration of the four disciplines into “a new ‘whole’ rather than in bits and pieces” (Ejiwale, 2013), STEM education as “meta-discipline” signifies interdisciplinarity that focuses on solving real-world problems by integrating two or more disciplines into one cohesive and holistic teaching and learning process that transcends the limits of an individual discipline (Ejiwale, 2013; Martin-Paez et al., 2019).

2.3 Challenges of STEM Education

There are various hindering factors to the implementation of STEM education. However, lack of interest by students in STEM (DeCoito & Myszkal, 2018; Martin-Paez et al., 2019), and structural challenges in terms of traditional and compartmentalized educational systems that have dominated STEM disciplines appear to pose the most significant barriers to the effective enactment of STEM education (Breiner et al., 2012; DeCoito & Myszkal, 2018; Sanders, 2009). There has been wide-ranging agreement among science education scholars that one of the primary causes of underrepresentation of STEM in educational systems in Canada and United States has been lack of interest by students in STEM, especially during their initial school years (DeCoito & Myszkal, 2018; Martin-Paez et al., 2019; Sanders, 2009). As a result, there are more STEM job offerings than STEM graduates in Canada and the United States (Byars-Winston, 2014; DeCoito, 2016; Krug & Shaw, 2016).

It has also been agreed that the problems of integrated STEM education and the reasons behind the loss of interest by young minds in STEM have been primarily attributed to the fact that the attainment of integrated STEM education is impeded by educational systems with institutionalized and compartmentalized STEM structure that are discipline centered rather than inquiry and integration centred (Nadelson & Seifert, 2017). As argued by DeCoito and Myszkal (2018) and Sanders (2009), a great deal of STEM education is “business as normal”; neither integrating the STEM fields of study nor offering enhanced alternative instructional approaches.

2.4 STEM Enrichment Interventions

Through the years a considerable number of initiatives have been put forward to increase interest in STEM. National institutions for science and science education like the National Science Foundation in the United States, the Office of the Chief Scientist in Australia, and the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Fulbright Canada STEM Award have been advocating for the advancement and enactment of initiatives that reinforce teachers and support students’ STEM abilities and interest (Bagshaw, 2015; DeCoito, 2016; DeCoito & Myszkal, 2018; Krug & Shaw, 2016). These initiatives have emphasized STEM enrichment interventions that included extracurricular formal and informal learning opportunities (DeCoito & Myszkal, 2018).

STEM enrichment programs are generally divided into two categories: out-of-school and school-based programs. The most common out-of-school programs are robotics competitions (Ching et al., 2019), STEM summer camps, and after school science clubs (Young et al., 2017). The school-based enrichment programs include No Child Left Behind (Dee & Jacob, 2011), Project Lead the Way (Reid & Feldhaus, 2007), STEM focused schools (Wiswall et al., 2014), and STEM-OPs (Shanahan et al., 2011; Taylor et al., 2008). Regardless of program formats, both of the categories of STEM enrichment interventions intend to increase K-12 students' interest in STEM subjects and to motivate them to continue on STEM career pathways (George et al., 2019; Young et al., 2017).

My study was centred around a school-based STEM-OP. The STEM outreach interventions take forms such as interactive collaborative STEM workshops, STEM ambassador arrangements, mentoring, manufacturing field visits, STEM career sessions (Aslam et al., 2018), and science camps and clubs (DeCoito & Myszkal, 2018). STEM-OPs provide opportunities such as engagement with engineers and scientists, exposure to STEM role models and career pathways, hands-on investigative experiences (DeCoito & Myszkal, 2018), and financial assistance for competitive STEM students (George et al., 2019; Rincon & George-Jackson, 2016). Through these opportunities and resources, STEM-OPs (a) strive for widening student involvement in STEM pathways (George et al., 2019), and (b) seek to help students confront their stereotypes about STEM subjects (Martin, 2016) including that of gender stereotypes in science (Archer et al., 2013).

Represented by national organizations for science, professional institutions, voluntary organizations and universities, STEM-OPs (a) boost interest in STEM, (b) help value and appreciate the world of STEM subjects, and (c) motivate enrolling in STEM pathways (Aslam et al., 2018; DeCoito, 2016; DeCoito & Gitari, 2014; DeCoito & Myszkal, 2018; Krug & Shaw, 2016; Thomasian, 2011). Additionally, STEM enrichment programs are deemed to inspire career pursuits by participants through offering more enjoyable and interactive activities than the activities experiences by the conventional school curriculum (Mosatche et al., 2013).

Various studies have examined the influence of participation in STEM-OPs on students' attitudes and interests in STEM content and careers. For instance, data from mixed-methods evaluation of the Inquiry-Based Science and Technology Enrichment Program for middle school-aged female students (Kim, 2016) and a lab sciences outreach program for high school students at Oklahoma State University (Angle et al., 2016), that provided hands-on and interactive experience, reported substantial positive change in students' attitudes and interests in STEM and enhanced willingness to pursue a career in STEM disciplines. In another mixed-methods study of precollege outreach program intervention, Physics of Atomic Nuclei program, Constan and Spicer (2015) found that students who participated in the program indicated that their interest in STEM careers increased and became clearer and more focused. Regarding the outreach program and science stereotype, results from a study of a one-time science intervention by Laursen et al. (2007) showed that an inquiry-based science outreach program helped students to (a) better understand the connections between science concepts and day to day issues, (b) improve their attitudes towards science, and (c) revoke their stereotypical perceptions about scientists.

A three-year longitudinal study of hands-on and inquiry-based summer science camp by Gibson and Chase (2002) indicated that the outreach program could stimulate students' interest in science and motivate them to put extra effort into science activities. Similarly, results from studies (Abaid et al., 2012; Laut et al., 2014; Yates, 2013; Yilmaz et al., 2009) on summer engineering camps show increased interest in STEM fields. Also, on engineering enrichment intervention, Scherrer (2013) examined the impact of a one-time outreach program on K-12 students' attitudes towards engineering. The program, facilitated by undergraduate engineering students, focused on how to start preparing for an engineering degree in middle and high schools, and how engineers could contribute to the improvement of the world. The pre- and post survey results demonstrated that the outreach program helped enhance students' perceptions and awareness of the significance of engineering to the world and increased the likelihood of students choosing a career in engineering.

2.4.1 STEM Outreach Programs (STEM-OPs)

My study examined the influence of a STEM enrichment intervention on students' interest in STEM learning and careers and focused on a school-based STEM-OP that was initiated in Ontario as a partnership between a school board, a university, and outreach program and industry. The STEM-OP provided students with hands-on learning experiences in the form of half-day workshops (DeCoito & Myszkal, 2018) that were linked to Ontario's Science and Technology curriculum and covered subjects including matter, energy, systems and interactions, structures and functions, sustainability and stewardship, and change and continuity (Ontario Ministry of Education, 2007). The STEM-OPs, guided by scientists and engineers, help expose students to enriched STEM learning and career opportunities (Aslam et al., 2018; DeJarnette, 2012), and show great potential in terms of enhancing students' ability to acquire educational investigative and 21st century skills and develop a deepened understanding of STEM content and careers (DeCoito & Gitari, 2014; DeCoito & Myszkal, 2018).

2.4.1.1 Integrated Inquiry-Based STEM Curriculum

The hands-on STEM workshops are integrated in terms of STEM disciplines and inquiry-based in their instructional approaches (DeCoito & Myszkal, 2018). Regarding the integrated nature of the STEM-OPs, Canada's STIC urges educational institutions to enhance Canada's knowledge and talent bases through working "more closely with industry to develop curricula that better integrate science and technology knowledge with a broader set of business, entrepreneurship and commercialization skills that nurture creativity, intelligent risk taking and ambition" (STIC, 2015, p. 3). On a similar note, the National Research Council (NRC, 1996) states that "learning science is something students do, not something that is done to them" (p. 2) requiring encouraging students to develop learning through inquiry consisted of exploration, problem solving, collaboration, and connecting STEM subjects to the use of the everyday life issues (NRC, 2012, 2013). Accordingly, the STEM-OP in my research was aligned with integrated inquiry-based curriculum.

2.4.1.1.1 Integrated STEM Curriculum

The integrated STEM curriculum is based on the premise that the majority of real-world problems that students face are connected and multidisciplinary, and hence the STEM curriculum are required to provide opportunities that include integrative utilization of multiple STEM themes and concepts that reflect the real-life connectedness outside of school (Rennie et al., 2018; Wang et al., 2011). Numerous studies of integrated curriculum concluded that students process information through connections more successfully rather than disconnected pieces of information (Beane, 1996; Furner & Kumar, 2007; Satchwell & Loepp, 2002). According to Stohlmann et al. (2012), “much of the newest and most valuable knowledge” has involved “more than one subject” (p. 32). Integrated curriculum, as shown by various studies, (a) improves students’ problem-solving skills through enhancing their ability to understand connections among STEM themes and concepts and make relevance of them to their everyday lives (Berlin & White, 1994; Froyd & Ohland, 2005; Lonning & DeFranco, 1997; Mason, 1996), and (b) boost student retention in STEM (Crosling et al., 2009).

Despite the above-mentioned benefits of the integrated STEM curriculum, much of the educational practice is business as usual favoring a unidisciplinary approach to knowledge that does not embed the curriculum in the multiple and complex real-world problems in which students live (DeCoito & Myszkal, 2018; Rennie et al., 2018; Sanders, 2009). The unidisciplinary approach to curriculum creates “snippets of content for students to digest by stripping away the connectedness and context from real-world science” and “removes the excitement of knowledge building and its significance in solving the problems of the day” (Rennie et al., 2018, p. 93). In a study on content-driven and transmissive science curricula, Osborne and Collins (2001) reported that “pupils were being frog-marched across the scientific landscape, from one feature to another, with no time to stand and stare, or absorb what it was that they had just learnt” (p. 450). The compartmentalized curriculum has resulted in students having little interest in and giving peripheral relevance to STEM disciplines (Lyons & Quinn, 2010; Stocklmayer et al., 2010).

Therefore, it is suggested that it is a fruitful course of action to develop integrated STEM curriculum that responds to the needs of students’ learning in a complex and multifaceted world and empower them to become successful and valuable citizens (DeCoito & Myszkal, 2018; Rennie et al., 2018). The question here is What does this integrated STEM curriculum entail? The term curriculum derives from the Latin word "currere" and means a "course to be run" (Eisner, 2002, p. 25). The literature reveals many conceptions of curriculum (Doyle, 1992; Eisner, 2002) because of its confusing orientations (e.g., curriculum as a course of study, content, experience) and its contested nature "comprised of various and autonomous discourses" (Pinar et al., 2008, p. 26). In his book, *The Curriculum*, Franklin Bobbitt (1918) defines curriculum as "the entire range of experiences, both undirected and directed, concerned in unfolding the abilities of the individual" (p. 43). Noting his disagreement with the notion that children can be separated from their experience, John Dewey (1902) states that "the child and the curriculum are simply two limits which define a single process" (p.11).

The differing perceptions of curriculum that underline the complexities of curriculum conceptualization are also present in the concept of integrated STEM curriculum. However, as it is emphasized in the conceptualization of STEM education (Breiner et al., 2012; Vasquez, 2015), integrated STEM curriculum is distinguished by the aspect of integration (Jackson et al., 2020; Moore et al., 2014). Deriving from the Latin word "integrates", integration means making whole (Rennie et al., 2018). In its straightforward conception, curriculum integration refers to connecting previously fragmented contents and skills together (Kysilka, 1998). According to Mason (1996), curriculum integration is defined as "a knowledge view and curriculum approach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience" (p. 264).

Although there is no agreement on the precise definition for integrated STEM curriculum, my study follows a consensus among scholars for conceptualizing it as a range of experiences that enables students to make connections between science, technology, engineering, and mathematics in the context of complex real-world situations (Bybee, 2013; Czerniak & Johnson, 2014; Honey et al., 2014; Jackson et al., 2020; National Academy of Engineering and National Research Council, 2014).

Further to the conceptualization, the concept of integrated STEM curriculum is interchangeably used with multidisciplinary, interdisciplinary and transdisciplinary curriculum. In fact, scholars have approached integrated STEM curriculum from these three starting points (Rennie et al., 2012; Rennie et al., 2018; Wang et al., 2011). Multidisciplinary approach to integrated curriculum draws on more than one separate discipline to address a central theme (Drake & Burns, 2004; Rennie et al., 2012). In interdisciplinary approach to integrated curriculum, the boundaries between disciplines are blurred and the curriculum emphasizes the commonality in learning concepts and skills across disciplines to examine a particular phenomenon or a theme (Drake & Burns, 2004; Mansilla, 2005; Rennie et al., 2012).

Transdisciplinary curriculum is considered as fully integrated in which the boundaries between disciplines disappear (Rennie et al., 2012). In transdisciplinary approach to integrated curriculum, disciplines are fused together and the curriculum is developed and implemented around students' questions, concerns and real-life contexts rather than being confined to the borderlines of disciplines (Drake & Burns, 2004; Rennie et al., 2012). In my study of the influence of the STEM-OP workshops on students' interests in STEM learning and career, the interdisciplinary approach to curriculum integration intersects with inquiry-based curriculum in terms of the emphasis on student questions and real-world issues.

2.4.1.1.2 Inquiry-Based Curriculum

Inquiry, simply, means the process of asking question (Cambridge Dictionary, n.d). In the realm of education, inquiry is an approach to learning driven by curiosity and wonderings that invoke learners to raise questions and engage in investigative attempts to make sense of the world around them (Lindfors, 1999; Ontario Public Service, 2016; Wells, 1999; Zuckerman et al., 1998). According to NRC (1996), inquiry-based learning incorporates multifaceted activities that involve students raising questions and making the use of observation and various sources of data "to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results" (p. 23).

In other words, in inquiry-based learning students use methods and practices that are comparable to those of professional scientists (Keselman, 2003) in terms of identifying causal relations, framing hypotheses and testing them by experiments and/or observations (Pedaste et al., 2012).

Accordingly, inquiry-based learning is also known as a scientific practice which refers to a process that divides learning “into smaller, logically connected units that guide students and draw attention to important features of scientific thinking” (Pedaste et al., 2015, p. 48). The individual units and their connections in the scientific process models an inquiry cycle which enables students to perform a self-regulated and a combination of inductive and deductive learning practices to investigate a relationship between variables (Pedaste et al., 2015; Wilhelm & Beishuizen, 2003). In terms of curricular enactment, inquiry-based curriculum is described as inquiry cycle (Bishop et al., 2004; Laxman, 2013).

The educational literature has approached inquiry cycles through various forms (Bybee et al., 2006; Klahr & Dunbar, 1988; White & Frederiksen, 1998). For instance, Dewey (1933) highlighted some important phases of inquiry-based learning including outlining a problem, framing a hypotheses, and carrying out tests. Based on a systematic review of literature on inquiry phases and cycles, Pedaste et al (2015) proposed an inquiry-based learning framework that was composed of five inquiry cycles: orientation, conceptualization, investigation, conclusion, and discussion. *Orientation* emphasizes motivating curiosity and interest around a problem. In this cycle, a learning topic or a learning challenge is introduced by a teacher or a learner and a problem is stated (Pedaste et al., 2015; Scanlon et al., 2011). *Conceptualization* refers to a process of apprehending a concept or concepts regarding a stated problem and is divided into two sub-cycles: questioning and hypotheses generation (Pedaste et al., 2015). While questioning is concerned about framing investigable questions (White & Frederiksen, 1998), hypothesizing is about formulation of a testable set of statements (De Jong et al., 2010).

Investigation is the cycle where students’ curiosity is put into action to answer the questions and hypotheses that were stated (Scanlon et al., 2011). The sub-cycles of investigation include exploration, experimentation, and data interpretation (Pedaste et al., 2015). Both exploration and experimentation encompass the design and execution of investigative activities. However, while it is not required to state a hypotheses in exploration, the starting point of an experimentation phase is a specific hypotheses (De Jong et al., 2010; Lim, 2004; Pedaste et al., 2015; White & Frederiksen, 2005). The outcome of exploration and experimentation is data collection. The final phase of investigation focuses on interpretation of the collected data to answer the research questions and produce a synthesis of new knowledge (Bruce & Casey, 2012; Lim, 2004; White

& Frederiksen, 1998; Wilhelm & Walters, 2006). *Conclusion* is the primary findings of the inquiry-based learning stated (Scanlon et al., 2011). *Discussion* consists of sub-cycles of communication and reflection (Pedaste et al., 2015). Communication is seen as external discussion with others where students present their findings to others and gather feedback from them (Scanlon et al., 2011). Reflection refers to the process of self-reflecting on the overall inquiry cycle to make suggestions to improve the current inquiry-based learning process and devise a proposal for another inquiry cycle (Lim, 2004; White & Frederiksen, 1998).

Curriculum is implemented in classrooms through transmissive and transactional modes (Haber et al., 2019; MacPherson, 2011). In other words, schools generally practice either direct instruction-based curriculum or inquiry-based curriculum (Haber et al., 2019) or a combination of both (MacPherson, 2011). In a direct instruction-based curriculum, also called transmission approach to curriculum, students depend heavily on teachers to accumulate factual and static knowledge (Haber et al., 2019; MacPherson, 2011; Miller, 2019; Rennie et al., 2018). The transmissive curriculum, historically, has had two styles: behavioural and traditional. The relationship between curriculum and child in behavioural style is identified as stimulus-response (S-R), while the subject curriculum in traditional approach is taught through traditional methods (e.g., lecture, recitation, memorization). In both styles, there is a one-way transmission from curriculum and teachers to students (Miller, 2019).

In contrast, inquiry-based curriculum, also known as transactional curriculum, focuses on students actively constructing their knowledge through exploration, experimentation, and investigation (Alfieri et al., 2011; Edson, 2013; Haber et al., 2019; MacPherson, 2011). The transactional curriculum is aimed at promoting learning as a process of acquiring thinking abilities including reasoning, questioning and problem solving rather than attaining fixed and inert information (Kuhn, 2005; Miller, 2019). The transaction approach to curriculum finds its roots in the educational theories of John Dewey (1938) who emphasized the importance of scientific methods that put learners' autonomy and improving their thinking and reasoning skills over content knowledge. Dewey (1938) asserts that the scientific method is:

> The only authentic means at our command for getting at the significance of our everyday experiences of the world in which we live… Consequently, whatever the level of experience,

> we have no choice but either to operate in accord with the pattern it provides or else to neglect the place of intelligence in the development and control of a living and moving experience. (p. 88)

After describing the integrated STEM curriculum and inquiry-based curriculum and the purpose of my study, I conceptualize the integrated inquiry-based STEM curriculum as a range of scientific experiences that enable students to make connections between science, technology, engineering, and mathematics (Bybee, 2013; Czerniak & Johnson, 2014; Honey et al., 2014; Jackson et al., 2020; National Academy of Engineering and National Research Council, 2014). This is accomplished through engaging them in the process of formulating and investigating questions regarding real world problems and communicating findings to others (De Jong et al., 2010; Keselman, 2003; Pedaste et al., 2012; Pedaste et al., 2015; Scanlon et al., 2011; White & Frederiksen, 1998; Wilhelm & Beishuizen, 2003; Wilhelm & Walters, 2006).

2.5 STEM Education, Career Pathways, and Theoretical Framework

As discussed above, STEM education has been mainly driven by developing STEM-capable and STEM literate students who are able to compete in the global economy (Breiner et al., 2012; DeCoito & Myszkal, 2018). On this note, the primary purpose of STEM enrichment programs has been to develop students' STEM literacy along the STEM educational and career pathways (Ashford et al., 2016; Blotnicky et al., 2018; DeCoito & Myszkal, 2018; VanIngen-Dunn et al., 2016). The study examined the impact of a STEM-OP on middle and high-school students' STEM interests and career pathways and was guided by an extended version of SCCT with the inclusion of science identity theory.

2.5.1 Social Cognitive Career Theory (SCCT)

Considered as an integrative framework, SCCT is primarily derived from Bandura's (1986) social cognitive theory. It also draws on other socio-cognitive theories of academic and career behaviours including Krumboltz's (1997) social learning theory of career decision making, Holland's (1997) theory of career choice, Super's (1990) career development theory, and cognitive theories of vocational interest (Barak, 1981), and achievement-related decisions

(Eccles, 1987). SCCT, as an integrative framework that bridges diverse perspectives, provides a greater explanatory system that helps better delineate the essential processes that connect various variables (Lent et al., 2002) and understand "the relationships among values, needs, aptitudes, and interests as they operate in concert to influence occupational choice making" (Brown, 1990, p. 346). It is suggested by Hackett and Lent (1992) that a unifying theoretical approach can:

> (a) bring together conceptually related constructs (e.g., self-concept, self-efficacy); (b) more fully explain outcomes that are common to a number of career theories (e.g., satisfaction, stability); and (c) account for the relations among seemingly diverse constructs (e.g., self-efficacy, interests, abilities, needs). (p. 443)

Adapting and extending Bandura's (1986) social cognitive theory to the spheres of academic and career development, SCCT offers a framework of process models that helps examine students' educational and occupational pursuits (Lent, 2013; Lent et al., 1994, 2002). Generally, SCCT explains the processes and mechanisms that take place within educational and career pursuits by investigating five conceptually different yet interlocking models of interest, choice, performance (Lent et al., 1994), satisfaction (Lent & Brown, 2006), and self-management (Lent & Brown, 2013). Before attending to the SCCT models in detail, it is essential to address the underlying assumptions and constructs of the theory.

2.5.1.1 Underlying Assumptions

There are two major assumptions that are fundamental to understanding how SCCT approaches the transactions between person, behaviour and environment. The first is concerned with the debate about whether the interaction between persons and their environment is static or dynamic. The principal career theories (known as P-E fit theories) incline to perceive person and environment interaction in trait-oriented terms that base the variables that drive career behaviour in personal attributes (e.g., cognitive and affective features, physical characteristics), and consider them as predictable and static across situations and time (Lent, 2013; Lent et al., 2002).

While SCCT recognize the importance that the foundational career theories give to the role of features like interests and goals in career development (Lent, 2013), it argues that P-E fit theories do not adequately manifest the fluid nature of person-environment interaction, and, accordingly, underestimate personal agency to transform, improve, and self-regulate (Lent et al., 2002). By emphasizing personal cognitions and behaviour, SCCT offers a framework that complements what the P-E fit theories are missing from the social cognitive theory that underlines the significance of “the situation and domain-specific nature of behavior, relatively dynamic aspects of the self-system, and the means by which individuals exercise personal agency” (Lent et al., 1994, p. 82). Deemed as the critical mediators of the development of educational and career interests and choices, people’s personal cognitions (e.g., self-efficacy, outcome expectations, interest) are not fixed, but dynamic and change depending on specific performance domains and behavioural and environmental situations (Lent, 2013; Lent et al., 2000).

The second underlying assumption entails SCCT’s conceptualization of causal influences that distinguish it from P-E fit theories. Following partially bidirectional view on causality, the P-E fit theories perceive persons and their environments as affecting each other, but they conceive behaviour as an outcome of the person-environment interaction (Lent et al., 2002). With regard to the causal influence between persons and their behaviour and environment, SCCT endorses Bandura’s (1986) fully bidirectional, triadic-reciprocal model of causality. The triadic model (Figure 2.1) promotes the position of a co-determinant of the causal transactions and contends that each aspect of the personal, behavioral and environmental factors, that affects human functioning, influences the other two and is in turn influenced by them (Bandura, 1986, 1997).

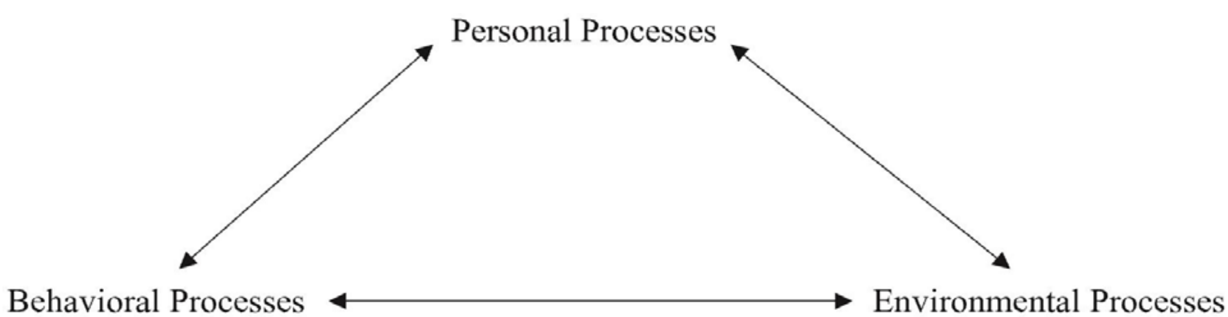

Figure 2.1: Model of Reciprocal Interactions Between Behavioral, Environmental, And Personal Processes

Stated differently, the social cognitive theory underlines the dynamic and cyclical features of human functioning in which “people are agentic operators in their life course, not just on-looking hosts of internal mechanisms orchestrated by environmental events”, and their cognitive, affective and biological factors interact with “behavioral patterns” and “environmental events” to influence each other, such that changes in one result in changes in the other” within “a network of reciprocally interacting influences” (Bandura, 2001, pp. 156–169). For instance, students who believe they are competent in mathematics (self-efficacy-personal) choose to increase their effort to learn (behavioural) (Schunk & Usher, 2019), and a teacher’s compliment of their competence in learning (environmental) may foster their perception of self-efficacy (personal) and motivate them persist in engaging in constructive behaviours (Schunk & DiBenedetto, 2020). SCCT, in accordance with Bandura’s (1986) triadic system, perceives behaviour as a part of “mutual, interacting influences among persons, their environment, and behavior” which "operate as interlocking mechanisms that affect one another bidirectionally" to influence career-related attitudes and behaviour (Lent et al., 2002, p. 261).

2.5.1.2 Theoretical Constructs

Anchored in the underlying assumptions advanced in the previous section, SCCT is subdivided into two reciprocal levels of analysis (Lent et al., 1994, 2000). The first level incorporates cognitive-person variables including self-efficacy, outcome expectations, and personal goals (Lent, 2013; Lent et al., 1994). The second level includes experiential, personal, and environmental variables and is based on the argument that cognitive-person variables do not “arise in a social vacuum” (Lent et al., 2005, p. 107). Rather, they function in a concert with experiential variables (e.g., informational sources of self-efficacy), person inputs (e.g., gender and race) and contextual factors (e.g., sociostructural support and barriers) to influence career-related behaviour (Lent & Brown, 2006; Lent et al., 2001, 2000, 2005). This section introduces self-efficacy, outcome expectancy, personal goal, learning experience, person input, and environmental influence as the theoretical constructs of SCCT. The six constructs are viewed as the fundamental mechanisms by which individuals exert human agency regarding their educational and career pursuits (Lent, 2013; Lent & Brown, 2006; Lent et al., 1994, 2000, 2002).

Self-Efficacy. Viewed as the principal component of Bandura’s (1986) social cognitive theory, self-efficacy signifies people’s beliefs about “their capabilities to organize and execute courses of action required to attain designated types of performances” (Bandura, 1986, p. 391). Answering the question “Can I do this?”, self-efficacy portrays individuals’ internally garnered confidence that motivates them to believe that they can perform the tasks needed to achieve their goals (Bandura, 1997). Self-efficacy, constituting the foundation of SCCT, is an essential predictor of educational and career choices along the lines of academic and career development (Lent et al., 2000, 2002). According to SCCT, it is hypothesized that individuals are more likely to form interests in and choose activities at which they hold strong self-efficacy beliefs (Lent, 2013).

Outcome Expectations. Outcome expectation beliefs refer to individuals' judgement about the possible consequences of carrying out a particular behaviour or fulfilling a given task (Bandura, 1986, 1997). While self-efficacy beliefs are "concerned with one's capabilities (Can I do this?)", outcome expectations imply "the imagined consequences of performing given behaviors (If I do this, what will happen?)" (Lent, 2013, p. 118). The results expected from performing a particular action are categorized into three forms of outcome beliefs: social (e.g., prestige, social approval or disapproval), material (e.g., monetary and financial rewards), and self-evaluative (e.g., self-satisfaction, emotional reflections including fear, guilt, grief, joy) (Bandura, 1986). Generally featured as evaluative, outcome expectations focus on individuals' positive (e.g., satisfying and useful) or negative (e.g., bad and harmful) outcomes from performing a particular course of activities. In terms of outcome expectations, it is assumed that people engage in attempting behaviours that enable them to attain valued outcomes, and avoid involving in activities that may lead to undesirable consequences (Bandura, 2006).

Various theories, including the ones that are in the vocational domain (Barak, 1981) and motivational realm (Schunk & DiBenedetto, 2020), argue that outcome expectations can motivate people's behaviour. In this regard, Bandura (1986) maintains that self-efficacy and outcome expectation both determine how individuals are motivated to pursue or avoid engaging in activities. But self-efficacy holds more determining influence than outcome expectations. For instance, an individual may avoid pursuing a career even if he or she holds a high outcome expectation (i.e., anticipation of medical career offering status and opportunities to aid others) but he or she has low self-efficacy for success (i.e., doubting one's capabilities in math). Also, an individual may choose not to involve in activities that lead to a career path if he or she has a high self-efficacy with low outcome expectation (e.g., a female student having confidence in math but expecting negative outcomes from math-related careers) (Lent, 2013). Accordingly, in the view of SCCT, it is hypothesized that high outcome expectations with a high self-efficacy would positively influence academic and career interests and choices (Lent & Brown, 2006; Lent et al., 1994).

Personal Goals. The third construct in the cognitive-person variables is personal goals which refer to one's intention to participate in a particular activity or to engage in producing a particular outcome (Bandura, 1986). Positioning it in the reciprocal relationship with self-efficacy and outcome expectations, social cognitive theory maintains that personal goals play a crucial role in the self- regulated individual behaviour (Bandura, 1986). Through identifying goals, individuals arrange, drive, and exercise self-empowerment over their own behaviour (Lent et al., 2002) and transcend the "indefinite but omnific 'history of reinforcement'" (Bandura, 1986, p. 468). SCCT differentiates between two types of personal goals: choice goals which signify the type of an activity or a career an individual intends to pursue (e.g., intention to choose to study a university major), and performance goals that indicate the type and quality of performance an individual aims to attain within a particular task or domain (e.g., grades) (Lent, 2013; Lent & Brown, 2006). SCCT considers personal goals along with self-efficacy and outcome expectations as an essential mechanism by which individuals "exercise agency in their educational and occupational pursuits" (Lent, 2013, p. 119).

Learning Experience. Bandura (Bandura, 1986, 1995, 1997) theorized that self-efficacy and outcome expectation beliefs are developed through four major sources of influence: mastery experience, vicarious experience, social persuasion, and psychological and emotional states. SCCT integrates these four variables into its framework of career development models as a single construct and name them learning experiences (Lent et al., 1994) which, through self-efficacy and outcome expectations, influence personal goals of academic and career pursuits.

Mastery Experiences. Providing "authentic evidence" (Bandura, 1997, p. 80) that an individual has the capabilities needed for success and offering opportunities for regrowth through feedbacks, mastery experiences are considered to have the most powerful influence on creating strong efficacy beliefs. Mastery experience, also known as enactive attainment, refers to individuals' interpretations of previous experiences of successes and failures in the accomplishment a certain task (Bandura, 1997). According to Bandura (1986, 1995), while one's self-efficacy is assured with successes, it is decreased by failures. More specifically, success experiences that are attained through overcoming failures motivate individuals to try newer and higher accomplishments and elevate their self-efficacy to achieve their personal goals (Bandura, 1986, 1997).

However, how previous experience influence self-efficacy perceptions depends on two elements. First, mastery experience that improve efficacy beliefs should not be limited to the practices of easy-made successes. It is, rather, the experiences that are acquired through prevailing over difficulties and obstacles and obtaining “the cognitive, behavioral, and self-regulatory tools for creating and executing appropriate courses of action” (Bandura, 1997, p. 3) to meet the ever-changing societal challenges. Second, although failure/successes are strong influencers of self-efficacy, they are dependant on how one interprets his or her failure or success. For example, if an individual perceives a successful mastery experience as a failure, his or her efficacy beliefs are not improved even though that experience is considered by others as success. In contrary, a mastery experience that are viewed by general public as failure may increase the efficacy beliefs of the ones who perceive that experience as success. In this regard, Bandura (Bandura, 1997) states that “appraisal of personal efficacy is an inferential process in which the relative contribution of ability and nonability factors to failure successes and failures must be weighted” (p. 81).

Vicarious Experience. The second major source of enhancing one’s self-efficacy and outcome expectation is obtained through observational experience. Although viewed as having a lesser influence compared to mastery experience, in many cases, vicarious experience, as argued by (Bandura, 1997), turns out to be more influential than mastery experience. Bandura (1997) stresses that much of the learning is gained through a process of social modelling. There are several factors that influence the impact of social modelling on efficacy beliefs. Appraising self-efficacy through social modeling is shaped by observers’ perception of similarity to role models’ previous performance and attributes and modeling format (Bandura, 1997). In words of Bandura (1995), “the greater the assumed similarities the more persuasive are the models’ successes and failures” (p. 3). Being "diagnostic of one's own capabilities" (Bandura, 1997, p. 87) and observing the past accomplishments of others enable observers to (a) judge their own capabilities, (b) involve in self-development, and (c) enhance their efficacy and expectation beliefs that they also have the ability to carry out and succeed at similar tasks by making similar efforts (Bandura, 1986, 1995).

Vicarious information obtained from observing others is based on similarity not only to models' comparative performance but also to their attributes including age, gender, educational and socioeconomic status, race and ethnicity (Bandura, 1997). Worth noting that similarity in age and gender is considered to be more significant among personal characteristics that influence perceptions of vicarious experience (Bandura, 1997). Individuals who observe coping models who articulate self-assurance and determination in the face of impediments may enhance their self-efficacy more than following mastery models (Bandura, 1995). People aspire to competent models who, through their proficiencies and perseverance, present observers the strategies and tools that help them face their failures with tenacity and raise their efficacy beliefs to meet the challenges of societal demands (Bandura, 1986, 1995, 1997).

Social Persuasion. The third source of self-efficacy, social persuasion, denotes verbal feedback of encouragement (Bandura, 1995) conveying the message of a belief from a social support system (parents, educators, science professional, and peers, etc.) in one's abilities to accomplish a particular task. Individuals who are persuaded by significant people in their lives that "they possess the capabilities to master given tasks are likely to mobilize greater effort and sustain it than if they harbor self-doubts and dwell on personal deficiencies when difficulties arise" (Bandura, 1997, p. 101). Verbal encouragement alone may not be powerful enough to raise self-efficacy beliefs. For a verbal persuasion to successfully enhance efficacy perception, (a) the persuaders construct conditions that can boost success and avoid putting people in premature circumstances that lead to their failure (Bandura, 1995), and (b) the verbal feedbacks should be authentic, practical and realistic (Bandura, 1997). While individuals who "receive realistic encouragement" are "more likely to exert greater effort and to become successful" (Wood & Bandura, 1989, p. 365), their capability beliefs can be weakened by unrealistic encouragements with false expectations (Bandura, 1997).

Physiological and Affective States. The fourth source of self-efficacy is concerned with individuals' appraisal of their physiological and affective states (Bandura, 1997). How individuals improve their physical states and ease their emotional tendencies (e.g., stress, anxiety, fear) influence their efficacy beliefs, especially, when they engage in tasks that are physically perplex or emotionally exhausting. Bandura (1997) asserts that “failure of complex activities requiring intricate organization and precise execution are more vulnerable to impairment by interfering processes that accompany high emotional activation" (pp. 108-109).

Environmental Factors. As emphasized above in the conceptualization of the triadic-reciprocal model of causality (Bandura, 1986), people’s person-cognitive and experiential variables do not occur in a vacuum. Instead, their career-related learning experiences that give access to self-efficacy, outcome expectations and personal goals are pervaded by social influences that are found in the socialization of gender and ethnicity (Bussey & Bandura, 1999; Eccles, 1987, 1994; Gracia, 2017); in the messages from role models such as parents, teachers, and peer (Bandura, 1986); and in social encouragement and discouragement (Lent et al., 2000). In other word, individuals’ cognitive perceptions are influenced by the interaction with their person and environmental variables.

Environmental influences, referred to as person inputs and contextual factors that support or deter educational and occupational pursuits, are identified as playing very crucial role not only in strengthening the predictive relationships between cognitive variables and career interest and choice but also in pinpointing productive ways for intervention (Lent & Brown, 2006; Lent et al., 2001). SCCT divides environmental variables into two contextual categories with reference to their relative proximity to the career development process, that is, distal and proximal (Lent et al., 1994, 2000).

The first category of environmental influences is called distal contextual variables (displayed in the left-hand side of the Figure 2.2). These include person inputs and background contextual affordance. Person inputs denote an individual’s visible physical attributes (e.g., ethnicity, gender, age) that influence his or her career development (Lent et al., 1994). In social theories, sex and race are considered as biological variables and distinguished from gender and ethnicity which are argued to be social constructions (Bussey & Bandura, 1999; Gracia, 2017). Viewing gender and ethnicity as socially constructed wields profound significance on the process of career development in terms of orchestrating the type of learning experiences and opportunities that are responsive to the “development of career-related self-efficacy and outcome expectations" of particular gender and ethnic groups (Lent et al., 1994, p. 106). According to SCCT, the impact of the genetic on sources of learning experience, self-efficacy and outcome expectations to influence career interest and choice is linked to environmental factors (Lent et al., 1994, 2000).

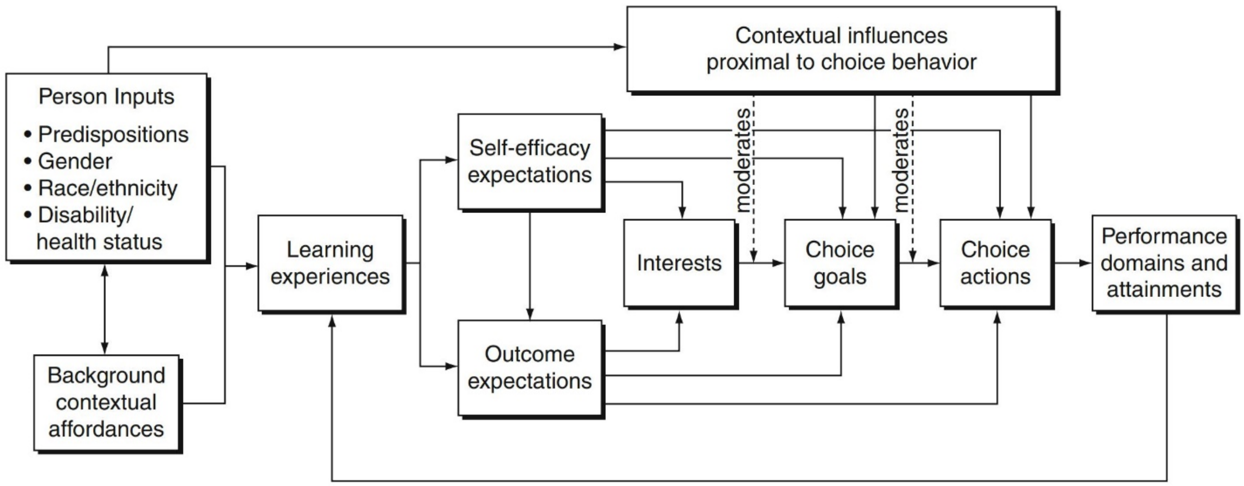

Figure 2.2: Model of Person, Contextual, and Experiential Factors Affecting SCCT's Integrated Models of Career-Related Interest Development and Choice-Making Behaviour

The background contextual affordances consist of variables such as exposure to role models (e.g., parents, educators, scientists, peers) and socioeconomic conditions (Lent et al., 1994, 2000, 2003). SCCT hypothesizes that distal contextual variables, composed of person inputs and background contextual affordance, affect career interest and choice indirectly through the mechanisms of learning experience, self-efficacy and outcome expectations (Lent et al., 2000, 2003; Lent & Brown, 2013).

As illustrated in the upper right of Figure 2.2, the second category of contextual variables refer to the proximal contextual support and barriers (e.g., the availability or lack of extracurricular learning opportunities or informal career contacts) that either aid or hinder career choices (Lent et al., 1994). It is postulated by SCCT that the contextual affordance that are proximal to the process of career development predict educational and career choice behaviours directly (Lent et al., 1994) or indirectly through self-efficacy and outcome expectations (Lent et al., 2001; Sheu et al., 2010, 2018). In the following section, the SCCT's cognitive and environmental constructs are applied to the models of interest and choice.

2.5.1.3 Models of Interest and Choice

Extending Bandura's (1986) social cognitive theory to the domains of educational and occupational pursuits, SCCT presented a framework of process models that described the pathways of direct and indirect influences among cognitive and environmental variables on the academic and career-related decision making (Lent et al., 1994). The SCCT's original pathway models help explain how individuals': (1) academic and occupational interests are developed, (2) academic and career-related choices are made, and (3) academic and occupational performance is attained (Lent et al., 1994).

The original three models have been complemented with two more models: model of satisfaction and well-being in academic and occupational contexts (Lent & Brown, 2006), and model of self-management which explores career-related tasks and challenges across one's lifespan (e.g., decisions regarding job search, work and life dynamics, retirement) (Lent & Brown, 2013). My study examines the influence of a STEM-OP on middle and high-school students' interest and their intention to pursue a STEM career, and only focuses on interest and choice models. The other three models were outside the boundaries of my study.

Interest model is defined as "people's pattern of likes, dislikes, and indifferences regarding various occupations and career-relevant activities" (Lent et al., 2002, p. 264). It emphasizes "both the experiential and cognitive factors that give rise to career-related interests, while tracing the role of interests in helping to motivate choice behavior and skill acquisition" (Lent et al., 2002, p. 265). In SCCT, the choice model is divided into three parts: (1) identifying a choice goal to enter a particular major, (2) actions taken to execute the choice, and (3) successive performance experience (e.g., working towards high grades) that develop a feedback loop that help shape one's upcoming career choice options (Lent et al., 1994). Choice goal, the focus of my study, is conceptualized as one's intention to engage in series of actions to pursue a particular academic and occupational path (Lent et al., 1994; Lent & Brown, 2019).

The model of interest in my study is discussed as it is incorporated in the model of choice because the interest model is considered "a built-in component of the choice model, though it can be studied independently" (Lent & Brown, 2019, p. 2). Integrated interest and choice models provide a better conceptual framework for comprehending the "developmental continuity between the evolution of basic vocational interests and their eventual translation into career-relevant choices" (Lent et al., 2002, p. 272). The remaining paragraphs of this section highlight the hypothesized relations among cognitive and environmental variables that influence the interest and choice models regarding educational and occupational pursuits.

2.5.1.3.1 Cognitive Variables Predicting Interest and Choice Goal Models

As illustrated in Figure 2.2, the interest model is based on the assumption that interests are predicted by both self-efficacy and outcome expectation (Lent et al., 1994). SCCT maintains that individuals develop a lasting interest in an activity when they (a) see themselves as competent in the activity, and (b) expect a positive outcome from performing it. In contrast, individuals do not show interest in an activity when they view themselves as less competent in the activity and anticipate a negative outcome from engaging in it (Lent, 2013; Lent et al., 2002). According to SCCT's choice model, self-efficacy and outcome expectations are posited to predict people's choice goals directly (Lent et al., 2002). It is also hypothesized that self-efficacy and outcome expectations influence choice goals indirectly through interests (Sheu et al., 2010). Self-efficacy and outcome expectations influence interests, which then serve to promote academic and occupational choice goals (Lent et al., 1994). In other words, individuals "develop goals to pursue academic and career-relevant activities that are consistent with their interests as well as with their self-efficacy and outcome expectations" (Sheu et al., 2010, p. 253).

A substantial number of studies has shown direct and indirect association between the cognitive variables and interest and choice models. For instance, studies by scholars (Inda et al., 2013; Lent & Brown, 2019; Lent et al., 2005; Lent, Lopez, et al., 2008; Lent et al., 2018; Sheu et al., 2010, 2018), that utilized SCCT to investigate middle and high-school students' STEM educational and occupational pursuits found that self-efficacy and outcome expectations were strong predictors of STEM academic and career interests and choice goals. Synthesizing data from 143 studies, Lent et al. (2018) tested the interest and choice models of SCCT in the context of STEM. In line with prior meta-analysis by Rottinghaus et al. (2003) and Sheu et al. (2010), bivariate correlation of self-efficacy to interests (.60) and of outcome expectations to interests (.58) were large in scale. Self-efficacy and outcome expectations jointly predicted 46% of the variance in STEM interest. Regarding SCCT's choice model, Lent et al.'s (2018) review reported true score correlations of interest to choice goals as .60 in STEM disciplines. Self-efficacy and outcome expectations were also found to predict (above .50) choice goals in these fields. Concerning the multivariate analysis of choice model that include indirect path analysis of self-efficacy and outcome expectation to STEM choice goals via interest, findings from Lent et al.'s (2018) study reported a good fit to predicting the model.

2.5.1.3.2 Environmental Factors Predicting Choice Goals

As noted above, cognitive-person variables do not operate in a social vacuum. Instead, they are forged with environmental factors to influence educational and career interests and choices (Lent, 2013; Lent et al., 1994, 2002). It should be noted that SCCT, keeping faithful to social cognitive theory's triadic-reciprocal model of causality, maintains that the person and their behaviour and environment are "seen as influencing one another bidirectionally over time", for example, "self-efficacy promotes interest; in cyclical fashion, interest promotes opportunities for self-efficacy development" (Lent et al., 2002, p. 294). However, SCCT's analysis focuses on directional paths that posit that the cognitive-person variables, environmental factors and academic and career choice behaviours influence each other directionally (Lent et al., 2002). Consistent with SCCT's conceptualization, the environmental factors that are assumed to predict individuals' educational and career choice goals are divided into two types: distal contextual influence and proximal contextual influence (Lent, 2013).

Displayed in the left side of Figure 2.2, the distal person and background contextual variables jointly form individuals' "social address" and "covary in the sense that educational and career-relevant resources are often differentially conveyed to children and adolescents on the basis of how key social agents respond to their gender, race/ethnicity, and other person characteristics" (Lent & Brown, 2013, p. 563). Representing a starting pathway, the social address offers an essential context for social learning through which self-efficacy and outcome expectations are attained regarding career choices. The effects of distal contextual factors on career choice goals are mediated by the four learning experiences (personal performance accomplishments, observational learning (or modeling), social encouragement and persuasion, and physiological and affective states) and cognitive-person variables. It should be highlighted that the social address factors affect individuals' career agency indirectly through cultural socialization of distal variables (e.g., gender, ethnicity, role model which were discussed in previous section) that communicate the four learning experiences to self-efficacy and outcome expectation (Lent & Brown, 2013). The social address variables may also influence choice goals (seen in the upper right of Figure 2.2) via conveying "continuous, proximal information about which goals are deemed socially or culturally normative and which actions are likely to be supported or discouraged by the environment" (Lent & Brown, 2013, p. 563). In other words, the influences of cognitive variables on career choice goals can be different when they are dependent on gender, race/ethnicity and socioeconomic status (Lent et al., 2018; Lent & Brown, 2019).

The second type of environmental factors refers to the proximal contextual supports and barriers that affect choice goals during the active process of choice-making (Lent & brown 2013). My study focuses on the second type, proximal contextual supports, in the form of STEM-OP. The process of career choice is influenced by environmental agents that play a ''potent role in helping to determine who gets to do what and where, for how long, and with what sorts of rewards'' (Lent & Sheu, 2010, p. 692). In other words, individuals' perceptions of their abilities about and interest in pursuing a career are either enhanced by the presence of a supportive environment (e.g., economic support, quality education including outreach programs) or deterred by contextual barriers (e.g., lack of quality education and economic support) (Lent, 2013; Lent et al., 1994, 2000, 2002). In SCCT, proximal contextual supports and barriers are assumed to predict choice goal behaviour (a) through direct paths, and (b) by moderating the relationships of interest to choice goals (Lent et al., 1994), and (c) indirectly throughout self-efficacy and outcome expectations (Lent et al., 2001; Sheu et al., 2010).

The first pathway includes contextual supports (e.g., system support such as extracurricular learning opportunities, outreach programs) and barriers (e.g., sociostructural barriers like discrimination) that directly influence individuals' career choice goals (Lent et al., 1994, 2000). The direct influences are shown with solid-line pathways from proximal contextual variables to career choice goals in Figure 2.2. In the second pathways, proximal contextual variables moderate relationships from interest to career choice goals (Lent et al., 1994, 2002). The moderating effects are shown in the dotted lines in Figure 2.2. In SCCT, career-related interests are more likely to flourish into career choice goals when their interest (a) are encouraged by strong contextual support and (b) avoid hostile and non-supportive environment (Lent, 2013).

Third, in addition to the direct and moderating effects, proximal supports and barriers are assumed to influence career choice goals indirectly (illustrated in Figure 2.3) through self-efficacy and outcome expectations (Lent et al., 2001; Sheu et al., 2010). The indirect pathway was not specified in Lent et al.'s (1994) original SCCT. Congruent with Bandura's (2000) suggestion that contextual factors may associate with choices indirectly through self-efficacy, subsequent empirical SCCT studies have indicated that proximal contextual variables indirectly predict career choice goals via self-efficacy and outcome expectations (Lent et al., 2001, 2018; Lent & Brown, 2019; Sheu et al., 2010). It is worth mentioning that environmental conditions (especially in terms of economic support) often compels individuals to compromise their personal interests and choose career-related paths based on their efficacy and outcome expectation beliefs and the availability of resources (Lent, 2013).

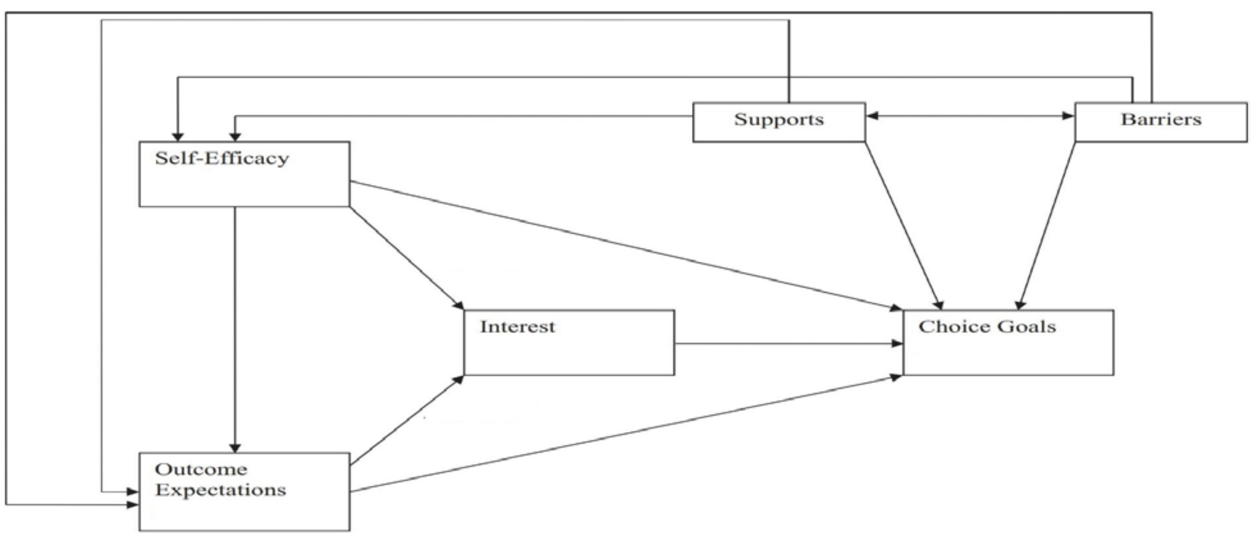

Figure 2.3: SCCT's Integrated Models of Career-Related Interest Development and Choice-Making Behaviour

Employing SCCT (Lent et al., 1994) and social cognitive theory (Bandura, 2000), Lent et al. (2001) investigated the association of contextual supports and barriers with STEM choice behaviour. The authors reported partial support for SCCT's direct path from contextual variables to choice goals and a strong support for Bandura's mediated path where contextual variables mediated choice goals indirectly via self-efficacy and outcome expectations. These findings were reinforced by other studies (Brown et al., 2018; Kantamneni et al., 2018; Lent et al., 2003, 2005, 2008, 2018; Sheu et al., 2010). In the meta-analysis by Lent et al. (2018), contextual supports were found to modestly relate to STEM choice goals (.30) compared to social cognitive variables that yielded stronger relations to choice. Lent et al. (2018) have shown that contextual variable primarily strengthened or weakened the role of self-efficacy and outcome expectations in predicting and promoting STEM interest and choice.

2.5.2 Science Identity Theory

Identity commonly denotes people's perceptions about themselves as persons with specific characteristics. Nevertheless, despite its undeniable significance, the concept of identity has been found by scholars in social sciences as one of the most complicated and slippery terms with respect to its conceptualization and application in a research (Radovic et al., 2018; Wetherell, 2010). One of the primary reasons behind the hurdles to define and study identity is that identity theory is rooted in various disciplinary domains including education, sociology, psychology, and anthropology (Godwin et al., 2020). Additionally, individuals hold multiple identities at any given time (Burke & Stets, 2009; Gee, 2000). For instance, a student can be a sister or a brother and a hockey player in addition to being a "STEM person". Accordingly, Oyserman et al. (2012) try to capture the complexity of identity by defining it as "traits and characteristics, social relations, roles, and social group memberships that define who one is" (p. 69).

Reflecting the multiple "selves" of individuals and the various contexts in which identity is enacted, literature has used different conceptualization of identity that included "nature identity," "institution identity," "discourse identity," "affinity identity" (Gee, 2000), and "disciplinary identity" (e.g., science, engineering, mathematics) (Kane, 2011). Scholars have also conceptualized identity through categorizing it into personal and social. Burke and Stets (2009) defines personal identity as a set of characteristics that "define the person as a unique individual" (p. 124). Personal identity may encompass individual biological maturation (e.g., sexual identity) (Kim et al., 2018), and may also include personal goals, self-esteem and value beliefs (Burke & Stets, 2009).

For my purpose of the study, STEM identity is defined as a part of social identity in line with Kim et al. (2018) and Seyranian et al. (2018). Although identity has been described as a “core sense of self” (Jones & McEwen, 2000, p. 405), this “core” is not self-sufficient as it is consisted of personal identities which need to be fostered by social identities that function to enhance a sense of belonging to a group (Jones & McEwen, 2000; Kim et al., 2018; Tajfel & Turner, 1986). Social identity is defined by Tajfel (1981) as “that part of an individual's self-concept which derives from his [or her] knowledge of his [or her] membership in a social group (or groups) together with the value and emotional significance attached to that membership” (p. 255). Social identity theory pinpoints two primary grounds for individuals to be socially identified: (a) attaining constructive self enhancement (Tajfel, 1981), and (b) lessening a state of unpredictability about the self (Hogg, 2007).

There are two elements that are essential for the development of social identity (Kim et al., 2018; McDonald et al., 2019; Seyranian et al., 2018). First, social identities delineate boundaries of a group membership where individuals hold a sense of belonging to a particular group (e.g., mathematicians) (Burke & Stets, 2009; Hogg et al., 1995). Cheryan et al. (2015) argue that the social environment that enhances sense of belonging in STEM plays an important role in cultivating or hindering STEM identity. The second element is concerned with social identity content which identify a variety of norms (e.g., biologists work in a lab), attitudes (e.g., biologists are environmentalists), traits and stereotypes (e.g., biologists are nerds), and behaviour (e.g., biologists conducts experiments on frogs) (Hogg & Abrams, 2001; Kim et al., 2018). The social identity content, also termed as ingroup prototype (Turner, 1991), identify an individual as a prototypical member of a group and distinguish him or her from other groups (Hogg, 2007). According to Cheryan et al. (2015), the existing STEM prototype seems to be male, White, and socially awkward. For instance, the well-celebrated show The Big Bang Theory advances the protype of a physicist (McIntosh, 2014).

Building on the social identity perspective, STEM identity in my study refers to the extent to which students identify as a member of a particular STEM field (e.g., mathematics major, mathematicians), and perceive themselves as prototypical members of the STEM field (e.g., mathematicians are nerds) (Kim et al., 2018; Seyranian et al., 2018).

2.5.2.1 Science Identity Constructs

Carlone and Johnson (2007) identified three interrelated constructs for science identity formation, namely, performance, competence and recognition. The authors proposed that students' science identity that influence their science-related career choice is constructed when they perceive that (a) they have the ability to acquire knowledge that are essential to understand science contents and methods (i.e., competence), (b) they have the ability to prove that they can showcase their competence (i.e., performance), and (c) their competence and performance are recognized by themselves and others (e.g., science community).

Hazari et al. (2010) advanced Carlone and Johnson's (2007) framework to investigate students' STEM-related identities by adding a fourth construct, interest. Interest was defined by Godwin et al. (2016) as "students' desire to participate in STEM-related activities" (p. 315). Hazari et al., (2010) reported that affective factors like interest have been essential for identification with STEM, especially for minoritized students (e.g., female students). It is worth noting that the four constructs were factored by Hazari et al. (2010) into three constructs composed of performance/competence, recognition and interest. Factoring competence and performance into one construct was because students were not able to differentiate between developing disciplinary content knowledge and attaining grades (Godwin et al., 2016; Hazari et al., 2010).

Various studies (Dou et al., 2019; Godwin et al., 2016; Hazari et al., 2010; Lock et al., 2015; Lock et al., 2019; Monsalve et al., 2016; Verdin et al., 2018) that utilized the science identity theory have reported a strong correlation between STEM interests and career choices when they are mediated by STEM identity. Identity has been examined more broadly in science and mathematics than engineering and technology (Godwin et al., 2020). For example, scholars have studied the role of learning identity in science (Varelas, 2012), in mathematics (Darragh, 2016; Radovic et al., 2018), and engineering (Rodriguez et al., 2018; Tonso, 2006).

Studies have explored identities through a sense of belonging with (a) a STEM community that can change over time (Darragh, 2013) and (b) cultural norms that students bring to classrooms and influence the way by which they identify with STEM subjects (Anderson & Gold, 2006; Nasir & Hand, 2008). Other studies have examined identities through the tensions that arise from interactions in classrooms (Lim, 2008). In a study by Bishop (2012), it was found that students' identification with mathematics content was influenced by their interactions with their peers. Also, elementary teachers' utilization of particular instructional practices was found to impact students' description of themselves as engineers (Kelly et al., 2017). These studies underline the complexity of STEM identity formation that involves a variety of psycho-social factors that contribute to how students identify with STEM subjects and careers.

Additionally, one of the crucial areas of research discussed in science identity theory has been the intersection between gender and race/ethnicity differences and identification as a scientist (Byars-Winston & Rogers, 2019; Carlone & Johnson, 2007; Chemers et al., 2011; Hazari et al., 2010; Puente et al., 2021; Syed et al., 2019). Studies by Williams and George-Jackson (2014) and Robinson et al. (2018) indicated that male students reported higher identification beliefs as a scientist than their female peers. Byars-Winston and Rogers (2019) studied group differences by gender and race-ethnicity of Black/African American and Hispanic/Latino/a men and women to examine the possible cultural variations in the effects of SCCT and science identity variables on students' research career intentions. The authors found that the effect of vicarious learning on science identity was large for Black/African American male student compared to other groups in the study.

STEM fields, where women and ethnic minorities are least represented, are mainly typified by cultural norms ingrained in White and masculine values (Carlone & Johnson, 2007; Foor et al., 2007; Williams & George-Jackson, 2014). The cultural norms can create stereotypes that female and minority students do not belong in a STEM community, thus complicate the prospect of them developing a sense of identification with STEM (Ben-Zeev et al., 2017), and increase the likelihood of departure from STEM pathways (Beasley & Fischer, 2012). Together, the studies show that students' STEM career intentions are positively associated with their STEM identity, and the STEM identity interact with their gender, racial and ethnic identities and there is underrepresentation by women and minority groups. Therefore, scholars (Byars-Winston & Rogers, 2019; Johnson et al., 2011; Ladson-Billings, 1995; Pfund et al., 2006; Singh, 2011) suggest that it is imperative for intervention contents, that aim at enhancing female and minority students' STEM identity and career intentions, to be culturally relevant that can (a) value and validated ethnic cultural heritage and (b) address the negative influence of the stereotypes inherent in STEM in complicating female and ethnic minority students' sense of identification as science person.

2.5.3 Extending Social Cognitive Career Theory with Science Identity Theory

There is a similarity between the concept of self-efficacy of SCCT (Bandura, 1986) and competence/performance construct of science identity theory (Hazari et al., 2010). Hazari et al's (2010) science identity theory meets with SCCT on constructs including outcome expectations and learning experiences. Hazari et al (2010) utilized outcome expectations and learning experiences from SCCT (Lent et al., 1994; Lent et al., 2003) to study the impact of the three constructs (i.e., competence/performance, recognition and interest) on the development of science identity. According to Hazari et al's (2010) framework, the three influencing components that impact science identity formation are shaped by students' career-related outcome expectations and learning experiences. Additionally, the science identity theory (Hazari et al., 2010) and SCCT (Lent et al., 1994) conceptualize the interest construct in a similar vein in the sense that interest, in both theories, is defined as individuals' desire to involve in career-related activities and predicted by career-related outcome expectations and learning experiences. Nonetheless, science identity theory's (Hazari et al., 2010) argument that interest influence the development of career choice indirectly via variances in students' science identity is distinguished from SCCT's (Lent et al., 1994) focus that students' career choice goals are impacted by their interest directly. Accordingly, my study only utilized the recognition construct, which refers to the extent to which one recognize oneself or recognized by others as a science person (Carlone & Johnson, 2007), from the science construct to form the hybrid framework. More specifically, self-recognition component of science identity theory's recognition construct was used to measure middle and high-school students' STEM identity (detailed in measures section of the following Chapter 3).

A hybrid conceptual framework (as detailed in Chapter 1) was developed from six constructs (contextual support in the form of STEM-OP, self-efficacy, outcome expectations, interest, identity, and choice goal) selected from the extended version of SCCT with science identity theory. The hybrid conceptual framework was used as the lens through which the secondary data was analyzed and interpreted to answer the research questions and test the hypotheses of the study on the influence of the STEM-OP on middle and high school students' interest in STEM learning and career.

2.6 Research Gap

A search for literature showed that the studies that combine SCCT (Lent et al., 1994) and science identity theory (Carlone & Johnson, 2007) to investigate students' STEM learning and career pursuits appeared to emphasize bivariate and multivariate correlations among environmental, cognitive, identity and career goals. There is a scarce literature that examines indirect effect of SCCT and science identity constructs. Broadening the SCCT to include science identity theory, my study will fill this gap by investigating whether middle and high-school students' participation in the STEM-OP influenced their STEM-CCGs directly and indirectly through STEM self-efficacy, outcome expectations, interest and identity.

Furthermore, as discussed in the section 2.5.1.3.2 on environmental factors affecting choice goals, the SCCT was upgraded by scholars (Lent et al., 2001, 2018; Lent & Brown, 2019; Sheu et al., 2010) to include the indirect effects of proximal contextual variables on career choice goals through self-efficacy and outcome expectations which were missing from original SCCT (Lent et al., 1994). The original and upgraded versions of SCCT (Figure 2.3) did not include an indirect pathway from contextual variables to career choice goals via interest. The study sought to contribute to the theoretical base of SCCT by examining an additional pathway, that is, the indirect effect of the STEM-OP on middle and high-school students STEM-CCGs through STEM interest. Finally, a meta-analysis of literature, guided by SCCT Lent et al. (2018), reported that there is a lack of longitudinal studies that assess temporal precedence of SCCT variables. My study aspired to contribute to the advancement of the SCCT by investigating the temporal effects of the direct and indirect association between the STEM-OP, social cognitive constructs, interest, identity and career choices.

2.7 Chapter Summary

This chapter provided a review of literature on the impact of a STEM-OP on STEM interest and career choice. Firstly, a description of rationale, definition, challenges and enrichment interventions for STEM education was presented. Then, situating the study in curriculum studies through conceptualization of integrated inquiry-based STEM curriculum was highlighted. Finally, the theoretical framework of the study that proposed an extended version of SCCT to include identity theory was detailed. The literature review noted a lack of studies that combine both theories to examine STEM educational and career behaviours. The review also highlighted a need for longitudinal and SCCT-derived STEM intervention studies. Through extending the SCCT to science identity theory and utilizing longitudinal data analysis, my study intends to fill this gap by examining whether middle and high-school students' STEM educational and career pursuits are influenced by the correlation between participation in STEM program, and attitude toward, interest in and identification with STEM.

Chapter 3

3 Methodology

The purpose of the study was to examine whether (a) there were direct and indirect effects of the STEM-OP on high-school students' STEM-CCGs via STEM self-efficacy, outcome expectations, interest and identity, and (b) there was a change from P2 to P3 in the direct and indirect effects of the STEM-OP on middle-school students' STEM-CCGs via STEM self-efficacy, outcome expectations, interest and identity. The mediation and longitudinal mediation analysis of the secondary data was guided by the following research questions and hypotheses, that were proposed consistent with the hybrid conceptual framework drawn on SCCT (Lent et al., 1994) and science identity theory (Hazari et al., 2010):

1. To what extent did the STEM-OP influence high-school students' STEM-CCGs directly and indirectly through STEM self-efficacy, interest, and identity?

    Hypothesis 1A: The STEM-OP directly influences high-school students' STEM-CCGs.

    Hypothesis 1B: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM self-efficacy, interest, and identity.

2. To what extent did the STEM-OP influence high-school students' STEM-CCGs directly and indirectly through STEM outcome expectations, interest, and identity?

    Hypothesis 2A: The STEM-OP directly influences high-school students' STEM-CCGs.

    Hypothesis 2B: The STEM-OP indirectly influences high school students' STEM-CCGs through STEM outcome expectations, interest, and identity.

3. To what extent did the direct and indirect effects of the STEM-OP on middle-school students' STEM-CCGs through STEM self-efficacy, interest, and identity change from P2 to P3?

    Hypothesis 3A: Direct effect of the STEM-OP on middle-school students' STEM-CCGs changes from P2 to P3.

    Hypothesis 3B: Indirect effects of the STEM-OP on middle-school students' STEM-CCGs through STEM self-efficacy, interest, and identity change from P2 to P3.

4. To what extent did the direct and indirect effects of the STEM-OP on middle-school students' STEM-CCGs through STEM outcome expectations, interest, and identity change from P2 to P3?

Hypothesis 4A: Direct effect of the STEM-OP on middle-school students' STEM-CCGs changes from P2 to P3.

Hypothesis 4B: Indirect effects of the STEM-OP on middle-school students' STEM-CCGs through STEM outcome expectations, interest and identity change from P2 to P3.

In this chapter, an overview of research design is provided. Following this, the data source in the form of S-STEM survey responses from which the items were selected to measure the SCCT and science identity constructs are illustrated. Next, mediation and longitudinal mediation procedures that were employed to examine and test the hypotheses of the study are discussed. Finally, issues related to measurement validity and reliability, generalizability and ethical consideration are described.

3.1 Research Design

A research design refers to a framework for data collection and analysis (Bryman, 2016). The study employed secondary data analysis (SDA) design to analyse secondary data collected by Dr. DeCoito to answer the research questions. Generally, secondary data and its analysis refer to a study where data collected for a previous study is analyzed to investigate new questions (Cohen et al., 2018; Ruggiano & Perry, 2019). While SDA has been a well recognized methodology with increasing amounts of publications, scholars have been debating whether the reuse of data is in line with the basic principles of conducting research (Bishop, 2005, 2009; Heaton, 2008; Irwin, 2013; Irwin et al., 2012; Ruggiano & Perry, 2019). The problem of secondary researchers not having participated in the context of the primary data has been the primary issue (Johnston, 2017; Morrow et al., 2014). However, others (Bishop, 2009, 2012, 2013; Corti, 2012; N. Moore, 2006) have called for building on value found in SDA instead of overemphasizing the contextual nature of data. Among these scholars are Ruggiano and Perry (2019) who asserted that secondary researchers may be in a beneficial position in reanalyzing secondary data in the sense that they "may find themselves less emotionally invested in the data and therefore more objective" (p. 83).

Despite the above mentioned concerns, researchers have acknowledged SDA's advantages in terms of time, cost and quality, which can provide significant opportunities for researchers to generate new insights and knowledge (Chatfield, 2020; Cohen et al., 2018; Irwin et al., 2012;

Ruggiano & Perry, 2019; Smith, 2008). It is argued that, as the data has already been gathered, secondary researchers are (a) relieved from the burden of spending time in securing access to and collection of the data (Ruggiano & Perry, 2019; Smith, 2008) and (b) provided with extra time to focus on a more thorough analysis and interpretation. An additional benefit connected to the previous advantage is the potential avoidance of financial costs related to data collection (Cohen et al., 2018; Sindin, 2017). Further, secondary datasets are usually collected on a larger scale than an individual investigator can gather, thus affording the secondary researcher greater validity and breadth for his or her study analysis and interpretation (Chatfield, 2020; Cohen et al., 2018; Ruggiano & Perry, 2019).

3.2 The Setting

The data for this study was derived from secondary data from a larger longitudinal study that was conducted by Dr. Isha DeCoito. My study utilized a subset of the student data from the longitudinal study to answer the research questions and test the related hypotheses. The attention that was given by Dr. DeCoito's study in terms of students' STEM-related engagement and career choices was greatly aligned with core points highlighted in my study's purpose statements. Furthermore, comprehensiveness of the data allowed me to operationalize constructs from both SCCT and science identity theory. In other words, the richness of the collected data enabled me to conduct an empirical investigation of the influence of contextual support in the form of the outreach workshops on students' STEM self-efficacy, outcome expectations, interest, identity and career pursuits. Dr. DeCoito's 7-year longitudinal STEM study consisted of two parts. Part A, involving grades 6, 7 and 8 students, included Phases I, II and III and occurred between 2013 and 2016. Part B of the study, focusing on high-school students who were participants of the middle school study, commenced in 2017 and concluded in 2020. Phase I of the Part B study was conducted in 2017/2018 school year and involved grade 10, 11 and 12 students. Phase II of the Part B study was undertaken in 2018/2019 and included grade 11 and 12 students.

The longitudinal study was a STEM enrichment intervention, a STEM-OP, that was implemented as a partnership between industry, a school board, a university and a charitable organization in Ontario, Canada. The STEM-OP provided students with hands-on and inquiry-based learning experiences connected with Ontario's Science and Technology curriculum (Ontario Ministry of Education, 2007). The workshops were about 2.5 hours and took place during school time. The resources that were needed for the workshops and often not available at schools were provided by facilitators of the program. The workshop facilitators set the stage by making connections between the ideas and concepts of STEM disciplines and real-life applications. They also highlighted the skills and careers related to STEM. Informed by integrated and inquiry-based learning approach (Keselman, 2003; Laxman, 2013; Pedaste et al., 2015; Zuckerman et al., 1998), the workshops enabled students to work collaboratively to (a) make predictions and hypothesizing before starting their investigations, and (b) engage in carrying out tests or experiments to confirm and uncover particular laws and/or theories of STEM regarding a phenomenon under examination. For instance, in the workshop, titled *Air and flight: Understanding Structures and Mechanisms - Flight*, students were given the opportunity to learn a variety of concepts and conduct experiments pertaining to the science and technology of air and flight. The workshop involved students (a) pouring water, that is coloured in red and warm, into a mug of cooler, blue water, to show how a hot air balloon can be pushed up into the air, (b) spilling water over the side of a cup to experiment the Coanda Effect, and (c) utilizing a hair dryer as a force of air to control propeller blades' edges for the best spinning operation.

3.3 Participation

Teachers, students and administrators from 95 grade 6-8 classrooms (about 2500 students and 78 teachers) from four schools were involved in the study. These schools shared comparable profiles according to the Social Risk Index in Ontario. Ethnicities of the participants were Afro-Canadians, Asian, Middle Eastern, and Southeast Asian. The Part A middle-school students respectively participated in 1-3, 4-6, or more than 7 STEM-OP workshops. For the Part B study, grade 10, 11 and 12 students who participated in Part A of the longitudinal study were traced in the 2017-2018 and 2018-19 school years across 5 high school in Ontario. These schools were also identified by the Social Risk Index as high to moderate risk. The high-school students completed a survey and interview questions regarding the determinants of their goal of remaining in a STEM pathway.

To answer mediation-question of whether there were direct and indirect effects of the STEM-OP on high-school students' STEM-CCGs via STEM self-efficacy, outcome expectations, interest and identity, data collected from grade 12 students who participated in Phase II of the Part B of the longitudinal data was used. This data was selected instead of grade 8 because of the belief that grade 12 students would provide more clearer picture about their career intentions. My research used data collected from grade 7 and grade 8 students who participated in both of the Phase II and Phase III of the Part A of the study to examine the longitudinal-mediation question of whether there was a change from P2 to P3 in the direct and indirect effects of the STEM-OP on middle-school students' STEM-CCGs via STEM self-efficacy, outcome expectations, interest and identity. Both of the two points of data time that were required to conduct the repeated measures analysis concerning longitudinal-mediation question (detailed later in the data analysis section) were selected from the middle-school study. Initially, time point one from Part A and a time point two from Part B of the study were to be selected for the analysis. However, between 10 and 43 students from the Part A participated in the Part B of the study. The sample size of 43 was not sufficient to test the longitudinal mediation analysis. Additionally, data collected from grades 7 and 8 students was selected as it produced better results in terms of missing values, statistical assumptions and measurement reliability tests. The participants selected for the study from the longitudinal data included a representative sample of 66 grade 7, 66 grade 8 and 74 high-school students (n=206) (Table 3.1). Out of 206 participants, 128 were female (62%) and 78 were male (48%).

Table 3.1: Demographic Data Frequency by Gender and Grade

		Grade			Total
		7	8	12	
Gender	Male	19	19	40	78
	Female	47	47	34	128
Total		66	66	74	206

3.4 S-STEM Survey and Measures

In the longitudinal study, Dr. DeCoito collected data in the forms of surveys, interviews, STEM-OP workshop observations, and student reflections. For the purpose of addressing my research questions and related hypotheses, the research utilized a subset of survey data from the longitudinal study. Students in the longitudinal study completed middle and high-school student attitudes toward STEM surveys (S-STEM) which were developed by the Friday Institute for Educational Innovation (2012).

Grade 12 students completed the High School S-STEM survey in 2019 as a segment of Part B of the study. Grade 7 students answered the Middle School S-STEM survey questions in 2016 (Phase II). The same grade 7 students were measured on the S-STEM constructs in 2017 (Phase III) at the time when they were in grade 8 of Part A of the study. The middle school students responded to the S-STEM survey questions before and after they participated in the STEM-OP workshops in each of three phases of the study. The study used the data collected from the survey responses that was completed after the participation took place. This was because the items that were added to the middle-school survey by Dr. DeCoito to measure students' perception about their participation in the STEM-OP were only included in the one that students completed after they participated in the workshops.

The S-STEM survey started by asking students to provide demographic information (gender and grade level). Following this, students were asked about their attitudes toward math, science, engineering and technology, and 21st century learning. Other items in the survey asked students about their interest in 12 different STEM career areas, their attitudes toward their performance expectations in the next year, whether or not they have plans to attend postsecondary school, and whether or not they know adults who work in STEM fields. The survey was modified by Dr. DeCoito by the addition of a question about the number of outreach workshops students attended, and an environmental construct that asked students about their perceptions on the influence of an outreach program on their attitude and interest in STEM learning and career aspirations.

Overall, the S-STEM survey that was modified by Dr. DeCoito mainly consisted of three types of questions. The first set of questions collected demographic data including students' gender and grade level and asked them to provide information regarding the number of workshops they participated in during middle school. The second set of questions measured students' confidence and attitudes towards all major STEM disciplines and 21st century learning, and interest in twelve STEM career pathways including physics, environmental work, biology and zoology, veterinary work, mathematics, medicine, earth science, computer science, medical science, chemistry, energy, and engineering. The final set of questions asked students about their (a) reflection on the influence of the outreach workshops on their attitude toward and interest in STEM learning and careers, (b) academic performance expectations in mathematics and science in the next year, (c) plans for attending postsecondary school, (d) perceptions on the impact of twelve influencers (e.g., teacher, internet) on their postsecondary STEM discipline and career choices, and (d) whether or not they happen to know adults who work in STEM fields.

To answer the research questions and test the hypotheses, my study focused on specific items from the survey to measure the six constructs from SCCT and science identity theory comprising of contextual support, self-efficacy, outcome expectations, interest, identity and career choice goal. Items that were selected to measures those constructs are illustrated in Table 3.2.

Table 3.2: Study constructs and selected items from S-STEM survey

Construct	Selected Items
STEM-OP	STEM-OP workshops made me more confident in my ability to do science, technology, engineering, and/or math in high school. STEM-OP workshops made me more interested in science, technology, engineering, and/or math. STEM-OP programs encouraged me to think about a career in science, technology, engineering, and/or math. STEM-OP workshops made me more aware of the importance of science, technology, engineering, and/or math to the world around me.
STEM self-efficacy	I am confident when I do science. I know I can do well in science. I am good at science. I am sure I could do advanced work in science.
STEM outcome expectations	I expect to use science when I get out of school. Knowing science will help me earn a living. I will need science for my future work. Science will be important to me in my life's work. I will need a good understanding of science to make decisions in my daily life.
STEM interest	I think scientists have interesting jobs. I believe that science is interesting.
STEM science identity	In general, I enjoy science. I would like to be a scientist.
STEM-CCG	I would consider a career in science.

Contextual Support. Contextual support in terms of the STEM-OP refer to the factors that boost STEM students' academic and career-related interests and choice goals (Lent, 2013; Lent et al., 1994, 2000, 2002; Sheu et al., 2010). Contextual support was measured with four items on a 5-point Likert-scale. Students were asked to show their level of agreement with each statement on a scale from 1 (strongly disagree) to 5 (strongly agree). The questions asked students about their perception of the influence of the outreach program on their STEM self-efficacy, outcome expectation, interest and career choice goals (e.g., "[outreach programs] made me more confident in my ability to do science, technology, engineering, and/or math in high school".

STEM Self-Efficacy. STEM self-efficacy signifies students' perceived beliefs about their ability and confidence to perform academic tasks and activities (Bandura, 1986). Students' STEM self-efficacy was measured with four items on a 5-point Likert-scale. The students were asked to indicate the level of agreement with statements (e.g., "I am confident when I do science") regarding their perceptions on their ability to act on STEM related tasks and activities on a scale from 1 (strongly disagree) to 5 (strongly agree).

STEM Outcome Expectation. Outcome expectations indicates a belief about the results that STEM students expect from performing an academic task or activity (Bandura, 1986). Outcome expectations were measured with six items on a 5-point Likert-scale reflecting students' perceptions of the relevance of STEM disciplines to their future life and job plans. Students responded by indicating how strongly they agree that engaging in STEM disciplines would allow them to obtain expected outcomes (e.g., "Science will be important to me in my life's work") on a scale from 1 (strongly disagree) to 5 (strongly agree).

STEM Interest. Interest denotes students' likes and dislikes about a STEM activity, task or career (Lent et al., 2002). Interest was measured by two items asking students to demonstrate their degree of interest in STEM subjects and careers (e.g., "I believe that science is interesting."). Responses were obtained on a 5-point Likert-scale ranging from 1 (strongly disagree) to 5 (strongly agree).

STEM Identity. **STEM Identity**. Students' identity refers to the extent to which they recognize themselves and recognized by others as members of a particular STEM field (Carlone & Johnson, 2007). Focused only on self-recognition owing the limitations of the secondary data, the study measured students' STEM identity by two items composed of "In general, I enjoy science" and "I would like to be a scientist". These items are supported by subconstruct of recognition of self as scientist (Carlone & Johnson, 2007; Gee, 1999, 2000). Carlone and Johnson (2007) used recognition items (e.g., "Enjoy the subject matter of science") to examine ways students recognize themselves as scientists. Additionally, the science identity framework by Carlone and Johnson (2007) is informed by the works of Gee (1999, 2000) who defines identity, partly, as someone who recognize self as "the 'kind of person' one is seeking to be and enact in the here and now'' (1999, p. 13). Students replied to the questions by revealing the degree of their enjoyment with science and desire to be a scientist on a 5-point Likert scale averaging between 1 (strongly disagree) and 5 (strongly agree).

STEM Career Choice Goal. Career choice goal is operationalized as students' intention to pursue STEM-related academic and occupational path (Lent & Brown, 2019; Lent et al., 1994). Students' career choice goals were measured by one item that asked them to rate themselves on a 5-point Likert scale indicating their degree of intention (1 = strongly disagree, 5 = strongly agree) whether to choose a career in STEM subjects (e.g., "I would consider a career in science"). Discussions on using single-item measurement were presented in the section on measurement reliability in Chapter 4.

3.5 Data Analysis

The S-STEM survey data was analysed quantitatively by mediation and longitudinal mediation procedures. This involved preparation of the data and conducting preliminary descriptive statistics and primary analysis of hypothesis tests.

3.5.1 Preparation of Data

Data, after having been received from Dr. DeCoito, was renamed, recoded and screened for missing values and violation of statistical assumptions before carrying out the analysis. The data, that was received in Excel files, was imported into SPSS. Codes for participant identification in the data were recoded and all of the survey items were given different variable names to differentiate them from the original data. The items that measured middle and high-school students' self-efficacy, outcome expectations beliefs and intentions about STEM learning and career were assigned a 4-point or a 5-point Likert scale value. Irrespective of how well the survey data was collected, it is always imperative to check for missing data (Creswell & Plano Clark, 2018) because missing values can reduce sample size and impair the validity and power of study conclusions (Polit, 2009). In an effort to check the relevance of the data for the mediation and longitudinal mediation analysis, statistical assumptions, that are aligned to those of multiple regression analysis, were tested including *linearity, homoscedasticity, independence, and noncollinearity* (Hayes, 2022; Hahs-Vaughn & Lomax, 2020). Normality assumption was not tested because bootstrap resampling procedure that was used to conduct the mediation and longitudinal mediation analyses manages violation of normality assumption of variable distribution (Hayes, 2022; Montoya & Hayes, 2017). Test results for missing values and statistical assumptions are detailed in Chapter 4.

3.5.2 Preliminary and Primary Data Analysis Procedures

Descriptive statistics was conducted first using statistical product and service solutions (SPSS) software. This included checking for missing values, measurement reliability, violation of statistical assumptions, mean, standard deviation and correlation of variables. The primary analysis of the survey data was conducted by mediation analysis procedures which is subdivided into simple, parallel and serial mediation. Simple mediation refers to the analysis of indirect effects, where effects of an independent variable, *X*, on a dependent variable, *Y*, are causally exerted directly and indirectly through one mediating variable. Parallel mediation indicates that independent variable influences dependent variable both directly and indirectly through two or more mediating variables where the mediators do not causally impact each other. Serial mediation implies that the effect of independent variable on dependent variable flows directly and indirectly through two or more variables causally and serially (Darlington & Hayes, 2016, Hayes, 2022).

Mediation analysis is built on regression-based path-analytical framework (Hayes, 2022). Path analysis is an extension of multiple regression (Bryman & Cramer, 2005). Multiple regression analysis refers to statistical procedures where a dependent variable, *Y*, is regressed on more than one independent variable, *X*, which is also understood as Y being predicted by more than one X (Hahs-Vaughn & Lomax, 2020). In multiple regression, the regression coefficient only quantifies the direct effect of X variables on Y ignoring possible indirect effects that may operate through additional variables (Darlington & Hayes, 2016). Path analytical framework extends regression analysis by adding a third possibility where the effects of X on Y are partitioned into direct and indirect paths of influences (Hayes, 2022; Scheiner et al., 2000). The effects of direct and indirect pathways are estimated as results of regression coefficients (Bryman & Cramer, 2005; Hayes, 2022). Path analysis allows researchers to estimate the strength of causal direct and indirect effects of X on Y (Bryman & Cramer, 2005; Scheiner et al., 2000). According to Darlington and Hayes (2016) and Hayes (2022), utilizing path analysis to investigate the indirect effects in addition to direct effects can further deepen our understanding of a phenomenon under study.

To answer mediation question of whether the STEM-OP exerted its effects on high-school students' STEM-CCGs directly and indirectly through their STEM self-efficacy beliefs, outcome expectations, interests and identity, two serial-mediation analyses were conducted. Haye's (2022) PROCESS Macro for SPSS 28 was performed to conduct the serial-mediation analysis. The PROCESS was developed by Andrew F. Hayes as a computational modelling macro for SPSS and statistical analysis system (SAS), both of which lack tools for testing indirect effects. The PROCESS has been one of the simple and widely used macro by researchers for mediation and moderation process analyses (Hahs-Vaughn & Lomax, 2020; Keith, 2019).

Two longitudinal serial-mediation analysis was conducted to examine the research question of whether the indirect effects of the STEM-OP on middle-school students' STEM-CCGs through STEM self-efficacy beliefs, outcome expectations, interests and identity change from P2 to P3. Longitudinal mediation refers to a research design in which independent, mediating and dependent variables are measured over time (MacKinnon, 2008). MEMORE macro for SPSS 26 (Montoya & Hayes, 2017) was used to perform the longitudinal serial-mediation analysis. MEMORE, based on two-condition within-participant mediation and moderation models, allows researchers to estimate the effects of an independent variable on a dependent variable through one ore more mediating variables measured on same participants in two situations (Matos et al., 2022; Montoya & Hayes, 2017). The MEMORE procedure has been increasingly employed by scholars for longitudinal mediation and moderation analysis (Goodboy et al., 2021; Kolijn et al., 2022; Maehler, 2022; Magson et al., 2021; Matos et al., 2022; Villarosa-Hurlocker et al., 2022).

MEMORE creates averages and differences for longitudinal mediation designs and permits to test whether a difference in the effect of an independent variable measured at two conditions (X2-X1) generates a difference in a dependent variable measured at two conditions (Y2-Y1) through a difference in one or more mediating variables measured at two conditions (M2-M1; Montoya & Hayes, 2017). By utilizing the MEMORE macro, the study examined whether a change in the effects of the STEM-OP measured at P2 and P3 (X2-X1) produced a change in middle-school students' STEM-CCGs measured at P2 and P3 (Y2-Y1) through a change in

STEM self-efficacy, outcome expectations, interest and identity measured at P2 and P3 (M2-M1).

The PROCESS and MEMORE macros for SPSS provide path analysis tools that use ordinary least square (OLS) regression to estimate regression coefficients for all effects in mediation and longitudinal mediation models. The macros also offer inferential tests for the direct and indirect effects through bootstrap and Monte Carlo confidence interval tests in addition to *t*- and *p*-values (Darlington & Hayes, 2016; Hayes, 2022; Montoya & Hayes, 2017). For the purpose of testing the hypotheses of my study, bootstrap confidence interval method was selected. Bootstrapping is one of various resampling procedures for hypotheses testing (Preacher, Rucker & Hayes, 2007). In bootstrapping, the sample is considered as a pseudo-representation of the population from which the original sample was drawn, and new series of sample of size *n* is created by resampling with replacement. Repeating the resampling with replacement procedure over many times – thousands preferably – produces an empirical representation of sampling distribution which is then utilized for inferential tests (Hayes, 2022; Preacher et al., 2007).

Bootstrap method has been proposed for almost any inferential statistics especially for testing indirect effects (Darlington & Hayes, 2016; Hayes, 2022; Keith, 2019; Preacher et al., 2007). It has been argued that bootstrapping would provide more accurate and powerful inferences for testing a hypotheses than normal theory approach because it (a) does not require normality of variable distribution and (b) allows to better estimate the irregularities of sampling distribution through repeating resampling of the original samples with replacement, thus type 1 errors are better controlled (Baron & Kenny, 1986; Darlington & Hayes, 2016; Hahs-Vaughn & Lomax, 2020; Hayes, 2009; Hayes, 2022; Keith, 2019; Preacher et al., 2007).

The PROCESS and MEMORE macros allow researchers to use 1000-50000 bootstrap samples to create a bias-corrected %90-%99 confidence interval to assess the statistical significance of direct and indirect effects. The output from the macro generates regression coefficients for all pathways of influence that include R^2, standard errors and *p*-values and bootstrap confidence intervals for direct effects, and bootstrap standard errors and bootstrap confidence intervals for indirect effects (Darlington & Hayes, 2016; Hayes, 2022; Montoya & Hayes, 2017). Testing whether there is evidence of significance for indirect effects is performed as follows: if zero, which is the null hypotheses, does not fall between the lower and upper bound of the bootstrap confidence interval, the null hypotheses is rejected, and it is inferred that the indirect effects are statistically significant. On the other hand, if the lower and upper bound of the bootstrap confidence interval contain a zero, the null hypotheses in not rejected and it is inferred that the indirect effects are not statistically significant (Hayes, 2022; Montoya & Hayes, 2017). In other words, the indirect effects are significant at $\alpha = 0.05$ when %95 bootstrap confidence intervals for those effects do not contain zero (Hayes, 2022; Kang et al., 2021; Montoya & Hayes, 2017).

3.6 Validity and Reliability

A crucial component of research, commonly agreed upon by scholars (Bryman, 2016; Bryman et al., 2008; Cohen et al., 2018; Creswell & Creswell, 2018; Plano Clark & Ivankova, 2016), is quality assessment of interpretations and conclusions drawn from results of data analysis. Validity and reliability have been considered as widely agreed criteria for assessing the merits of inferences generated from quantitative research (Bryman et al., 2008; Creswell & Plano Clark, 2018). Quantitative validity indicates the degree to which a claim made by a measurement is accurate, and quantitative reliability refers to extent to which scores generated from a specific measurement are dependable and produces same results in repeated trials (Neuman, 2011; Thorndike & Thorndike-Christ, 2013). Results of reliability tests are displayed in Chapter 4.

3.7 Generalizability

Once researchers have established the quality of inferences made from their studies, it is suggested that they would look for the generalizability of these inferences (Teddlie & Tashakkori, 2009). It is emphasised that social/behavioural researchers with quantitative focus usually aim from their studies to solve a problem that has a usefulness to those who make decisions or bring social change; thus, they are concerned about being able to articulate that their interpretations and conclusions can be generalized beyond the limits of their research context (Braun & Clarke, 2013; Bryman, 2016). Generalizability, also called as external validity, refers to the extent to which conclusions from a study may be applicable to the wider population and to different individuals, contexts and times (Bryman, 2016; Creswell & Plano Clark, 2018). The inferences and recommendations that were developed from examining the influence of the outreach program are believed to have applicable relevance for decision makers in educational institutions to better develop integrated STEM curriculum and for teachers to design hands-on and problem-solving oriented learning materials in the wider research populations and other similar school contexts

3.8 Ethical Considerations

It is advised by Guba and Lincoln (1994) and Patton (2002) that researchers pay attention to the significance of ethical considerations as a part of the quality of their studies. This requires them to be reflexive about their biases and inclusive of voices of all the participants when they analyse interpret their data. Throughout the analysis of the data, I continually reflected on possible biases, that could emanate from my personal assumptions and professional experiences as a former student and a teacher, to ensure that my preconceptions would not affect the data interpretation. I maintained my deep interest in the experiences of students and was committed myself to represent authentic, accurate and adequate account of their experiences. Additionally, there are concerns regarding ethical considerations that are associated with secondary analysis of data such as confidentiality and anonymity (Cohen et al., 2018; Mauthner & Parry, 2013; Morrow et al., 2014; Ruggiano & Perry, 2019). Accordingly, one of the primary principles of research ethics including that of secondary data analysis is avoidance of harming research participants in terms of breaching privacy (Dargentas, 2006; Mauthner, 2012). The researcher followed rigorous measures to avoid misrepresentation of the data and ensure the anonymity and confidentiality of participants. These measures included (a) changing pseudonyms to participant codes during transcription, analysis, and interpretation, and (b) storing all electronic data in a password protected methods that are only accessible to the researcher. Furthermore, the ethics approval of the Non-Medical Research Ethics Board (NMREB) at the University of Western Ontario (UWO), required to assure the protection of human participants from harms and breach of privacy, was acquired before receiving the secondary data from Dr. DeCoito and starting the analysis (see Appendix A).

3.9 Chapter Summary

Chapter 3 presented an overview of the advantages and disadvantages of the research design involving secondary data analysis. Next, the secondary data source in the form of S-STEM survey responses was described. Participants, including a representative sample of 206 middle and high-school students along with an explanation of the constructs selected from the longitudinal data to examine the research questions of the study were described. This was followed by a detailed discussion of mediation and longitudinal mediation procedures and the PROCESS and MEMORE macros employed to conduct the analysis. Finally, measurement validity and reliability, generalizability and ethical consideration were addressed. Chapter 4 presents the findings of the analysis.

Chapter 4

4 Findings

In this chapter, findings of the serial mediation and longitudinal serial-mediation analysis aligned with the purpose of the study are presented. To recap, my study investigated whether (a) there were indirect effects of the STEM-OP on high-school students’ STEM-CCGs via STEM self-efficacy, outcome expectations, interest and identity, and (b) there was a change from P2 to P3 in the indirect effects of the STEM-OP on middle-school students’ STEM-CCGs via STEM self-efficacy, outcome expectations, interest and identity. The secondary analysis of the data and findings were guided by the following research questions and hypotheses:

1. To what extent did the STEM-OP influence high-school students’ STEM-CCGs directly and indirectly through STEM self-efficacy, interest, and identity?

   Hypothesis 1A: The STEM-OP directly influences high-school students’ STEM-CCGs.

   Hypothesis 1B: The STEM-OP indirectly influences high-school students’ STEM-CCGs through STEM self-efficacy, interest, and identity.

2. To what extent did the STEM-OP influence high-school students’ STEM-CCGs directly and indirectly through STEM outcome expectations, interest, and identity?

   Hypothesis 2A: The STEM-OP directly influences high-school students’ STEM-CCGs.

   Hypothesis 2B: The STEM-OP indirectly influences high school students’ STEM-CCGs through STEM outcome expectations, interest, and identity.

3. To what extent did the direct and indirect effects of the STEM-OP on middle-school students’ STEM-CCGs through STEM self-efficacy, interest, and identity change from P2 to P3?

   Hypothesis 3A: Direct effect of the STEM-OP on middle-school students’ STEM-CCGs changes from P2 to P3.

   Hypothesis 3B: Indirect effects of the STEM-OP on middle-school students’ STEM-CCGs through STEM self-efficacy, interest, and identity change from P2 to P3.

4. To what extent did the direct and indirect effects of the STEM-OP on middle-school students’ STEM-CCGs through STEM outcome expectations, interest, and identity change from P2 to P3?

   Hypothesis 4A: Direct effect of the STEM-OP on middle-school students’ STEM-CCGs changes from P2 to P3.

Hypothesis 4B: Indirect effects of the STEM-OP on middle-school students' STEM-CCGs through STEM outcome expectations, interest and identity change from P2 to P3.

This chapter consists of two major parts. In the first part, the results of descriptive statistics are described. Following this, the findings of the primary data analysis are explained. In the first strand of the second part, results of serial-mediation analysis that used the PROCESS procedure (Hayes, 2022) for SPSS to examine research questions one and two and test the related hypotheses are provided. Finally, the findings of longitudinal serial-mediation analysis that utilized the MEMORE macro (Montoya & Hayes, 2017) for SPSS to answer research questions three and four and test the related hypotheses are provided.

4.1 Preliminary Analysis

Findings of checking for missing values, measurement reliability, effect size and statistical assumptions are presented as part of the preliminary analysis. Results of tests for mean, standard deviation and correlation of variables are also described in this section.

Missing Data. Tests of missingness in the data were conducted using frequency option in SPSS. The missing value tests revealed that 16 cases out of 206 participants that were selected from the longitudinal study by Dr. DeCoito had missing values. There are two options for researchers to manage missing values. One option is elimination of participants with missing values and the other is to substitute numbers such as "-9" and/or "-1" for the missing data for cases (Creswell, 2015). It is suggested by scholars that substituting up to 15% of the missing values for a participant with scores would not impair the general statistical inferences (Creswell, 2015; George & Mallery, 2001). The PROCESS and MEMORE macros for SPSS by which the primary analysis of the study was conducted require handling the missing data with imputation beforehand because it assumes complete data and deletes cases with missing values. For this study, there were 9 cases in middle-school data which were deleted because they had more than 15% of missing values. Additionally, there were seven cases in grade 7 data with missing values that met the threshold of responding to at least 85% of the survey questions and were imputed with substitute scores using SPSS to increase the power of study findings. After deleting the cases with missing values, the population for studying the longitudinal questions were composed of a representative sample of 57 grade 7 students and 57 grade 8 students (n = 188; Table 4.1). There were no missing values in high-school data.

Table 4.1: Demographic Data Frequency by Gender and Grade

		Grade			Total
		7	8	12	
Gender	Male	15	15	40	70
	Female	42	42	34	118
Total		57	57	74	188

Power Analysis. Using G*Power 3.1 software (Faul et al., 2007), a post-hoc power analysis was conducted for multiple regression analysis with four predictor variables with power of 0.80 and alpha level of 0.05. It is suggested by Cohen (1988) that a sample size of 53 are required to achieve a medium to large effect size (f^2 = .25) for a regression analysis with four independent variables. Based on the findings from SCCT that demanded a medium to large effect size (da Silva Cardoso et al., 2013; Lent, 2005; Lent, Lopez, et al., 2008; Mullikin, Bakken, & Betz, 2007; Turner & Lapan, 2005) and Cohen's (1988) rule of thumb, the 74 participants for mediation analysis and 114 participants for the longitudinal mediation analysis exceeded the needed sample size to reach the necessary statistical power for the study.

Measurement Reliability. Unfried and his colleagues (2015) utilized iterative design, various methodological procedures and a sample of 17,485 to determine the validity and reliability of the Middle/High S-STEM component of the survey. Findings from the study revealed that the interpretations of results generated from the scores on the survey's subscales and items measuring middle and high-school students' attitudes toward and interest in STEM were valid (Unfried et al., 2015). Cronbach's alpha was calculated to determine reliability consistency of the four constructs using all sample data (Unfried et al., 2015). It is suggested by scholars that for a measurement to be deemed as acceptable, Cronbach's alpha coefficients should be between .60 and .95 (Hulin et al., 2001; Ursachi et al., 2015). According to the study by Unfried et al. (2015), all four constructs revealed adequate level of Cronbach's alpha coefficient ranging from .89 to .92 (Table 4.2).

Table 4.2: Cronbach's Alpha for Middle/High School S-STEM Survey

Construct	Unfried et al.'s (2015) Cronbach's α
Math	.90
Science	.89
Engineering/technology	.90
21st century skills	.92

As previously mentioned in Chapter 3, my study selected certain items from the Middle and High School S-STEM survey data to answer the research questions and test the hypotheses. These items were indexed based on constructs from SCCT and science identity theory using SPSS, except career choice goal construct. The internal-consistency reliability of the indexes was measured using Cronbach's alpha option in SPSS. All of the five constructs demonstrated sufficient level of Cronbach's alpha coefficient averaging between .69 and .91 (Table 4.3).

Table 4.3: Cronbach's Alpha for Reliability Test

	Cronbach's α		
Construct	Grade 7	Grade 8	Grade 12
STEM-OP	.72	.88	.83
STEM self-efficacy	.85	.87	.89
STEM outcome expectations	.81	.91	.91
STEM interest	.70	.73	.72
STEM science identity	.69	.70	.77

There was only a single item ("I would consider a career in science") that was at my disposal from the S-STEM survey to measure students' STEM-CCGs. Although there is a widespread agreement that multiple-item measures are preferable, there is support among scholars for the use of single-item measures that can provide valuable and needed information about constructs that are concrete, unambiguous and noncomplex (Bergkvist & Rossiter, 2007; Bergkvist, 2014; Diamantopoulos et al., 2014; Fisher et al., 2016; Wanous & Hudy, 2001; Wanouset al., 1997).

Various advantages are associated with the use of single-item measure including (a) reduced survey length that, less tedious and time consuming, can improve the total response rate (Rogelberg & Stanton, 2007; Stanton et al., 2002; Wanous et al., 1997), and (b) increased face validity where the use of multiple-item measures, that oftentimes are composed of similar items in essence, are lessened and respondents' resentment from "being asked questions that appear repetitious" (Wanous et al., 1997, p. 250) are avoided (Fisher et al., 2016; Jordan & Turner, 2008). Reflecting these advantages, there are respectable amount of literature that utilised single-item measures (Christophersen & Konradt, 2011; Coker, 2021; DeSalvo et al., 2006; Elo et al., 2003; Jordan & Turner, 2008; Núñez-Peña et al., 2014; Sawyer et al., 2008; Snyder et al., 2021).

Despite the advantages, the perceived inability of measuring internal consistency has been the primary criticism of using single-item measures (Jordan & Turner, 2008; Wanous & Reichers, 1996). As a response to the criticism, scholars have shown that the internal reliability of single items can be measured (Fisher et al., 2016; Kwon & Ko, 2006; Nagy, 2002; Wanous & Hudy, 2001; Wanous & Reichers, 1996; Wanous et al., 1997). One of the prevalent approaches of estimating the reliability of single-item measures has been to establish communality h^2 of single items through exploratory factor analysis (EFA) (Kwon & Trail, 2005; Wanous & Hudy, 2001; Wanous & Reichers, 1996). The communality indicates the degree of variance of an item which is resulted from its communality and specificity and described in factor loadings extracted in EFA (Heck, 1998; Wanous & Hudy, 2001). While an item's communality refers to the proportion variance described by factors that are common to all items in the analysis, an item's specificity signifies the variance that is exclusive to that item and is not related to any other items in factor analysis (Hair et al., 1998).

It is suggested by Wanous and Hudy (2001) that a reliable variance of an item, that is included in EFA along with multiple-item measures, is formed by "the sum of its communality and its specificity" (p. 363) and is counted as a conservative estimate of that item's internal consistency. It is argued that communalities of .50 and above can be interpreted as a meaningful indication of internal consistency of single items (Fleeson, 2001). Communalities of the single-item measure ("STEM career choice goal") with the multiple-item measures ("contextual support, self-efficacy, outcome expectations, interest and identity") were calculated using exploratory factor analysis in SPSS as suggested by Wanous and Hudy (2001) to determine the internal consistency of the single item. As displayed in Table 4.4, the communality measure of the CCGs ranging from .70 to .85 met the conventional threshold for determining the internal reliability of single-item measures.

Table 4.4: Estimates of Communalities for Multiple-Item and Single-Item Measures

Construct and Item	Communalities		
	Grade 7	Grade 8	Grade 12
STEM-OP			
STEM-OP workshops made me more confident in my ability to do science, technology, engineering, and/or math in high school.	.68	.78	.79
STEM-OP workshops made me more interested in science, technology, engineering, and/or math.	.68	.81	.72
STEM-OP programs encouraged me to think about a career in science, technology, engineering, and/or math.	.73	.69	.66
STEM-OP workshops made me more aware of the importance of science, technology, engineering, and/or math to the world around me.	.46	.73	.68
STEM self-efficacy			
I am confident when I do science.	.85	.76	.78
I know I can do well in science.	.85	.75	.77
I am good at science.	.80	.84	.82
I am sure I could do advanced work in science.	.52	.56	.65
STEM outcome expectations			
I expect to use science when I get out of school.	.76	.83	.75
Knowing science will help me earn a living.	.78	.59	.88
I will need science for my future work.	.64	.76	.90
Science will be important to me in my life’s work.	.80	.83	.92
I will need a good understanding of science to make decisions in my daily life.	.78	.57	.59
Understanding science is important for finding solutions to environmental challenges.	.76	.53	.76
STEM interest			
I think scientists have interesting jobs.	.68	.53	.74
I believe that science is interesting.	.79	.59	.75
STEM science identity			
In general, I enjoy science.	.82	.79	.75
I would like to be a scientist.	.83	.64	.55
STEM-CCG			
I would consider a career in science.	**.70**	**.75**	**.85**

Statistical Assumption Tests. In an effort to check the relevance of the data for the mediation and longitudinal mediation analysis, statistical assumptions, that are aligned to those of multiple regression analysis, were tested including *linearity, homoscedasticity, independence, and noncollinearity* (Hayes, 2018; Hahs-Vaughn & Lomax, 2020; Montoya & Hayes, 2017). Firstly, assumption for independence was tested. Assumption about independence is that the errors in prediction residuals (i.e., e_i) are estimated to be random and each error should be independent from other errors (Hahs-Vaughn & Lomax, 2020). In other words, two variables should not provide similar information (Hayes, 2022). Durbin-Watson was tested to check for independence of errors using regression option in SPSS and the result was between 1.88 and 2.34 (Table 4.5). As a rule of thumb, values of Durbin-Watson that range between 1 and 3 are indicative of uncorrelated errors (Hahs-Vaughn & Lomax, 2020), thus there was no violation of assumption of independence.

Table 4.5: Durbin -Watson Test

Grade	*R*	R^2	Adjusted R^2	*Std. Error of the Estimate*	*Durbin-Watson*
7	.77	.59	.54	.72	2.26
8	.88	.72	.69	.68	1.81
12	.91	.83	.81	.56	2.04

a. Dependent variable: STEM-CCG.
b. Independent variables: the STEM-OP, self-efficacy, outcome expectations, interest and identity.

Secondly, the assumption of homoscedasticity, which refers to the requirement that variance of residuals should exhibit constant variance across dependent variable and across each of independent variables, was tested. Heteroskedasticity refers to circumstances in which the variance of residuals does not show equal variance across dependent variable and across each of independent variables (Hayes, 2018; Hahs-Vaughn & Lomax, 2020). Violation of homoscedasticity was evaluated by regressing square of unstandardized residuals on independent variables (Hayes & Cai, 2007) using regression option in SPSS. As per Table 4.6, the statistical test revealed that there was no significant variation in squared residuals ($F(1,55) = .09$, $p > .05$; $F(1,55) = .09$, $p > .05$; $F(6,67) = .06$, $p > .05$) which was suggestive of absence of heteroscedasticity and presence of homoscedasticity.

Table 4.6: ANNOVA Summary for Testing Homoscedasticity

Grade	*Model*	*Sum of Squares*	*df*	*Mean Square*	*F*	*p*
7	Regression	.09	1	.09	.09	.77
	Residual	54.47	55	.99		
	Total	54.56	56			
8	Regression	.04	1	.09	.09	.77
	Residual	54.47	55	.99		
	Total	54.56	56			
12	Regression	.01	1	.01	.06	.81
	Residual	9.98	72	.14		
	Total	9.99	73			

a. Dependent variable: square of unstandardized residuals.
b. Independent variables: the STEM-OP, self-efficacy, outcome expectations, interest, and identity.

Thirdly, assumption for linearity was tested. Linearity assumption simply signifies that there should be a linear relationship between X and Y (Hahs-Vaughn & Lomax, 2020). Similar to non-independence and heteroskedasticity, non-linearity affects the estimated standard error of regression coefficients which results in increasing Type 1 and Type 2 errors and reducing the power of statistical inferences (Hayes, 2018; Hayes & Cai, 2007; Hahs-Vaughn & Lomax, 2020). Linearity was tested by comparing the standard deviations of residuals and dependent variables. As a rule of thumb, suggested by Garson (2002, 2012), there is linearity when the standard deviations of residuals are not greater than that of the standard deviation of dependent variable. The standard deviation of the residuals that were between .54 and .69 (Table 4.7) was not greater than that of the standard deviation of the dependent variable that were between 1.07 and 1.30 (Table 4.8). Accordingly, based on Garson's (2002) standard, the linearity assumption in my study was established.

Table4. 7: Residual Statistics for The Linear Regression Model

	Residual			
Grade	*Min*	*Max*	*M*	*SD*
7	-2.06	2.33	.00	**.69**
8	-1.36	1.45	.00	**.64**
12	-0.93	1.20	.00	**.56**

Table 4.8: Descriptive Statistics

	SD		
	Grade 7	Grade 8	Grade 12
STEM-CCG	**1.07**	**1.22**	**1.30**
STEM-OP	.60	.88	0.74
STEM Self-efficacy	.88	.79	0.90
STEM Outreach expectations	.83	.95	1.07
STEM Interest	.55	.62	0.55
STEM identity	1.04	.91	1.04

Finally, the assumption of noncollinearity was tested. Violation of this assumption is called as collinearity where strong linear relationship exists between independent variables (Hahs-Vaughn & Lomax, 2020) contributing to a confusion about effects of each independent variables. Noncollinearity assumption was assessed via variance inflation factor (VIF) statistics using regression option in SPSS that allowed to evaluate how strong each independent variable was explained by other independent variables. It was suggested that VIF values should not be more than 10 in order to meet the noncollinearity assumption (Freund et al., 2006). The VIF tests in Table 4.9 revealed that none of the independent variables had VIF values more than 10. The assumption of noncollinearity was not violated.

Table 4.9: Variance Inflation Factors for Independent Variables

	VIF		
Variable	Grade 7	Grade 8	Grade 12
STEM-OP	1.65	2.05	1.16
STEM self-efficacy	1.90	2.33	2.64
STEM outcome expectations	1.58	2.63	2.23
STEM interest	2.55	2.75	1.88
STEM identity	2.19	3.68	3.07

a. Dependent variable: STEM-CCG.
Note. *VIF* = variance inflation factor.

Correlation. Table 4.10 presents mean, standard deviation and correlation among predictor and dependent variables. The Pearson correlation among the study's variables were found to be between low positive (r =.13) and high positive (r = .87).

Table 4.10: Means, Standard Deviations and Correlation of Study Measures

Grade and Variable	1	2	3	4	5	*M*	*SD*
Grade 7							
1. STEM-CCG						3.12	1.07
2. STEM-OP	.49**	-				3.32	.60
3. STEM Self-efficacy	.54**	.47**	-			3.66	.88
4. STEM outcome expectations	.67**	.56**	.44**	-		3.27	.83
5. STEM interest	.46**	.48**	.64**	.45**	-	4.08	.85
6. STEM science identity	.56**	.42**	.58**	.37**	.72**	3.11	1.04
Grade 8							
1. STEM-CCG						3.11	1.22
2. STEM-OP	.54**	-				3.64	.88
3. STEM Self-efficacy	.59**	.54**	-			3.64	.79
4. STEM outcome expectations	.79**	.65**	.51**	-		3.32	.95
5. STEM interest	.60**	.62**	.58**	.69**	-	4.21	.74
6. STEM science identity	.76**	.55**	.73**	.70**	.74**	3.21	.91
Grade 12							
1. STEM-CCG	-					2.99	1.30
2. STEM-OP	.23	-				3.28	.73
3. STEM Self-efficacy	.65**	.31**	-			3.16	.90
4. STEM outcome expectations	.87**	.22	.67**	-		3.18	.95
5. STEM interest	.54**	.13**	.53**	.60**	-	3.82	.81
6. STEM science identity	.75**	.35**	.75**	.66**	.64**	2.80	1.04

** p <0.01 (2-tailed) * p<0.05; N=74.

4.2 Primary Analysis

In the first strand of this section, findings of serial-mediation analysis that were conducted using model 6 of the PROCESS macro (Hayes, 2022) for SPSS are displayed. In the later strand, results of longitudinal serial-mediation analysis that were carried out utilizing model 1 of the MEMORE procedure (Montoya & Hayes, 2017) for SPSS are illustrated. Both procedures generate regression coefficients through ordinary least square (OLS) regression for the direct and indirect effects of independent variable. The regression coefficients in PROCESS and MEMORE macros are estimated using *p*-values and bootstrap confidence intervals for direct effects and bias-corrected 95% bootstrap confidence intervals for the indirect effects. If the lower and upper bound of the bootstrap confidence interval for the products of indirect effects do not contain zero, the indirect effects are deemed to be statistically significant at the conventional $\alpha = 0.05$. In contrast, if the lower and upper bound of the bootstrap confidence intervals for the indirect effects include zero, the indirect effects are considered statistically non-significant. Model 6 of the PROCESS and model 1 of the MEMORE produce seven specific indirect effects, total indirect effect, ten direct effects including the direct effect of X on Y and total effect. My study, following its theoretical framework drawn on SCCT (Lent et al., 1994) and science identity theory (Carlone & Johnson, 2007), only focused on analysing the direct and the indirect effects. Hypotheses of the research that were tested by these macros were proposed according to these effects.

4.2.1 Serial-mediation Analysis

Research questions one and two and related hypotheses were the basis for the serial-mediation analysis. In the first research question, direct and indirect effects of the STEM-OP on high-school students' STEM-CCGs via STEM self-efficacy, interest and identity were addressed. In this first question, STEM self-efficacy was used as the first mediator. The focus of the second research question was to examine direct and indirect effects of the STEM-OP on STEM-CCG via STEM outcome expectations, interest and STEM identity. Here, STEM outcome expectations was treated as the first mediator.

4.2.1.1 Results for Research Question One and Related Hypotheses

1. To what extent did the STEM-OP influence high-school students' STEM-CCGs indirectly through STEM self-efficacy, interest and identity?

Hypothesis 1A: The STEM-OP directly influences high-school students' STEM-CCGs.

Hypothesis 1B: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM self-efficacy.

Hypothesis 1C: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM interest.

Hypothesis 1D: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM identity.

Hypothesis 1E: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM self-efficacy and interest.

Hypothesis 1F: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM self-efficacy and identity.

Hypothesis 1G: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM interest and identity.

Hypothesis 1H: The STEM-OP indirectly influence high-school students' STEM-CCG through STEM self-efficacy, interest and identity.

To answer research question one and test the related hypotheses, model 6 of PROCESS macro (Hayes, 2022) for SPSS 28 was used with 5000 bootstrapping samples to generate bias-corrected 95% bootstrap confidence intervals. In this serial-mediation model, the STEM-OP served as independent predictor variable (X), STEM self-efficacy (M_1), STEM interest (M_2) and STEM identity (M_3) served as serial-mediator variables, and STEM-CCG served as the outcome variable (Y). The serial-mediation analysis, that was conducted to test whether the influence of the STEM-OP on high-school students' STEM-CCGs was serially mediated through STEM self-efficacy, interest and identity, produced direct and indirect effects.

Direct Effects: Ten distinct direct effects were found among predictor, mediator and outcome variables, generated as a product of OLS regression coefficients with *p-values* and bootstrap confidence intervals (Figure 4.1). Indirect effects are derived from multiplying these direct effects. Only *p-values* were given for confidence interval statistics to avoid repetition.

First, five regression coefficients (coloured in green) that were positive and statistically significant were observed on the direct effects of the STEM-OP on STEM self-efficacy ($B = .38$, $SE = .14$, $p < .01$), of STEM self-efficacy on STEM interest ($B=.48$, $SE = .10$, $p < .01$), of STEM self-efficacy on STEM identity ($B=.61$, $SE = .10$, $p < .01$), of STEM interest on STEM identity ($B=.43$, $SE = .10$, $p < .01$), and of STEM identity on high-school students' STEM-CCGs ($B =$

.70, *SE* = .17, *p* < .01). Second, three regression coefficients (coloured in yellow) that were positive but non-significant were found on the direct effects of the STEM-OP on STEM identity (*B* = .20, *SE* = .10, *p* > .01), of STEM self-efficacy on STEM-CCG (*B*=.30, *SE* = .17, *p* > .01), and of STEM interest on STEM-CCG (*B* = .12, *SE* = .16, *p* > .01). Finally, two regression coefficients (coloured in red) that were both negative and non-significant were identified on the direct effect of the STEM-OP on STEM interest (*B* = -.35, *SE* = .12, *p* > .01), and the direct effect of independent variable, the STEM-OP, on dependent variable, STEM-CCG, (*B* = -.08, *SE* = .15, *p* > .01).

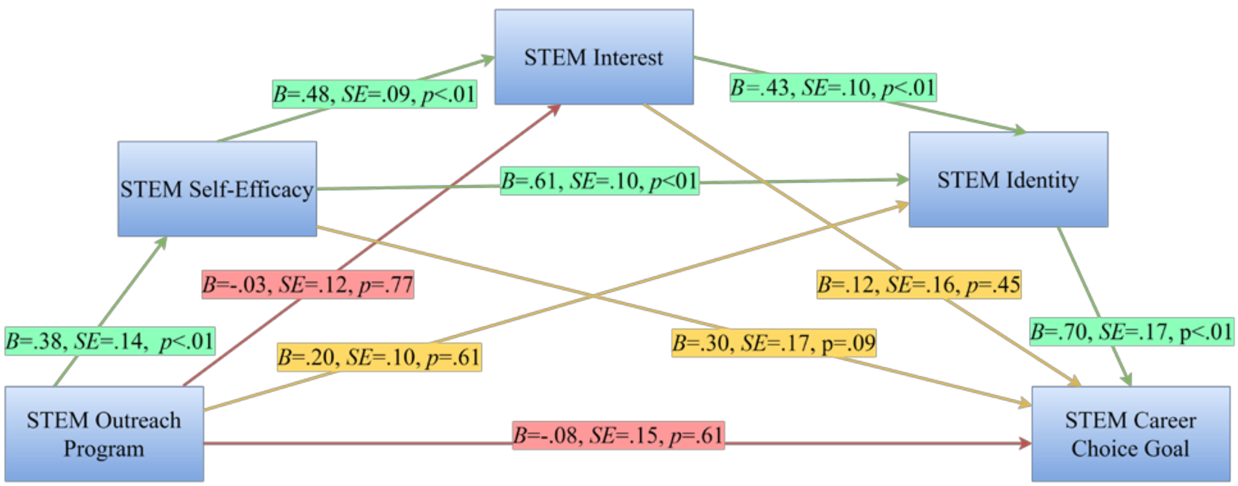

Figure 4.1: Regression Coefficients of Direct Effects with Self-Efficacy as First Mediator

Indirect Effects: Utilizing the PROCESS procedure for SPSS 28 with 5000 bootstrap samples and OLS regression analysis to generate bias-corrected 95% bootstrap confidence intervals, the first serial-mediation analysis generated seven specific indirect effects concerning research question one (Table 4.11). The specific indirect effects are derived by multiplying coefficients of pathways traced from independent variable to dependent variable via one or more mediating variables.

Three of the seven specific indirect effects (coloured in green) were positive and statistically significant because 95% bootstrap confidence intervals for these effects did not include zero. The indirect effect of the STEM-OP on high-school students' STEM-CCGs via STEM identity was positive and statistically significant (*B* = .14, boot *SE* = .08, 95% CI = [.01 − .33]). Additionally, the serial indirect effect of the STEM-OP on STEM-CCG via STEM self-efficacy and identity was positive and statistically significant (B = .16, boot SE = .09, 95% CI = [.03 − .37]). Also, the serial indirect effect of the STEM-OP on STEM-CCG via STEM self-efficacy, interest and identity was positive and statistically significant (B = .06, boot SE = .03, 95% CI = [.01 − .12]).

Table 4.11: Regression Coefficients for the Indirect Effects of the STEM-OP on High-School Students' STEM-CCGs Via STEM Self-Efficacy, Interest and Identity

Indirect Effects	Coeff.	Boot *SE*	95% CI [BootLLCI − BootULCI]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM self-efficacy (M_1)	.11	.11	[-.06 − .36]
Indirect effect of the STEM-OP (X) on students' STEM-CCGs (Y) through STEM interest (M_2)	.01	.03	[-.06 − .07]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM identity (M_3)	.14	.08	[.01 − .33]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM self-efficacy (M_1) → STEM interest (M_2)	.02	.03	[-.02 − .10]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM self-efficacy (M_1) → STEM identity (M_3)	.16	.09	[.03 − .37]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM interest (M_2) → STEM identity (M_3)	-.01	.05	[-.09 − .12]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM self-efficacy (M_1) → STEM interest (M_2) → STEM identity (M_3)	.06	.03	[.01 − .12]

Note. Boot *SE* = bootstrap standard error; 95% CI = 95% bootstrap confidence interval; *BootLLCI* = bootstrap lower-level confidence level; *BootULLCI* = bootstrap upper-level confidence interval.

However, three of the indirect effects (coloured in yellow) were found to be positive but statistically non-significant for 95% bootstrap confidence intervals for these effects included zero. Firstly, the indirect effect of the STEM-OP on high-school students' STEM-CCGs via

STEM self-efficacy was positive but statistically non-significant (*B* = .11, boot *SE* = .11, 95% CI = [-.06 − .36]). Secondly, the indirect effect of the STEM-OP on high-school students' STEM-CCGs via STEM interest was positive but statistically non-significant (*B* = .01, boot *SE* = .03, 95% CI = [-.06 − .07]). Thirdly, the serial indirect effect of the STEM-OP on high-school students' STEM-CCGs via STEM self-efficacy and interest was positive but statistically non-significant (*B* = .02, boot *SE* = .03, 95% CI = [-.02 − .10]). Moreover, one of the indirect effects (coloured in red) that was both negative and statistically non-significant because 95% bootstrap confidence interval for the effect included zero was observed on the serial indirect effect of the STEM-OP on high-school students' STEM-CCGs via STEM interest and identity (*B* = -.01, boot *SE* = .05, 95% CI = [-.09 − .12]).

4.2.1.2 Results for Research Question Two and Related Hypotheses

2. To what extent did the STEM-OP influence high-school students' STEM-CCGs indirectly through STEM outcome expectations, interest and identity?

Hypothesis 2A: The STEM-OP directly influences high-school students' STEM-CCGs.

Hypothesis 2B: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM outcome expectations.

Hypothesis 2C: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM interest.

Hypothesis 2D: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM identity.

Hypothesis 2E: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM outcome expectations and interest.

Hypothesis 2F: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM outcome expectations and identity.

Hypothesis 2G: The STEM-OP indirectly influences high-school students' STEM-CCGs through STEM interest and identity.

Hypothesis 2H: The STEM-OP indirectly influences high-school students' STEM-CCG through STEM outcome expectations, interest and identity.

To address research question two and test the related hypotheses, the same model 6 of PROCESS macro (Hayes, 2022) for SPSS 28 was utilized with 5000 bootstrapping samples to generate bias-corrected 95% bootstrap confidence intervals. In this second serial-mediation model, the STEM-OP served as independent predictor variable (X), STEM outcome expectations (M_1), STEM interest (M_2) and STEM identity (M_3) served as serial-mediator variables, and STEM-CCGs served as the outcome variable (Y). The serial-mediation analysis, that was conducted to test whether the influence of the STEM-OP on high-school students' STEM-CCGs was mediated through STEM outcome expectations, interest and identity produced direct and indirect effects.

Direct Effects: There were ten distinct direct effects among predictor, mediator and outcome variables, produced as a result of OLS regression coefficients with *p-values* and bootstrap confidence intervals to calculate statistical significance (Figure 4.2). Indirect effects are obtained from multiplying these direct effects. Only *p-values* were presented for confidence interval statistics to avoid repetition. First, six regression coefficients (coloured in green) that were positive and statistically significant were found on the direct effects of STEM outcome expectations on STEM interest (B = .51, SE = .08, p < .01), of the STEM-OP on STEM identity (B=.30, SE = .11, p < .01), of STEM outcome expectations on STEM identity (B=.43, SE = .10, p < .01), of STEM interest on STEM identity (B = .47, SE = .12, p < .01), of STEM outcome expectations on STEM-CCG (B = .95, SE = .10, p < .01), and of STEM identity on STEM-CCG (B = .46, SE = .10, p < .01). Second, two regression coefficients (coloured in yellow) that were positive but non-significant were identified on the direct effects of the STEM-OP on STEM outcome expectations (B = .29, SE = .15, p > .01) and on STEM (B = .01, SE = .11, p > .01). Finally, two regression coefficients (coloured in red) that were both negative and non-significant were established on the direct effect of the STEM-OP on STEM interest (B = -.18, SE = .11, p > .01), and the direct effect of independent variable, the STEM-OP, on dependent variable, STEM-CCG, (B = -.08, SE = .10, p > .01).

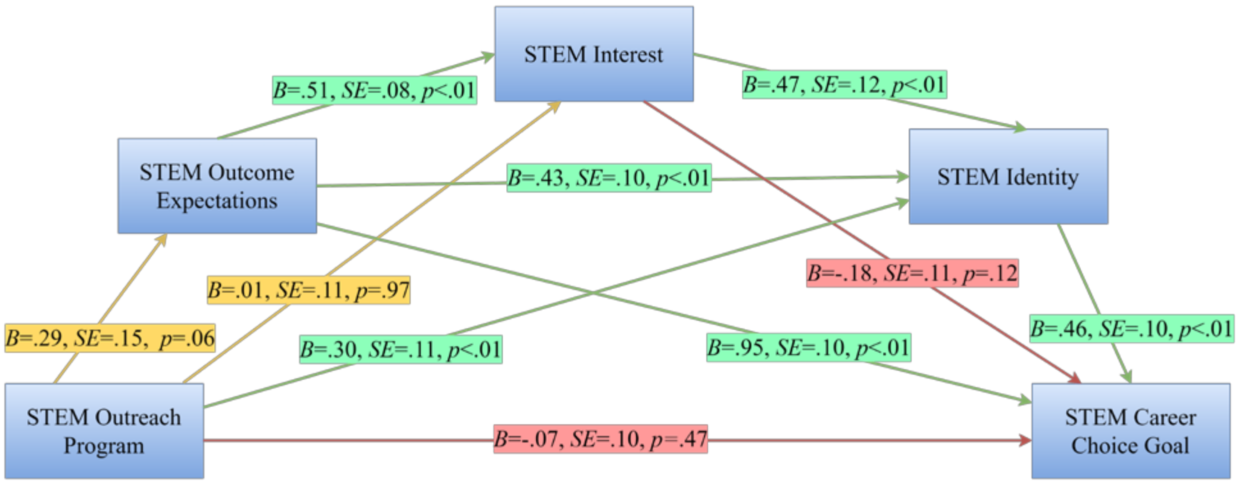

Figure 4.2: Regression Coefficients for Direct Effects with Outcome Expectations as First Mediator

Indirect Effects: The second serial-mediation analysis that also used Hayes' (2022) PROCESS with 5000 bootstrap samples and OLS regression analysis to generate bias-corrected 95% bootstrap confidence intervals with regard to research question two produced seven specific indirect effects (Table 4.12). The specific indirect effects are drawn by multiplying coefficients of pathways followed from independent variable to dependent variable through one or more mediating variables.

Four of the seven indirect effects (coloured in green) were positive and statistically significant because 95% bootstrap confidence intervals for these effects did not contain zero. The indirect effect of the STEM-OP on high-school students' STEM-CCGs via STEM outcome expectations was positive and statistically significant (B = .27, boot SE = .15, 95% CI = [.01 − .58]). Further, the indirect effect of the STEM-OP on high-school students' STEM-CCGs via STEM identity was positive and statistically significant (B = .14, boot SE = .08, 95% CI = [.03 − .32]). Additionally, the serial indirect effect of the STEM-OP on high-school students' STEM-CCGs via STEM outcome expectations and identity was positive and statistically significant (B = .06, boot SE = .04, 95% CI = [.01 − .15]). Also, the serial indirect effect of the STEM-OP on high-school students' STEM-CCGs via STEM outcome expectations, interest and identity was positive and statistically significant (B = .03, boot SE = .02, 95% CI = [.01 − .07]).

Table 4.12: Regression Coefficients for the Indirect Effects of the STEM-OP on High-School Students' STEM-CCGs Via STEM Outcome Expectations, Interest and Identity

Indirect Effects	Coeff.	Boot *SE*	95% CI [BootLLCI − BootULCI]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM outcome expectations (M_1)	.27	.15	[.01 − .58]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM interest (M_2)	.01	.03	[-.04 − .07]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM identity (M_3)	.14	.08	[.02 − .32]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM outcome expectations (M_1) → STEM interest (M_2)	-.03	.02	[-.07 − .02]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM outcome expectations (M_1) → STEM identity (M_3)	.06	.04	[.01 − .15]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM interest (M_2) → STEM identity (M_3)	.01	.03	[-.05 − .08]
Indirect effect of the STEM-OP (X) on high-school students' STEM-CCGs (Y) through STEM outcome expectations (M_1) → STEM interest (M_2) → STEM identity (M_3)	.03	.02	[.01 − .07]

Note. Boot *SE* = bootstrap standard error; 95% CI = 95% bootstrap confidence interval; *BootLLCI* = bootstrap lower-level confidence level; *BootULLCI* = bootstrap upper-level confidence interval.

Nevertheless, two of the indirect effects (coloured in yellow) were observed as positive but statistically non-signific for 95% bootstrap confidence intervals for these effects included zero. Firstly, the indirect effect of the STEM-OP on high-school students' STEM-CCGs via STEM interest was positive but statistically non-significant (B = .01, boot *SE* = .03, 95% CI = [-.04 − .07]). Secondly, the serial indirect effect of the STEM-OP on high-school students' STEM-CCGs via STEM interest and identity was positive but statistically non-significant (B = .01, boot *SE* = .03, 95% CI = [-.05 − .08]). Moreover, one of the indirect effects (coloured in red) that was both negative and statistically non-significant, because 95% bootstrap confidence interval for the effect included zero, was established on the serial indirect effect of the STEM-OP on high-school students' STEM-CCGs via STEM outcome expectations and interest (B = -.03, boot SE = .02, 95% CI = [-.07 − .02]).

4.2.2 Longitudinal Serial-mediation

Two two-condition within-participant mediation analysis was performed to address the longitudinal serial-mediation research questions three and four. The third research question addressed whether there was a change in direct and serial indirect effects of the STEM-OP on middle-school students' STEM-CCGs via STEM self-efficacy (used as first mediator), interest and identity from P2 to P3. In the fourth research question, evaluating whether there was a change in direct and indirect effects of the STEM-OP on middle-school students' STEM-CCGs via STEM outcome expectations (treated as first mediator), interest and STEM identity from P2 to P3 occurred.

4.2.2.1 Results for Research Question Three and Hypotheses

3. To what extent did the direct and indirect effects of the STEM-OP on middle school students' STEM-CCGs through STEM self-efficacy, interest and identity change from P2 to P3?

Hypothesis 3A: The direct effect of the STEM-OP on middle-school students' STEM-CCGs changes from P2 to P3.

Hypothesis 3B: The indirect effect of the STEM-OP on middle-school students' STEM-CCGs through STEM self-efficacy changes from P2 to P3.

Hypothesis 3C: The indirect effect of the STEM-OP on middle-school students' STEM-CCGs through STEM interest changes from P2 to P3.

Hypothesis 3D: The indirect effect of the STEM-OP on middle-school students' STEM-CCGs through STEM identity changes from P2 to P3.

Hypothesis 3E: The indirect effect of the STEM-OP on middle-school students' STEM-CCGs through STEM self-efficacy and interest changes from P2 to P3.

Hypothesis 3F: The indirect effect of the STEM-OP on middle-school students' STEM-CCGs through STEM self-efficacy and identity changes from P2 to P3.

Hypothesis 3G: The indirect effect of the STEM-OP on middle-school students' STEM-CCGs through STEM interest and identity changes from P2 to P3.

Hypothesis 3H: The indirect effect of the STEM-OP on middle-school students' STEM-CCG is mediated through STEM self-efficacy, interest and identity changes from P2 to P3.

To answer research question three and test the related hypotheses, model 1 of MEMORE macro (Montoya & Hayes, 2017)) for SPSS 26 was used with 5000 bootstrapping samples to generate bias-corrected 95% bootstrap confidence intervals. In this longitudinal serial-mediation model, the STEM-OP served as independent predictor variable (X), STEM self-efficacy (M_1), STEM interest (M_2) and STEM identity (M_3) served as longitudinal serial-mediator variables, and STEM-CCGs served as the outcome variable (Y). The longitudinal serial-mediation analysis, that was conducted to test whether there was a change in the influence of the serial indirect effects of the STEM-OP on middle-school students' STEM-CCGs through STEM self-efficacy, interest and identity from P2 to P3, produced direct and indirect effects.

Direct Effects: Ten distinct direct effects among predictor, mediator and outcome variables were produced as a product of OLS regression coefficients with *p-values* and bootstrap confidence intervals (Figure 4.3). Indirect effects were derived from multiplying these direct effects. Only *p-values* were given for confidence interval statistics to avoid repetition.

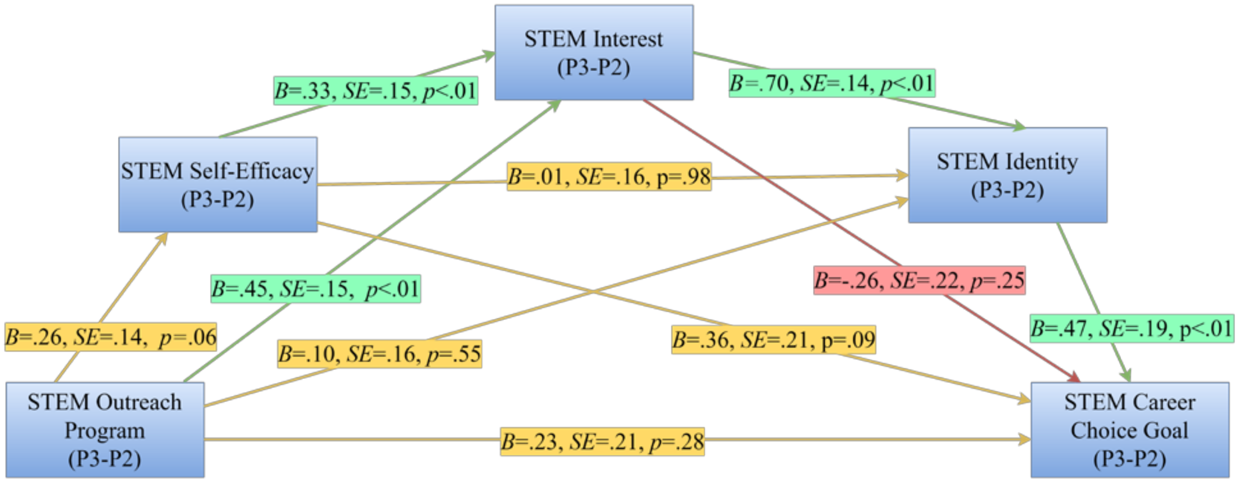

Figure 4.3: Regression Coefficients of Changes from P2 To P3 in the Direct Effects with Self-Efficacy as First Mediator

First, four of the regression coefficients (coloured in green) that revealed positive and significant changes from P2 to P3 were observed on the direct effects of the STEM-OP on STEM interest (B = .45, SE = .15, p < .01), of STEM self-efficacy on STEM interest (B=.33, SE = .15, p < .01), of STEM interest on STEM identity (B=.70, SE = .13, p < .01) and of STEM identity on middle-school students' STEM-CCGs (B = .46, SE = .19, p < .01). Second, five regression coefficients (coloured in yellow) that showed positive but non-significant changes from P2 to P3 were found on the direct effects of the STEM-OP on STEM self-efficacy (B = .27, SE = .14, p > .01), of the STEM-OP on STEM identity (B = .10, SE = .16, p > .01), of STEM self-efficacy on STEM identity (B = .01, SE = .16, p > .01) and of STEM self-efficacy on middle-school students' STEM-CCGs (B = .36, SE = .21, p > .01). This also included the direct effect of independent variable, the STEM-OP, on dependent variable, middle-school students' STEM-CCGs, which was positive but statistically not significant (B = .23, SE = .21, p > .01). Finally, the direct effect of STEM interest on middle-school students' STEM-CCGs was both negative and not statistically significant (B = -.26, SE = .22, p > .01).

Indirect Effects: Employing the MEMORE macro for SPSS 26 with 5000 bootstrap samples and OLS regression analysis to generate bias-corrected 95% bootstrap confidence intervals, the longitudinal serial-mediation analysis generated seven specific indirect effects with regard to the third research question. The specific indirect effects are derived by multiplying coefficients of pathways traced from independent variable to dependent variable via one or more mediating variables (Table 4.13).

Positive and statistically significant changes from P2 to P3 were observed on two of the specific indirect effects (coloured in green) because 95% bootstrap confidence interval for these effects did not contain zero. The change from P2 to P3 in the serial indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM interest and identity was positive and statistically significant (B = .05, boot SE = .04, 95% CI = [.01 − .16]). Also, the change from P2 to P3 in the serial indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM self-efficacy, interest and identity was also positive and statistically significant (B = .01, boot SE = .01, 95% CI = [.01 − .04]).

Table 4.13: Regression Coefficients for Changes from P2 to P3 in the Indirect Effects of the STEM-OP on Middle-School Students' STEM-CCGs Via STEM Self-Efficacy, Interest and Identity

Indirect Effects	Coeff.	Boot *SE*	95% CI [BootLLCI − BootULCI]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM self-efficacy (M_1)	.03	.03	[-.02 − .11]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM interest (M_2)	-.04	.05	[-.15 − .03]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM identity (M_3)	.02	.03	[-.05 − .10]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM self-efficacy (M_1) → STEM interest (M_2)	-.01	.01	[-.04 − .01]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM self-efficacy (M_1) → STEM identity (M_3)	.01	.01	[-.02 − .03]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM interest (M_2) → STEM identity (M_3)	.05	.04	[.01 − .16]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM self-efficacy (M_1) → STEM interest (M_2) → STEM identity (M_3)	.01	.01	[.01 − .04]

Note. Boot *SE* = bootstrap standard error; 95% CI = 95% bootstrap confidence interval; *BootLLCI* = bootstrap lower-level confidence level; *BootULLCI* = bootstrap upper-level confidence interval.

However, positive but statistically non-significant changes from P2 to P3 were revealed on three of the specific indirect effects (coloured in yellow) because 95% bootstrap confidence intervals for these effects included zero. Firstly, the change from P2 to P3 in the indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM self-efficacy (B = .03, boot SE = .03, 95% CI = [-.02 − .11]) was positive but statistically non-significant. Secondly, the change from P2 to P3 in the indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM identity was positive but statistically non-significant (B = .02, boot SE = .03, 95% CI

= [-.05 − .10]). Thirdly, the change from P2 to P3 in the serial indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM self-efficacy and identity was positive but statistically non-significant (*B* = .01, boot *SE* = .01, 95% CI = [-.01 − .03]).

Moreover, negative and non-significant change from P2 to P3 were identified in two of the specific indirect effects (coloured in red) for 95% bootstrap confidence intervals for these effects were not different from zero. The change from P2 to P3 in the indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM interest was negative and statistically not significant (*B* = -.04, boot *SE* = .05, 95% CI = [-.15 − .03]). The change from P2 to P3 in the serial indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM self-efficacy and interest was also negative and statistically not significant (*B* = -.01, boot *SE* = .01, 95% CI = [-.04 − .01]).

4.2.2.2 Results for Research Question Four and Related Hypotheses

4. To what extent did the direct and indirect effects of the STEM-OP on middle school students' STEM-CCGs through STEM outcome expectations, interest and identity change from P2 to P3?

Hypothesis 4A: The direct effect of the STEM-OP on middle-school students' STEM-CCGs changes from P2 to P3.

Hypothesis 4B: The indirect effect of the STEM-OP on middle-school students' STEM-CCGs through STEM outcome expectations changes from P2 to P3.

Hypothesis 4C: The indirect effect of the STEM-OP on middle-school students' STEM-CCGs through STEM interest changes from P2 to P3.

Hypothesis 4D: The indirect effect of the STEM-OP on middle-school students' STEM-CCGs through STEM identity changes from P2 to P3.

Hypothesis 4E: The indirect effect of the STEM-OP on middle-school students' STEM-CCGs through STEM outcome expectations and interest changes from P2 to P3.

Hypothesis 4F: The indirect effect of the STEM-OP on middle-school students' STEM-CCGs through STEM outcome expectations and identity changes from P2 to P3.

Hypothesis 4G: The indirect effect of the STEM-OP on middle-school students' STEM-CCGs through STEM interest and identity changes from P2 to P3.

Hypothesis 4H: The indirect effect of the STEM-OP on middle-school students' STEM-CCG through STEM outcome expectations, interest and identity changes from P2 to P3.

To investigate research question four and test the related hypotheses, the same model 1 of MEMORE macro (Montoya & Hayes, 2017) for SPSS 26 was utilized with 5000 bootstrapping samples to generate bias-corrected 95% bootstrap confidence intervals. In this second longitudinal serial-mediation model, the STEM-OP served as independent predictor variable (X), STEM outcome expectations (M_1), STEM interest (M_2) and STEM identity (M_3) served as longitudinal serial-mediator variables, and STEM-CCGs served as the outcome variable (Y). The longitudinal serial-mediation analysis, that was carried out to test whether there was a change in the influence of the serial indirect effects of the STEM-OP on middle school students' STEM-CCGs through STEM self-efficacy, interest and identity from P2 to P3, produced direct and indirect effects.

Direct Effects: Ten distinct direct effects among predictor, mediator and outcome variables were generated as a result of OLS regression coefficients with *p-values* and bootstrap confidence intervals (Figure 4.4). Indirect effects were developed from multiplying these direct effects. Only *p-values* were provided for confidence interval statistics to avoid repetition. Firstly, four of the regression coefficients (coloured in green) that showed positive and significant changes from P2 to P3 were observed on the direct effects of the STEM-OP on STEM outcome expectations (B = .38, SE = .14, p < .01), of the STEM-OP on STEM interest (B=.45, SE = .16, p < .01), of STEM interest on STEM identity (B=.63, SE = .15, p < .01) and of STEM outcome expectations on middle-school students' STEM-CCGs (B = .81, SE = .17, p < .01).

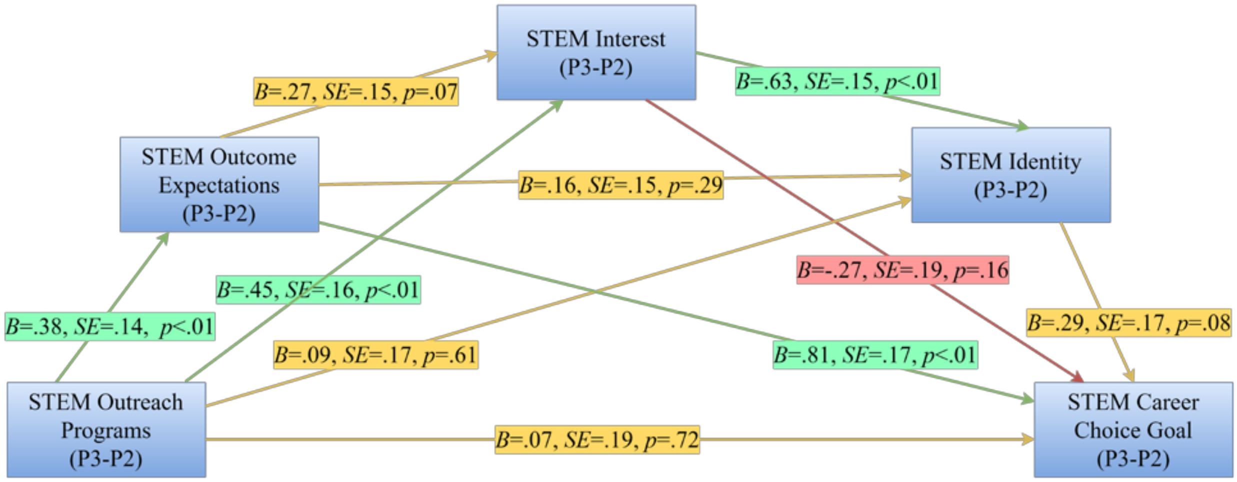

Figure 4.4: Regression Coefficients of Changes from P2 To P3 in the Direct Effects with Outcome Expectations as First Mediator

Secondly, five regression coefficients (coloured in yellow) that revealed positive but non-significant changes from P2 to P3 were found on the direct effects of STEM outcome expectations on STEM interest (B = .27, SE = .15, p > .01), of the STEM-OP on STEM identity (B = .09, SE = .17, p > .01), of STEM outcome expectations on STEM identity (B = .16, SE = .15, p > .01) and of STEM identity on middle-school students' STEM-CCGs (B = .29, SE = .17, p > .01). Among these five regression coefficients were the direct effect of independent variable, the STEM-OP, on dependent variable, middle-school students' STEM-CCGs, which was positive but statistically not significant (B = .07, SE = .19, p > .01). Finally, one regression coefficient (coloured in red) that unveiled both negative and non-significant change from P2 to P3 was identified on the direct effect of STEM interest on middle-school students' STEM-CCGs (B = -.27, SE = .19, p > .01).

Indirect Effects: Utilising the MEMORE macro for SPSS 28 with 5000 bootstrap samples and OLS regression analysis to generate bias-corrected 95% bootstrap confidence intervals, the second longitudinal serial-mediation regarding research question four produced seven specific indirect effects (Table 4.14). The specific indirect effects are obtained by multiplying coefficients of pathways traced from independent variable to dependent variable via one or more mediating variables.

Positive and statistically significant change from P2 to P3 was identified on three of the specific indirect effects (coloured in Green) because 95% bootstrap confidence interval for these effects did not include zero. First, the change from P2 to P3 in the indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM outcome expectations was positive and statistically significant (B = .10, boot SE = .06, 95% CI = [.03 − .27]). Second, the change from P2 to P3 in the serial indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM interest and identity was positive and statistically significant (B = .03, boot SE = .03, 95% CI = [.01 − .17]). Third, the change from P2 to P3 in the serial indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM outcome expectations, interest and identity was positive and statistically significant (B = .01, boot SE = .01, 95% CI = [.01 − .03]).

Table 4.14: Regression Coefficients for Changes from P2 to P3 in the Indirect Effects of the STEM-OP on Middle-School Students' STEM-CCGs Via STEM Outcome Expectations, Interest and Identity

Indirect Effects	Coeff.	Boot *SE*	95% CI [BootLLCI − BootULCI]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM outcome expectations (M_1)	.10	.06	[.03 − .27]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM interest (M_2)	-.04	.05	[-.20 − .01]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM identity (M_3)	.01	.02	[-.02 − .09]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCG (Y) through STEM outcome expectations (M_1) → STEM interest (M_2)	-.01	.01	[-.06 − .01]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM outcome expectations (M_1) → STEM identity (M_3)	.01	.01	[-.01 − .06]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM interest (M_2) → STEM identity (M_3)	.03	.03	[.01 − .17]
Indirect effect of the STEM-OP (X) on middle-school students' STEM-CCGs (Y) through STEM outcome expectations (M_1) → STEM interest (M_2) → STEM identity (M_3)	.01	.01	[.01 − .03]

Note. Boot *SE* = bootstrap standard error; 95% CI = 95% bootstrap confidence interval; *BootLLCI* = bootstrap lower-level confidence level; *BootULLCI* = bootstrap upper-level confidence interval.

Nonetheless, positive but statistically non-significant changes from P2 to P3 were observed on two of the specific indirect effects (coloured in yellow) because 95% bootstrap confidence intervals for these effects were not different from zero. The change from P2 to P3 in the indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM identity was positive but statistically non-significant (B = .01, boot SE = .02, 95% CI = [-.02 − .09]). Further, the change from P2 to P3 in the serial indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM outcome expectations and identity was positive but statistically non-significant (*B* = .01, boot *SE* = .01, 95% CI = [-.01 − .06]).

Finally, negative and non-significant change from P2 to P3 were identified on two of the specific indirect effects (coloured in red) for 95% bootstrap confidence intervals for these effects contained zero. The change from P2 to P3 in the indirect effect of the STEM-OP on middle-school students' STEM-CCGs via STEM interest was negative and statistically not significant (*B* = -.04, boot *SE* = .05, 95% CI = [-.20 − .01]). Additionally, the change from P2 to P3 in the serial indirect effect of STEM-OP on middle-school students' STEM-CCGs via STEM outcome expectations and interest was negative and statistically not significant (*B* = -.01, boot *SE* = .01, 95% CI = [-.06 − .01]).

4.3 Chapter Summary

Chapter 4 first presented descriptive results of demographic characteristics, missing values, power analysis, statistical assumptions and correlation of variables. In the remainder of the chapter, findings from PROCESS and MEMORE procedures that analysed the mediation and longitudinal mediation questions, and hypotheses were reported. In Chapter 5, discussions of findings and implications for the theoretical base of SCCT and practice are provided.

Chapter 5

5 Discussion, Implication and Suggestions for Future Research

The study utilized secondary data aimed at examining the extent to which high-school students' STEM self-efficacy, outcome expectations, interest and identity mediated the direct effect of an outreach program on the likelihood of these students pursuing a career in STEM. It also investigated the degree to which the direct and indirect effects of the outreach program on middle-school students' STEM career intentions changed from Phase II to Phase III. The first section of this chapter discusses the findings reported in Chapter 4. This is followed by addressing the theoretical and practical implications.

5.1 Discussion of the Findings

The present study was guided by a conceptual framework comprised of six constructs from integrated interest-choice model of social cognitive career theory that was expanded to incorporate recognition construct from science identity theory (Carlone & Johnson, 2007; Hazari et al., 2010; Lent et al., 1994, 2001). The hybrid conceptual framework was operationalized to cross-sectionally and longitudinally examine the direct and indirect relationships among contextual support in the form of the STEM outreach program, STEM self-efficacy, outcome expectations, interest, and identity and middle and high-school students' STEM career pursuits. Noteworthy to mention that the study only emphasized examining the direct and indirect effects of contextual support on choice goal. Therefore, the bivariate and multivariate relationships among the contextual, cognitive and choice intention variables were not included in the discussion. Additionally, it was mentioned in Chapter 1 that the hybrid conceptual framework that guided the study was subdivided into two conceptual models because the PROCESS and MEMORE macros do not have models for testing parallel-serial mediation and longitudinal parallel-serial mediation with more than three mediators. The findings that were analyzed and interpreted based on the two conceptual models in Chapter 4 were combined to reflect the original proposed framework and for the purpose of the discussion. As a result, findings about a direct effect and eleven indirect effects of each of the mediation and longitudinal mediation analysis are discussed.

Cohen's (1988) thresholds of .10, .30 and .50 (indicating small, medium, and large regression coefficients) were adopted to explain the practical significance of the direct and indirect effects. According to Cohen (1988), the effect is considered practically significant if the value of regression coefficient (*r*) is equal or greater than .10, medium if *r* varies around .30, and large if *r* varies greater than .50. The first strand of this section discusses findings of mediation analysis. The discussion continues to the results of longitudinal mediation analysis concerning the temporal relations in the integrated and expanded model of social cognitive career theory over two points of time, a year apart.

5.1.1 Discussion of Mediation Findings

It was hypothesized, based on the hybrid conceptual framework, that there would be a statistically significant direct effect of the STEM outreach program on high-school students' STEM career choice goals. The study also assessed the results of the hypothesis that the mediating effects of STEM self-efficacy, outcome expectations, interest and identity on the predictive relationship between the STEM outreach program and high-school students' STEM career intentions would be statistically significant. Consistent with prior literature by social cognitive career theory (Lent et al., 2001, 2005, 2018; Lent & Brown, 2019; Pugh et al., 2021; Sheu et al., 2010), the findings revealed that the direct pathway from the STEM outreach program to high-school students' STEM career choice was not significant. High-school students' participation in the outreach program did not increase the likelihood of their choice of a career in STEM. This finding was in contrast to other studies (Brown et al., 2018; Huziak-Clark et al., 2015; Lent et al., 1994; Oben & van Rooyen, 2022; Ozis et al., 2018; Phelps et al., 2018) that reported contextual supports as significant predictors of high-school students' intent to major in STEM.

Using Cohen's (1988) threshold for practical significance and consistent with findings by Chemers et al. (2011) and Dou et al. (2019), it was observed that STEM identity contributed significant though modest (.14) indirect pathway from the STEM outreach program to high-school students' STEM career goals. Participation in the outreach program helped high-school students develop their STEM identity which, in turn, increased the intention of choosing a career in STEM. Additionally, confirming results by Syed et al. (2019), STEM self-efficacy and identity produced significant though small (.16) serial indirect pathway from the STEM outreach program to high-school students' STEM career aspirations. Participation in the STEM outreach program increased confidence beliefs in STEM activities which, in turn, helped develop STEM identity, and the increased identification with STEM then kept high-school students' interest in choosing a STEM major.

Furthermore, congruent with the hypothesis of and findings from interest-choice model of social cognitive career theory (Lent, 2013; Lent et al., 2001, 2003, 2018; Pugh et al., 2021; Sheu et al., 2010) and Bandura's (1999, 2000) social cognitive theory, STEM outcome expectations yielded significant and medium (.27) indirect pathway from the STEM outreach program to STEM career intentions. Outcome expectations, in the study, stood out by having the strongest mediating effect that explained 27% of variance in high-school students' STEM career pursuits. The finding revealed that engagement with the STEM outreach program provided hands-on learning experiences and real-world application of integrating science, technology, engineering, and mathematics and increased high-school students' beliefs about eventual positive outcomes from participating in STEM activities which, in turn, increased the possibility of them choosing a career in STEM.

However, three of the statistically significant indirect effects produced coefficients that were below the .10 practical significance threshold. These included the serial indirect pathways from the STEM outreach program to STEM career intentions via STEM self-efficacy, interest and identity; outcome expectations and identity; and outcome expectations, interest and identity. Furthermore, there were five indirect effects that produced nonsignificant pathways. First, the serial indirect pathway from the STEM outreach program to high-school students' STEM career goals via STEM interest and identity was found to be nonsignificant. Second, in contrast to the results from literature by social cognitive career theory (Lent et al., 2001, 2018; Orji & Ogbuanya, 2022; Pugh et al., 2021; Sheu et al., 2010; Syed et al., 2019), the STEM outreach program yielded nonsignificant indirect pathways to high-school students' STEM career intentions via three simple and serial indirect effects: STEM self-efficacy; self-efficacy and interest; and outcome expectations and interest. Also, the mediating effect of STEM interest on the relationship between the STEM outreach program and high-school students' STEM career pursuits, that was not included in the hypothesis proposed by social cognitive career theory but examined in the study, produced nonsignificant indirect pathway.

5.1.2 Discussion of Longitudinal Mediation Findings

It was hypothesized that the direct effect of the STEM outreach program on middle-school students' STEM career choice goals would significantly change from Phase II to Phase III. It was also hypothesized that there would be significant change in the mediating effects of STEM self-efficacy, outcome expectations, interest and identity on the relationship between the STEM outreach program and middle-school students' STEM career intentions from Phase II to Phase III. Congruent with the cross-sectional results of the study, but contrary to the findings from studies by social cognitive career theory (Lent, Sheu, et al., 2008, 2010; Lent et al., 2016), the study revealed no significant change in the direct effect of the STEM outreach program on middle-school students' STEM career goals from Phase II to Phase III. The possibility of middle-school students' pursuit of a career in STEM did not change even after attending Phase III STEM-related outreach workshops compared to the direct effect of Phase II workshops over a year.

Regarding the longitudinal mediation results, it was revealed that the change from Phase II to Phase III in the indirect effect of the STEM outreach program on middle-school students' STEM career intentions via STEM outcome expectations was practically significant (.10). The changes in middle-school students' perception on the effects of STEM outreach workshops, measured at Phase III compared to Phase II, produced an increased change in their expectation beliefs about the usefulness of choosing a career in STEM for their future which, in turn, explained 10% of variance in predicting the increased change in the likelihood of their intention to major in STEM. However, there were changes in three indirect effects that were significant but fell below the .10 practical significance threshold. These significant pathways that were nonpractical included the changes from Phase II to Phase III in the serial indirect effects of the STEM outreach program on middle-school students' STEM career goals via STEM interest and identity; self-efficacy, interest and identity; and outcome expectations, interest and identity. Furthermore, it was observed that there were changes from Phase II to Phase III in seven mediating effects that were statistically nonsignificant, hence statistically nonpractical. They involved changes in the simple and serial indirect effects of the STEM outreach program on middle-school students' STEM career intentions via STEM self-efficacy; interest; identity; self-efficacy and interest; self-efficacy and identity; outcome expectations and interest; and outcome expectations and identity.

5.2 Theoretical and Practical Implications

The findings of the study presented theoretical and practical implications relevant for researchers, teachers and educational practitioners and administrators.

5.2.1 Theoretical Implications

Consistent with Bandura's (1999, 2000) and Lent et al.'s (2001) hypotheses, the pattern of findings from studies by social cognitive career theory provides a strong support for the model of indirect paths by which environmental factors are associated with choice behaviour in the context of STEM (Lent et al., 2001, 2003, 2005, 2018; Sheu et al., 2010). It is suggested by these studies that the influences of environmental supports on the process of choice goals are largely indirect. In the test of the direct and indirect models of theoretical paths by which contextual supports are linked to choice behaviour, the study's findings that only produced significant pathways from the STEM outreach program to STEM career goals via mediating predictors reaffirmed Bandura's (1999,2000) mediated model and contributed an addition to social cognitive career theory. It is argued by Baron and Kenny (1986) that in order for a mediating effect to take place, X needs to have a significant direct effect on Y. However, the approach by Baron and Kenny (1986) for determining the indirect effects has been challenged by scholars (Hayes, 2009, 2022; Preacher & Hayes, 2008) who argued that requiring a significant relationship between a predictor and an outcome variable as a precondition for mediation constrains the ability of researchers to examine mediation. Mediation can, the authors maintained, still be interpreted and provide valuable insights about the indirect effects of a predictor variable even in the absence of its direct effect.

Apart from confirming and building on the findings of the hybrid model of social cognitive career theory's interest-choice with science identity theory, the study contributed to the advancement of theoretical understanding of the influences of contextual and cognitive factors on students' career pursuits in several areas. First, as discussed in Chapter 2, the social cognitive career theory, that was further developed by Lent et al. (2001) with the inclusion of indirect effects of contextual support and barriers on choice goals via self-efficacy and outcome expectations, did not propose a mediating effect for interest. To the best of the researcher's knowledge, the finding on the indirect effect of STEM interest on the relationship between the STEM outreach program and STEM career intentions, though nonsignificant, was one of the scarce studies, if not the first, that investigated the mediating effect of contextual support on choice intentions via interest, thus expanded the understanding of social cognitive career theory's indirect pathways (coloured in blue in Figure 5.1).

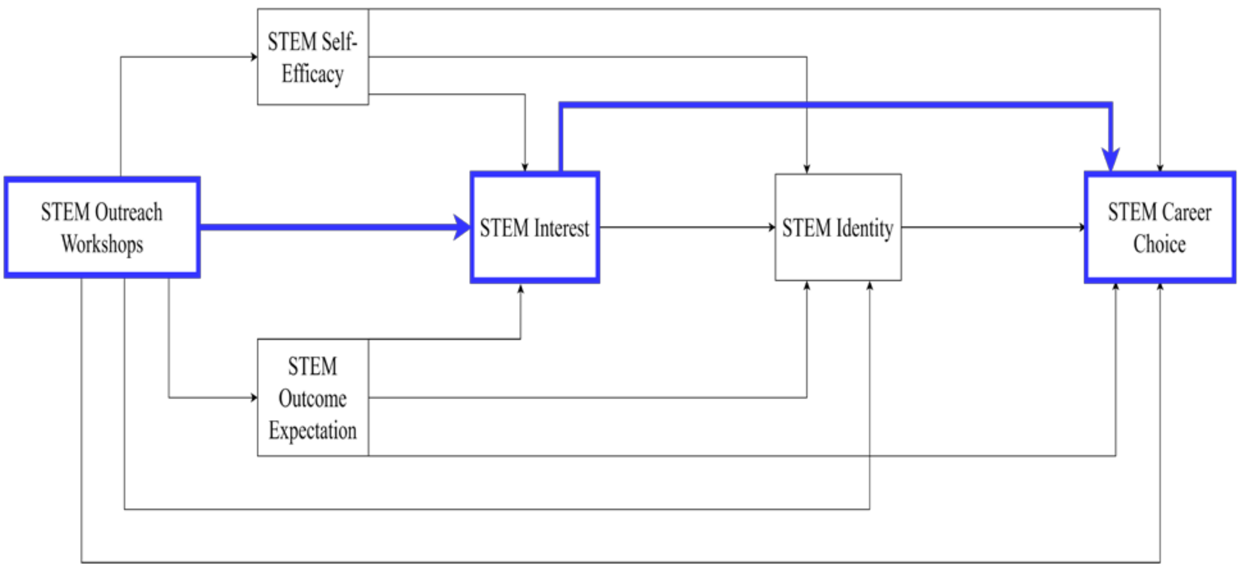

Figure 5.1: Integrated and expanded model of social cognitive career theory with science identity theory

Second, the studies that combine concepts from social cognitive, career and identity theories to examine students' career pursuits tend to focus on the bivariate and multivariate relationships between environmental, cognitive and career behaviours (Byars-Winston & Rogers, 2019; Hazari et al., 2010; Lock et al., 2015, 2019; Monsalve et al., 2016; Verdin et al., 2018). There appears to be limited literature that studies the mediating effects of integrated cognitive and identity variables on the association between environmental factors and career goals. In addition to supporting the studies by Chemers et al. (2011), Dou et al. (2019) and Syed et al. (2019) that found significant simple indirect effect of identity and significant serial indirect effect of self-efficacy and identity on the relationship between learning opportunities and students' career goals, the findings of my study further expanded social cognitive career theory by investigating the indirect effects of the STEM outreach program on high-school students' STEM career pursuits via four indirect pathways that included STEM interest and identity; self-efficacy, interest and identity; outcome expectations and identity; and outcome expectations, interest and identity (discussed in the previous section and coloured in blue in Figure 5.2).

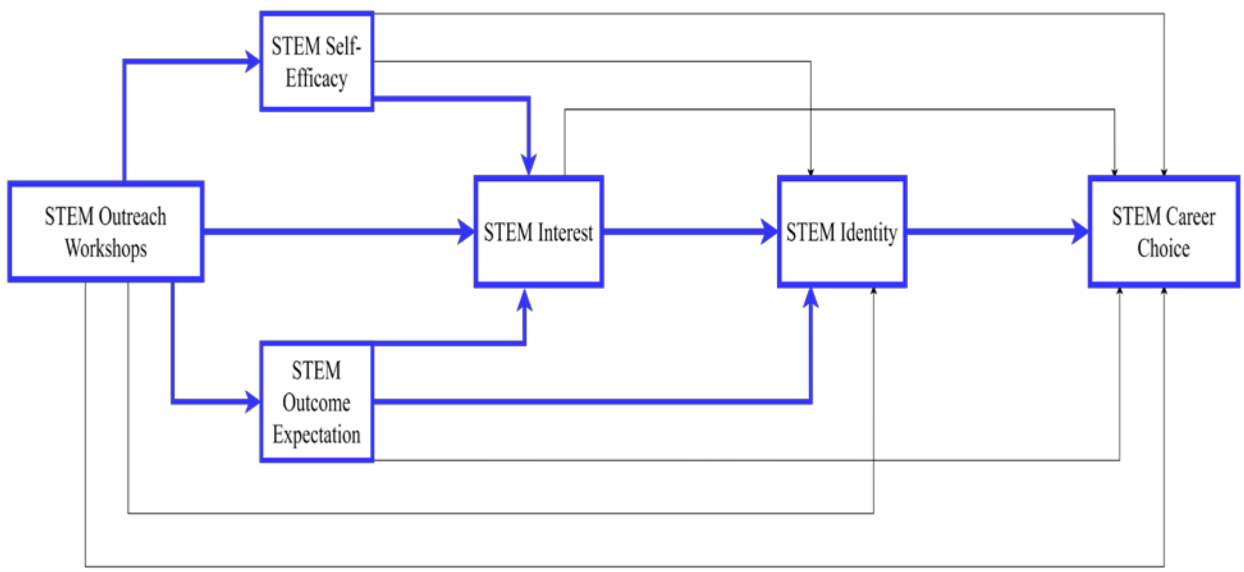

Figure 5.2: Integrated and expanded model of social cognitive career theory with science identity theory

Finally, a recent meta-analysis by Lent et al. (2018) and an extensive search of the literature revealed that there is a lack of studies that longitudinally examine social cognitive career theory's interest-choice model. Furthermore, the studies (Lent, Sheu, et al., 2008, 2010; Robnett et al., 2015; Syed et al., 2019) that adopted longitudinal analysis procedures also emphasized bivariate and multivariate temporal associations among environmental, cognitive and career behaviours. There is, to the best of my knowledge, a significant lack of research that employs longitudinal mediation to study the indirect effects of constructs of social cognitive career theory. The results of the study presented a reasonable addition to the adoption of the integrated and expanded model of SCCT with science identity theory to the understanding of students' career pursuits by investigating the longitudinal effects of the STEM outreach program on middle-school students' STEM career aspirations via eleven indirect pathways (discussed in the previous section and coloured in blue in Figure 5.3).

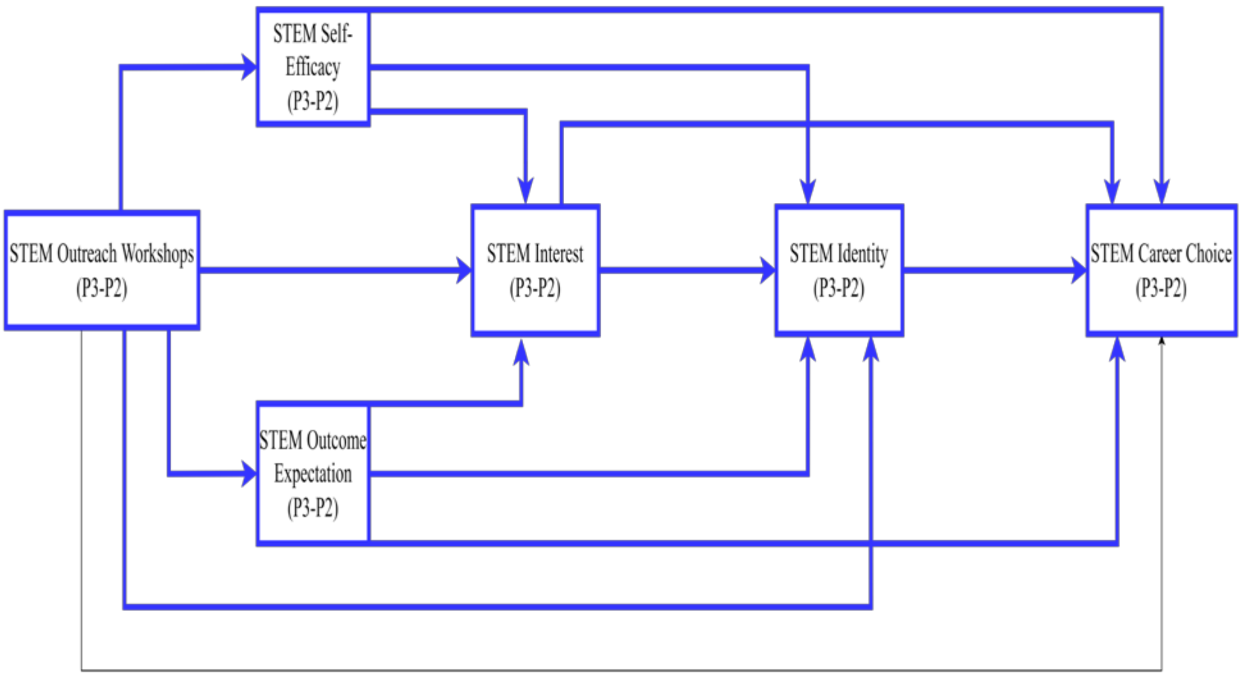

Figure 5.3: Integrated and expanded model of social cognitive career theory with science identity theory

5.2.2 Practical Implications

The purpose of the study was to examine cross-sectionally and longitudinally the direct and indirect influences of participation in the STEM outreach program on middle and high-school students' STEM career pursuits. The findings discussed previously with reference to the study purpose presents practical implications for instructional designs and development and implementation of curriculum by district and school administrators for improving learning and teaching. The STEM outreach program, facilitated by scientists, engineers and technologists with professional backgrounds in STEM, was implemented in the form of half-day workshops. In the program students were (a) able to explore and engage in investigative, hands-on and exciting STEM activities and (b) given opportunities to familiarize themselves with STEM careers and pathways. The STEM outreach program incorporated, according to the perspective of curriculum studies, integrated and inquiry-based learning experiences, which positively influenced students' identification with STEM. This, in turn, increased the likelihood of choosing a career in STEM. It was also observed that these workshops improved the probability of students' commitment to a career in STEM indirectly through bolstering their self-efficacy and identity beliefs.

The insights ascertained from the findings could assist teachers to design instructional materials with a focus on the premises of integrated STEM curriculum. Integrated curriculum refers to a range of learning experiences that integrate multiple themes and concepts from more than one STEM discipline and emphasize commonalities in the concepts and skills across disciplines to investigate a particular theme or phenomenon (Mansilla, 2005; Rennie et al., 2012). The primary purpose of the integrated curriculum is to enable students to make connections between science, technology, engineering, and mathematics and real-world situations (Bybee, 2013; Drake & Burns, 2004; Jackson et al., 2020; Rennie et al., 2018). Instructional materials that are designed by teachers according to the principles of integrated STEM curriculum are best implemented with students through inquiry-based learning approaches (Keselman, 2003; Laxman, 2013; Pedaste et al., 2015; Zuckerman et al., 1998). Implementing inquiry-based learning in classrooms entails invoking learners to raise questions and actively engage in constructing their knowledge through exploration, experimentation, and investigation to make the sense of the world around them (Alfieri et al., 2011; Edson, 2013; Haber et al., 2019; MacPherson, 2011; Zuckerman et al., 1998). Informed by the integrated and inquiry-based approach to learning and centred on challenging and allowing students to develop critical thinking abilities including reasoning, questioning and problem solving, teachers could utilize a learning environment to (a) promote and strengthen students' confidence beliefs in their ability to understand and succeed in STEM and (b) help them increase the sense of belonging to a STEM community. In other words, teachers could make use of the integrated and inquiry-based learning opportunities to enhance the possibility of students' STEM career goals indirectly by boosting their STEM self-efficacy and identity.

Additionally, it was found in the study that the mediating effect of STEM outcome expectations on the relationship between the STEM outreach program on STEM career goals was significant in both mediation and longitudinal mediation findings. In addition to the efforts aimed at promoting self-efficacy beliefs in and identification with STEM disciplines, teachers could also provide a platform in classrooms that focus on hands-on and problem-based activities where students are supported to engage in the process of formulating and investigating questions regarding everyday problems and connecting abstract STEM knowledge to real-world applications. By providing the most relevant information about the future usefulness of skills and work in STEM careers and emphasizing the utility of STEM disciplines to make a meaningful impact in the world, teachers could help students promote perceptions of positive STEM career outcome expectations which, in turn, may enhance the likelihood of them remaining in STEM career pathways.

The findings of the study provide beneficial insights for educational administrators. When devising STEM curriculum, district and school administrators could put more emphasis on including integrated and inquiry-based learning outcomes and activities that help strengthen students' efficacy and identity beliefs and career outcome expectations and hence facilitate their STEM career development. There is a lack of classroom implementation of meaningful integration of content and methods of various disciplines in a unified and efficient manner for students. This is a result of a persistent confusion among teachers when it comes to implementing integrated and inquiry-based STEM learning (DeCoito & Myszkal, 2018). Therefore, to ensure successful implementation of the integrated curriculum, district and school administrators should provide a supportive environment where teachers are equipped to professionally grow and learn how to best deliver the integrated and inquiry-based STEM curriculum to students in a way that can facilitate building their self-efficacy, identity and outcome expectations, and thus increasing their STEM career intentions.

Also, in terms of practical implications, the findings of the study suggest that STEM enrichment interventions should be designed and implemented with a special focus on enhancing students' confidence beliefs in performing STEM activities, improving the sense of belonging to STEM community, and bolstering their positive expectations from choosing a career in STEM. On this note, as discussed in Chapter 3, the vast majority of the study population was students of colour and ethnic minorities including Afro-Canadians, Asian, Middle Eastern, and Southeast Asian. Noteworthy is the fact that the STEM outreach program, aligned with the provincial curriculum, lacked culturally responsive workshops. The provincial curriculum in question is known for the exclusion of diversity and culturally responsive approaches in teaching and learning STEM/science (DeCoito et al., 2020; Lambie & DeCoito, 2017).

Culturally responsive approach to STEM learning refers to the utilization of cultural background and frames of references of ethnically diverse students to make meaningful and authentic connections between STEM contents and the students' lived experiences (Gay, 2018; Young et al., 2019). On one hand, numerous studies (Garvin-Hudson & Jackson, 2018; Mensah, 2010; Young et al., 2019; Yu et al., 2021, 2021) have shown promising effects of culturally responsive STEM enrichment programs on improving students' academic achievements, attitudes and interest in STEM. On the other hand, as explained in Chapter 2, a learning environment that does not provide culturally-relevant course contents and activities to students of minorities creates conflict between classroom culture and home culture, thus makes it hard for the culturally diverse students to involve in class activities and develop a positive STEM self-efficacy, outcome expectations and identity. This is resulted in minority students' alienation from productive participation in the school and the wider society and early departure from STEM career pathways (Beasley & Fischer, 2012; Ben-Zeev et al., 2017; Byars-Winston & Rogers, 2019; Ladson-Billings, 1995; Pfund et al., 2006; Singh, 2011).

On this note, lack of culturally responsive items in the STEM outreach program workshops may explain the study findings that the STEM outreach program could not positively increase students' interest in STEM and improve the possibility of them choosing a career in STEM. Therefore, as recommended by Ontario Ministry of Education's (2017) *Education Equity Action Plan*, stakeholders from school boards, universities, charitable organizations and industries should collaborate with each other to develop and provide culturally responsive the STEM outreach programs in order to enhance culturally diverse students' interest in STEM disciplines and careers. Acknowledging the influences of culture, race and ethnicity on students' learning, the program should make sure that the topics and related activities covered in the workshops (a) incorporate sufficient multicultural contents that can affirm diversity as an asset and validate ethnic cultural heritage as valuable (Banks et al., 2001; Brown-Jeffy & Cooper, 2011; Delpit, 2006), and (b) need not to reduce the culturally responsive curriculum and instruction to simplistic and meaningless tasks but to maintain and sustain high expectations in their students (Brown-Jeffy & Cooper, 2011).

5.3 Chapter Summary

Chapter 5 first provided a detailed discussion of the findings of the study that revealed STEM self-efficacy, outcome expectations and identity significantly mediated the relationship between the STEM outreach program and high-school students' STEM career intetions. It also unveiled that the longitudinal mediational effect of STEM outcome expectations on the association between the STEM outreach program and middle-school students' STEM career pursuits. Next, the theoretical implications of the findings with reference to contributing to the study the integrated and expanded model of social cognitive career theory with science identity theory through investigating indirect effects of STEM cognitive and identity variables on the pathway from the STEM outreach program to STEM career aspirations were discussed. This was followed by a presentation of practical implications of the study in terms of insights from the findings being of use for teachers, district and school administrators to design and implement an integrated and inquiry-based learning experiences. This chapter concluded by a demonstration of practical significance of the study findings for developing and implementing culturally responsive STEM workshops. Chapter 6 presents concluding remarks, limitations of the study and suggestions for future research.

Chapter 6

6 Concluding Remarks, Limitations and Suggestions for Future Research

6.1 Concluding Remarks

Guided by the integrated and expanded model of social cognitive career theory's interest-choice model with science identity theory, the study sought to examine whether the STEM outreach program influenced high-school students' STEM career choice goals directly and indirectly through STEM self-efficacy, outcome expectations, interest and identity. It also investigated whether there were changes from Phase II to Phase III in the direct and indirect effects of the STEM outreach program on middle-school students' STEM career intentions via cognitive and identity variables. To answer the research questions and test the related hypothesis, the study utilized a subset of S-STEM survey data from the longitudinal data collected by Dr. DeCoito. The S-STEM survey data was analyzed by mediation and longitudinal mediation procedures. While the hypotheses related to the mediation questions were tested using Hayes' (2022) PROCESS macro for SPSSS, the longitudinal-mediation hypotheses were analysed by Montoya and Hayes' (2017) MEMORE macro for SPSS.

The findings of the analysis showed that STEM self-efficacy, outcome expectations and identity were significant mediating predictors of the pathway from the STEM outreach program to STEM career pursuits. It was also observed that the longitudinal mediational effect of STEM outcome expectations on the relationship between the STEM outreach program and STEM career intentions was significant. Along with confirming the hypotheses of and literature by social cognitive career theory (Chemers et al., 2011; Dou et al., 2019; Lent et al., 2001, 2003; Lent, 2013; Lent et al., 2018; Orji & Ogbuanya, 2022; Pugh et al., 2021; Sheu et al., 2010), the results contributed to the theoretical understanding of the influences of contextual supports, cognitive and identity factors on students' career intentions in several areas. First, the research was one of the scarce studies, if not the first, to investigate the mediating effect of interest (STEM interest) on the relationship between contextual support (the STEM outreach program) and career intention (STEM career goals). Second, the findings of the study extended social cognitive career theory by examining the indirect effects STEM cognitive and identity variables on the association between the STEM outreach program and STEM career intentions that has been not sufficiently studied. Third, there is a significant lack of literature that utilizes longitudinal mediation to investigate the indirect effects of social cognitive career theory and science identity constructs. The study contributed to the temporal understanding of the integrated and expanded model of social cognitive career theory with science identity theory by examining the longitudinal mediational effects of STEM self-efficacy, outcome expectations, interest and identity theory on the relationship between the STEM outreach program and STEM career pursuits.

6.2 Limitations and Suggestions for Future Research

The present study is subject to a number of limitations which calls for conducing further research. First, STEM identity in my study was defined as the extent to which students recognize themselves and recognized by others as a STEM person (Carlone & Johnson, 2007). The study was only able to test self-recognition component of science identity theory's recognition construct owing to the lack of data to measure the degree to which students are recognized by other members of the STEM community. Therefore, it would be valuable to utilize the integrated and expanded model of social cognitive career theory with STEM identity to further examine the mediating and longitudinal mediating effects of both self-recognition and recognition by others on the association between STEM contextual supports and STEM career intentions.

Second, gender and race/ethnicity differences were found to be significant moderator of the multivariate relationships among social cognitive career theory's environmental, cognitive, identity and goal behaviour variables (Brown et al., 2018; Byars-Winston & Rogers, 2019; Chemers et al., 2011; Hazari et al., 2010; Lent et al., 2018). However, the present study could not test the moderated mediational effects of gender and race/ethnicity on the indirect effects of the STEM outreach program on STEM career aspirations via cognitive and identity variables (for details on moderated mediation, see Hahs-Vaughn & Lomax, 2020; Hayes, 2022; Keith, 2019). This was a result of issues related to data availability and the MEMORE macro that did not have in-built models to measure longitudinal moderated mediational influences of gender and race/ethnicity. Thus, future research is needed to investigate the moderated meditational and longitudinal moderated mediational effects gender and race/ethnicity on the indirect effects of self-efficacy, outcome expectations, interest and identity on the pathway from contextual support to career pursuits.

Third, the study employed quantitative method to analyze the secondary data to answer the research questions and test the related hypotheses. It is highly recommended that future research should utilize mixed methods to examine mediational and longitudinal mediational effects of STEM contextual variables on STEM career goals. Mixed methods, comprised of collecting qualitative and quantitative data and conducting separate analysis (Creswell & Plano Clark, 2018; Onwuegbuzie & Teddlie, 2003; Teddlie & Tashakkori, 2009), could allow researchers to integrate and corroborate the results of both forms of data to reach in-depth understanding of students' perception about the influences of environmental and cognitive factors on their STEM career aspirations.

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Appendices

Appendix A: Ethics Approval

Western Research

Date: 2 March 2022

To: Dr. Isha DeCoito

Project ID: 118118

Study Title: Outreach Programs, STEM Identity and Career Aspirations: A Longitudinal Mixed-Methods Study of High School Students

Application Type: Continuing Ethics Review (CER) Form

Review Type: Delegated

Date Approval Issued: 02/Mar/2022

REB Approval Expiry Date: 12/Mar/2023

Dear Dr. Isha DeCoito,

The Western University Non-Medical Research Ethics Board has reviewed this application. This study, including all currently approved documents, has been re-approved until the expiry date noted above.

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

The Office of Human Research Ethics

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Curriculum Vitae

Name:	Abdulehed Kasim Yarkin
Post-secondary Education and Degrees:	University of Western Ontario London, Ontario, Canada PhD in Curriculum Studies 2017-2022
	University of Western Ontario London, Ontario, Canada MPEd in Curriculum & Pedagogy 2015-2017
Related Work Experience:	Teaching Assistant International University Kuala Lumpur, Malaysia 2011-2013
	Primary School Teacher, Grade 1-3 Kuala Lumpur, Malaysia 2008-2013

Academic Conference Proceedings (refereed):

Yarkin, A. K., DeCoito, I. (2022). *A Parallel Mediation Analysis of the Influence of Outreach Workshops on Students' STEM Career Choices*. Paper presented at the annual meeting of the Canadian Society for the Study of Education (CSSE), Remote (May 14-20).