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Investigating Pre-service Teachers' Self Efficacy Beliefs in STEM Fields

By

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DEDICATION

To Moustapha and Chafica Shehab, my parents who believed in education even though they did not have degrees.

To my husband, AbdulHakim. Thank you for all the support, love, and patience. Thank you for believing in me.

To Zeina, Bilal, and Lynn, my children for your support and love. Thank you for being in my life.

On a final note, thank you for all those who were there for me when I needed it the most.

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Investigating Pre-service Teachers' Self Efficacy Beliefs in STEM Fields

Hanan Shehab

ABSTRACT

The subject of self-efficacy beliefs has been studied for over four decades now. The purpose of this study was to explore pre-service self-efficacy beliefs in Math and Science (STEM fields) in the context of Pedagogical Content Knowledge (PCK) courses at a private university in Lebanon. A sequential explanatory mixed methods design was adopted and a purposive sample of 22 pre-service teachers was selected for the study. Two quantitative instruments, the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) and the Science Teaching Efficacy Beliefs Instrument (STEBI-B) were administered, pre- and post, to determine the levels of the pre-service teachers' self-efficacy beliefs. For the qualitative data, participants wrote reflections on the PCK methods course 3 times during the semester and were interviewed at the beginning and at the end of the semester about the changes in their efficacy beliefs, namely in the Personal Math Teaching Efficacy Beliefs (PMTE), Personal Science Teaching Efficacy Beliefs (PSTE), Personal Science Outcome Expectancy (STOE), and Math Teaching Outcome Expectancy (MTOE). Findings indicate somewhat significant changes in PMTE, MTOE, and STOE as a result of teaching experiences during PCK courses, whereas the changes in PSTE were less influenced than in the other subfields. Moreover, STOE has improved for all branches, whereas PMTE, PSTE, MTOE's change varied between the branches. These changes were represented by a shift in teachers' perceptions concerning their abilities to teach math and science and the proficiency with which they can teach these subjects.

Key words: Self-efficacy Beliefs, Personal Math Teaching Efficacy (PMTE) Beliefs, STEM Approach, Outcome Expectation, STEM Fields, Mastery Experience, Vicarious Experiences, Psychological or Emotional Conditions, Pre-service Teachers, Personal Science Teaching Efficacy (PSTE) Beliefs, Pedagogical Content Knowledge Courses (PCK), STEM Education

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

CCS	Council of Common Services
IRB	Institutional Review Board
MEHE	Ministry of Education and Higher Education
MTEBI	Math Teaching Efficacy Beliefs Instrument
MTOE	Math Teaching Outcome Expectancy
NGSS	National Generation science standards
NTCM	National Council of Teachers of Mathematics
PCK	Pedagogical Content Knowledge
PMTE	Personal Math Teaching Efficacy beliefs
PSTE	Personal Science Teaching Efficacy beliefs
STEBI	Science Teaching Efficacy Beliefs Instrument
STEM	Science, Technology, Engineering and Mathematics
STOE	Science Teaching Outcome Expectancy
U.S.	United States

Chapter One

Introduction

Today, students need knowledge, skills, and dispositions in science, technology, engineering, and math (STEM) to succeed in a 21st century global economy. In particular, teaching STEM at the elementary level helps students construct their understanding of the material at hand in a more meaningful way that relates to everyday life (Claymier, 2014; Moore & Smith, 2014). Accordingly, it is important to prepare STEM elementary teachers, with needed skills, knowledge and efficacy (Nadelson, Callahan, Pyke, Hay, Dance, & Pfiester, 2013; Prentiss Bennett, 2016; Wu & Albion, 2019). These teachers can be seen as "the gate keepers to fostering the gifts and talents of future STEM innovations" (Cotabish, Dailey, Robinson, & Hughes, 2013, p. 216). One of the main constructs that has been shown to influence teachers' preparation for elementary STEM teaching is self-efficacy, which has led to further studies along this line (Prentiss Bennett, 2016; Setra, 2017, & Bursal, 2007, 2012)

1.1- Importance of self-efficacy

Over the last forty years, educators have tried to study and evaluate the concept of teacher self- efficacy beliefs (Bandura, 1977, 1997, Pajares & Urdan, 2002, Palmer, 2007). Bandura (1997) posited that self- efficacy is "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). His theory of self-efficacy suggests that teachers' efficacy is most flexible early in their university experience. Moreover, research (Setra, 2017; Prentiss Bennett, 2016; Zuya,

Kwalat & Attah, 2016; Zeldin, Britner & Pajares, 2008; Pajares & Urdan, 2002; Pajares & Graham, 1999) shows that pre-service teachers with high level of self- efficacy are more motivated to learn than their colleagues and would persevere longer in solving problems. In different circumstances, teachers with low self-efficacy are discouraged to learn and would be somehow fearing solving problems. Hence, preparing pre-service teachers with the needed knowledge, skills, pedagogies, attitudes and beliefs seems to be the goal of undergraduate education courses at the university level.

More particularly, educators examined self-efficacy beliefs in STEM education. Research looked into the effect of teachers' efficacy in many fields such as: science (Aydin & Boz, 2010; Tessier, 2010; Bracey, Brooks, Marlette, & Locke, 2013), technology integration (Pan & Franklin, 2011), engineering (Nathan, Tran, Atwood, Prevost, & Phelps, 2010, and mathematics (Bursal, 2010). Nevertheless, empirical studies exploring pre-service teacher self- efficacy in STEM fields are still in the infancy stages (Prentiss Bennett, 2016).

In addition, research has demonstrated that self-efficacy and academic performance are closely related (Sartawi, Alsawie, Dodeen, Tibi, & Alghazo, 2012; Hoffman, 2010). Also, Setra (2017) states that "it is vital to educate and prepare a well-trained scientific workforce" (p.3). Although this study is about pre-service teachers' self-efficacy, it is worth mentioning that students with high sense of self- efficacy show solid motivation and tackle problems as tasks to be mastered; on the other hand, students with low sense of self-efficacy show weak commitment and approach problems with nervousness (Bandura, 1977, 1994; Zuya, et al. 2016). Having examined the influence of

self-efficacy beliefs on both teachers and students, I now move to highlight the importance of STEM education.

1.2- Importance of STEM education

The STEM acronym was first coined by the National Science Foundation (NSF) to refer to any education that integrates science, technology, engineering and math (Bybee, 2010; National Research Council, 2011; Sanders, 2009). STEM education includes removing barriers between its fields and provides students with real problem based learning (Eckhoff, 2017). The interest in STEM education increased over the years. The United States Department of Commerce stated that employment in STEM professions grew at a rate of 24.4% versus 4 % in non-STEM professions. Also, it is estimated that the growth in STEM occupation will be 8.9 % from 2014 to 2024, compared to 6.4% growth for non-STEM jobs (Noonan, 2017). Moreover, the National Research Council (2011) argued that STEM education enhanced students' achievement in math and science fields (Valtorta & Berland, 2015). President Obama' administration initiated the Educate to Innovate program in November 2009 to help students with the needed skills and expertise in STEM fields (Obama, 2013). Several studies were conducted on the importance of preparing teachers with STEM education (Eckhoff, 2017; Prentiss Bennett, 2016). STEM teachers need to have a rigorous education to be able to teach STEM fields (Project Lead the Way, Inc., [PLTW], 2017). Likewise, in Lebanon, the need to consider the STEM approach as a cornerstone to enhance the Lebanese educational system must be considered.

1.3- Lebanese Educational System

Many countries in the Middle East and North Africa (MENA) have undergone major changes in the last half-century in the education field (Shuayb, 2018). In Lebanon, there have been several educational reforms, but there is little data related to how these reforms were developed (Shuayb, 2018). In an attempt to provide a valuable educational reform, Ghaith (2011) claimed that there is a need to study pre-service teachers' educational programs, in the departments of Education, in public and private universities. Specifically, the construct of teachers' self-efficacy needs to be examined (Ghaith, 2011). Moreover, studies pertaining to meagre success in education reforms in Lebanon attributes this to a top- down approach (Bashur 1997, 2005) or to political agenda devoid of educators' contribution (Karami Akkary, 2014). Hence, teachers' self-efficacy was not tackled in any of these reforms.

In addition, there is not enough research on self-efficacy in Lebanese higher education. As a matter of fact, there are several institutions of higher education in Lebanon and those universities belong to one of four categories of higher education model (Arab, American, French or Lebanese). Most of these universities offer teacher educational programs (El-Mouhayar & Bou Jaoude, 2012). Despite the fact that there is a good number of Lebanese universities offering programs in education, it is noteworthy to state that there are few research papers on self-efficacy that come out of these. Bou Jaoude and Abd-El-Khalick (2004) and Bou Jaoude, Abd-El-Khalick, and El-Hage (2009) stated that there are five studies on science teacher education between 1992 and 2002 and none between 2003 and 2008. Recently, El Takash, Rawas and Dokmak

(2018) evaluated science and math courses at the Lebanese university. Still, the construct of self-efficacy beliefs was absent in their study.

As a result, the way universities in Lebanon prepare teachers for the work field should be reviewed. The world we are living in is changing rapidly due to technological advances. The impact of robotics and telecommunications, and a number of new fields has transformed the agricultural and industrial markets into technological ones (National Science Board, 2010). Hence, equipping pre-service teachers with a thorough understanding in the areas of STEM would help them succeed in a technology-rich society (Prentiss Bennett, 2016).

1.4- STEM education in Lebanon

STEM education was introduced by the U.S. National Science Foundation in the 1990s (Kelley & Knowles, 2016). Sanders (2009) defined 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). Also, Moore, Stohlmann, Wang, Tank, Glancy, and Roehrig (2014) described integrated STEM education as " an effort to combine some or all four of the disciplines, namely 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 instance, an integrated STEM curriculum can cover STEM content of math but contexts can come from science (Moore et al., 2014).

Research shows that teachers are not well prepared to teach STEM at the elementary level (Nadelson et al., 2013). Researchers demonstrated that students' initial understanding of STEM is formed at the elementary level (Nadelson et al., 2013).

However, elementary teachers have limited knowledge, confidence, and efficacy for teaching STEM (Nadelson et al., 2013). Hence, teachers need to be prepared with the pedagogical content knowledge, expertise, and efficacy to effectively teach STEM content to students (Prentiss Bennett, 2016)

STEM education is absent in Lebanon schools and in most universities in Lebanon. With respect to schools, the Lebanese curriculum is rigid and calls for students to depend on rote learning and memorization in order for them to pass the official exams at grades 9 and 12 (Baytieh, 2014). As for universities, they follow the same trend as schools do. Kibbi, El Takach, and Ayoubi (2017) suggest that, even though pre-service teachers at the Lebanese University (LU), the Lebanese national university, have access to computers and technology, they lack competencies in the use of Information and Communication Technologies (ICT). Hence, the scarcity of teachers' preparation in STEM fields need to be addressed.

1.5- Statement of the problem

As previously mentioned, there is a need to prepare teachers to instruct the STEM field subjects (Prentiss Bennett, 2016; Setra, 2017). A number of research papers highlight the lack in teachers' preparation and confidence to teach science and physical science (Appleton, 2008, 2003; Bursal, 2010; Kim & Tan, 2011; Menon, 2015). Effective STEM teachers at the elementary level need to believe they are able to teach the content along with a thorough content knowledge (Menon, 2015; Prentiss Bennett, 2016).

While it is known that an additional number of courses will not enhance the content knowledge of teachers (Bursal, 2010), researchers indicate that pre-service

teachers need to be educated in milieu where they can learn math and science and at the same time improve their self-efficacy beliefs about instructing these subject areas (Cantrell, Young & Moore, 2003). A number of research papers focus on the absence of serving the four sources of self-efficacy to the pre-service teachers; these sources are the vicarious experience, the mastery experience, the emotional arousal and the social persuasion (Appleton, 2008, 2003; Bandura, 1977; Kim & Tan, 2011; Menon, 2015).

There is a scarcity of research papers pertaining to Lebanese elementary teachers' education that studies self-efficacy beliefs (Osta, 2012). In the same context, El Takach, Rawas, and Dokmak (2018) evaluated the implementation of the new curriculum at the science and math department at the Lebanese University, but they did not evaluate the self-efficacy beliefs of pre-service teachers. Accordingly, this underscores the need for the current research study investigating elementary teachers' self –efficacy beliefs for teaching STEM field subjects (Math and Science).

1.6- Purpose of the study

This study was designed to explore the personal self- efficacy beliefs of pre-service elementary teachers before and after taking the pedagogical content knowledge (PCK) courses in STEM fields, namely Math and Science. It will also investigate the possible existence of a relationship between the participants' math self-efficacy beliefs and science self -efficacy beliefs.

Teaching STEM fields effectively requires teachers to have thorough content knowledge, self-efficacy and skills in teaching this content. A large body of educational literature on elementary teacher preparation programs has focused on the problem of partial science content readiness (Bursal, 2012; Hechter, 2011). Also, close attention has

been paid to self-efficacy beliefs (Cantrell et al., 2003; Kazempour & Sadler, 2015). Educators have recognized strong associations between self-efficacy beliefs and teaching practices (Bandura, 1997; Tschannen-Moran, Anita, &Hoy, 1998) as well as student learning outcomes (Bandura, 1977, 1982). Consequently, elementary pre-service teachers may impede students' STEM learning if they are inadequately prepared throughout their academic years (Wu & Albion, 2019).

1.7- Research questions

The following research questions were formulated to guide the study:

1. Are there any significant differences between the Lebanese pre-service elementary teachers' personal math self-efficacy beliefs (PMTE) about teaching mathematics before and after enrolling in the PCK math course?
2. Are there any significant differences between the Lebanese pre-service elementary teachers' personal science self-efficacy beliefs (PSTE) about teaching science before and after enrolling in the PCK science course?
3. How did the course contribute to changes in self-efficacy beliefs of pre-service science and math (STEM fields) elementary teachers?
4. Does the baccalaureate branch that the pre-service teachers follow in high school level influence their self-efficacy beliefs after enrolling in the PCK courses?

1.8- Definition of key terms

The terms used in this study are the following: Personal self-efficacy beliefs, expectation outcomes, personal science teaching efficacy (PSTE), science teaching outcome expectancy (STOE), personal math teaching self- efficacy (PMTE), math

teaching outcome expectancy (MTOE), pedagogical content knowledge courses (PCK); science, technology, engineering, and math (STEM); vicarious experience, mastery experience, social persuasion, emotional condition.

1) *Self-efficacy beliefs*: "Self-efficacy is a judgment of one's ability to organize and execute given types of performances" (Bandura, 1997, p.21)

2) *Personal Math Teaching Efficacy (PMTE) beliefs*: The degree that teachers believe they have the ability to affect students' mathematics achievement positively. (Cantrell, et al., 2003)

3) *Personal Science Teaching Efficacy* (*PSTE) beliefs*: The level that teachers believe they have the ability to affect students' science achievement positively. (Cantrell, et al. 2003)

4) *Pedagogical Content Knowledge courses (PCK)*: Courses designed for pre-service teachers where instructional and pedagogical methods to deliver math and science at the elementary levels are taught.

5) *STEM education*: Teaching and learning in the subjects of science, technology, engineering and mathematics (Gonzales & Kuenzi, 2012)

6) *STEM approach*: Learning though problem based approaches, using critical thinking, collaboration, and creativity.

7) *STEM fields*: Science, Technology, Engineering and Math subjects.

8) *Outcome Expectation:* "A person's estimate that a given behavior will lead to certain outcomes" (Bandura, 1977, p.79).

9) *Sources of teacher self- efficacy beliefs*: Bandura (1986, 1997) conjectured that there are four sources for self-efficacy: mastery experiences, physiological and emotional arousal, vicarious experience, and social persuasion. Tschannen-Moran, Anita, and Hoy (1998) and Setra (2017) argued that the most powerful one is the mastery experience, since if teachers perceive that an experiment was successful, then most probably they will do it again. Also, when a teacher is satisfied physiologically and emotionally in her/his experience, then this will improve their self-efficacy beliefs. Social persuasion offers precise opinion on a teacher's performance. Bandura (1997) argues that the social context of verbal persuasion influences self- efficacy. Positive evaluation raises self-efficacy and the opposite is true (Cantrell et al., 2003).

Bandura (1986, 1997) proposed four sources of efficacy expectations: Mastery experience, emotional states, vicarious experiences, and social persuasion.

10-a- *Mastery experience* is the most powerful source of efficacy. When one perceives the experience as being a success or a failure, this will lead either to a higher or a lower self-efficacy belief in future performances.

10-b-*Vicarious experiences* are related to one's observation of a role model and the level of performance of that model. As a result of the identification with the role model, the self-efficacy of the observer is either enhanced or deteriorated (Tschannen-Moran et al., 1998). In this study, it refers to a pre-service teacher observing university faculty (science/math) instruction.

10-c- *Social persuasion* encompasses certain performance opinion from a teacher or a colleague. Positive feedback may lead one to persevere more in a given task or to

attempt new strategies. The more influential the persuader is, the more the persuasion is effective (Bandura, 1986)

10-d- *Psychological or Emotional Conditions*: This experience is related to a person's judgment of anxiety and vulnerability of stress (Bandura, 1977).

11) *Pre-service teachers*: the term as coined in this study refers to students enrolled at the university to become teachers specifically elementary and in their last year.

12) *Demographics:* Data collected on each of pre-service teacher that includes things like: personal, social, educational data, and the high school class branches (humanities, general science, life science, economics and social science).

1.9- Significance of the study

This study is significant in that it may offer important insight into the self-efficacy beliefs of pre-service teachers in relation to STEM fields in PCK courses. This information may be helpful to university professors in pinpointing the self-efficacy construct as a major item to tackle while preparing teachers to implement STEM education in elementary schools.

Based on the information highlighted so far, we notice the need for a researching of the related literature. The following chapter will provide an overview of the related literature.

Chapter Two

Literature Review

This section presents an analysis of the related literature concentrating on the areas of teachers' self-efficacy beliefs in math and science PCK courses. Menon (2015) argues that to prepare science teachers to educate pupils using the latest pedagogical theories, they must be subject to a rigorous preparation during their university program. The Next Generation Science Standards (NGSS) ensures that pre-service teachers' preparation must focus on: Disciplinary core ideas, scientific practices and crosscutting concepts (NGSS lead States, 2013). (Cantrell et al., 2003) state several recommendations such as: a) offer pre-service teachers early field work, b) arrange for pre-service teachers to help with extracurricular activities, c) prepare mastery experiences for these teachers, and d) build up a community of learners that provide the pre-service teachers with the four sources of self-efficacy. These recommendations are thought to enhance the preparation of pre-service science teachers in several fields. Specifically, Cantrell, et al. (2003) discuss the need to improve science self- efficacy beliefs in teaching and learning science.

2.1- Theoretical background (Self-efficacy- cognitive theory- kinds of self-efficacy)

Bandura's (1977) construct of self-efficacy theory provides the framework for this empirical research on two of the STEM content areas, namely math and science fields. Bandura (1977) used the term *reciprocal determinism* to explain that personal factors, environmental factors and people behaviors impact each other. He theorized that social environment influences the self-efficacy beliefs of persons to complete a task.

Tschannen-Moran, et al. (1998) stated “The efficacy question is: Do I have the ability to execute the necessary actions to accomplish a specific task at a desired level? The outcome question is: “if I accomplish the task at that level, what are the likely consequences?” (p. 210). In other words, when one is questioning his/her ability to do a certain task, it is the personal efficacy. Whereas the question related to the consequences is the outcome expectancy. Usually, the outcome expectancy is not accurate when measured according to pre-service teachers since they did not start teaching yet, and there are many variables included in their career later on.

2.2- Elementary STEM teacher preparation and training

Mathematics self-efficacy is one’s self-assurance in their capabilities to solve mathematical problems (Zuya et al., 2016).

Researchers have studied the importance of STEM education at the elementary level from the pre-service and in-service teachers’ point of view (Madden, Beyers, & O’Brien, 2016). Results showed that teachers believe that STEM is important at the elementary level for a number of reasons. It helps build a foundation for later academics, prepares children for future jobs, connects to everyday life, and promotes higher order thinking and problem solving skills. Also, studies have shown that when elementary teachers participate in STEM professional development opportunities, they develop increased confidence and self- efficacy as STEM teachers (Adams, Miller, Saul, & Pegg, 2014).

2.3- Lebanese research and self-efficacy construct

Ghaith (2011) reported that only two research projects on teacher education programs at universities in Lebanon were conducted. The first one was prepared by Freiha (1997) pertaining to curricula and course content of teacher preparation programs and the second by El-Mouhayar and Bou Jaoude (2012) about program requirements and theoretical perspectives on teacher preparation. While teacher self- efficacy is considered as an important construct in preparing pre-service teachers (Cantrell, et al., 2003), neither Ghaith (2011) nor Freiha's (1997) papers studied it as a main construct in preparing math and science teachers. Moreover, Osta (2012) claimed that even though some researchers discussed valuable concerns in teacher preparation in the Arab world, none of them mentioned teachers' self-efficacy as one of the valuable items in preparing teachers for the work field. In addition, Osta (2012) considered delving into teachers' preparation programs as a worth-while experience due to the variety of topics teachers are subject to in different fields such as: intellectual, psychological, affective, or didactic.

2.4- Lebanese students their self-efficacy outcome expectancy in STEM fields (math and science)

Years of research have shown that the most crucial element in the classroom is the teacher, and good instruction can have continuing effects on students' achievement (Chetty, Friedman, & Rockoff, 2014). For instance, Shahzad and Naureen (2017) studied the effect of 60 secondary teachers' self-efficacy on 100 secondary school students in Chiltan Town of Quetta city. The findings of the study showed that teachers' self-efficacy has positive impact on the students' academic achievement.

Understanding teacher's sense of efficacy in teaching mathematics and science is important in light of reports indicating that levels of Lebanese student achievement in both subjects are falling below acceptable international standards. For example, in TIMSS 2003, the Lebanese eighth graders fell behind their peers in several countries. They scored 433 whereas the international average was 466, in problem solving (Osta, 2007). Moreover, in year 2015, Lebanon scored an average of 422 in math and 398 in science, grade 8, which is also below average (National Council for Education Statistics, 2015). According to the Lebanese curriculum, grade 12 branches are the following: humanities, general science, life science, and the economics and social sciences. Each branch at grade 12 contains different math and science objectives, number of periods, and content.

2.5- Lebanese education system

2.5.1- Lebanese curriculum

The Lebanese educational reform was based on the Ta'if Accord in 1989. Accordingly, the Lebanese curriculum was published in year 1997 based on decree number 10277/97 (Choueiri, 2007). In 1999, the teachers' guide for evaluation for each class was designed by committees at the Center of Educational Research (CERD). Since then, the Lebanese curriculum has undergone many revisions.

2.5.2- Lebanese students and schools

The Lebanese school education system is made up of three cycles. They are as follows: six years elementary cycle, three years intermediate cycle, and three years secondary cycle. Hence, the basic education for a Lebanese student extends along twelve

years, in addition to a three-year pre-school cycle that most schools implement (Chahine & King, 2012).

2.5.3- Lebanese universities and teachers

There are two types of universities in Lebanon, the private universities and the public ones. Accordingly, a teacher who finishes the requirements in a private university may teach in any private school or on contract base in the public schools. On the other hand, to be enrolled in the public sector, and after an individual gets a bachelor's degree from any university in Lebanon, a person needs to pass a test advertised and administered by the Council of Civil Services (CCS) (Ballout, 2013). The CCS announcements for public sector jobs are based on Article 8 of the Staff Regulations and Article 54 (Law No. 583 dated 23/4/2004 (General Budget Law of 2004) and Article 1 of Law No. 23 of 5/9/2008 (amendment of Article / 87 / of the Staff Regulations) (Council of Civil Services, 2011).

2.6- Mathematics and science teaching self- efficacy

A person can have high STOE beliefs and low PSTE beliefs, hence they are not dependent on each other. Referring to Bandura's theory, self-efficacy is context bounded. Ashton and Webb (1986) followed Bandura's theory and inferred the notion of personal teaching efficacy or one's belief to teach effectively (Bursal, 2010). Therefore, teaching efficacy beliefs can be studied in different areas; mathematics and science modules in our case. There are two definitions in this paper: a) personal math teaching efficacy beliefs (PMTE), and b) the personal science teaching efficacy beliefs (PSTE)

(Bursal, 2010). Hence, PMTE and PSTE refer to teachers' beliefs about the extent to which they can affect students' achievement in math and science (Cantrell et al., 2003).

Since the introduction of the term teaching self -efficacy, there has been ample interest in investigating these beliefs in math and science education (Bursal, 2010). This study investigates pre-service teacher self-efficacy beliefs in STEM fields.

2.7- Science teachers' conceptual understanding at the university level

Some factors affecting PSTE scales were the gains in science conceptual understanding (Menon, 2015). This gain occurs through a rich process in learning science and not merely through the exposure to science courses (Menon, 2015). The researcher concluded that self-efficacy beliefs and the development of science conceptual understanding are related. Thus, it is crucial to develop science content in alignment with appropriate methodologies in order to improve pre-service content knowledge. Menon (2015) argued that studies investigating the relation between science content courses and self-efficacy beliefs yielded contradictory results (Jarrett, 1999; Wenner, 1995). Thus, it is important to study, in depth, the relation between PCK courses and personal self-efficacy beliefs. In addition, Cantrell et al. (2003) showed that while there was an increase in PSTE as a result of a science method course, the change in STOE was depicted only when the teachers started applying their knowledge in the class context.

In addition, a meaningful selection of the content of science courses may impact self-efficacy and reduce science anxiety (Kazempour & Sadler, 2015). Ekhoff (2017) argued that there is a positive correlation between inquiry based learning experiences in

a life science course for pre-service teachers and their self-efficacy. Through introducing educators to teach science via inquiry, teachers faced their lack of knowledge and started building understanding of the material. Implementing an inquiry based approach in a restrictive classroom atmosphere proved to be a challenge for them. However, it was found that as the course evolved, the pre-service teachers' self-efficacy beliefs were strengthened. On the other hand, Avery and Meyer (2012) posited that the negative experience pre-service teachers encounter at the university level impact their teaching in their classes later on.

2.8- Science experience before university

The negative experiences that science pre-service teachers faced when they were students translate into their classrooms once they become teachers (Avery & Meyer, 2012). Research on academic science achievement of U.S. students raised concerns. The pre-service elementary teachers had poor science background and/or negative experiences as students of science (Knaggs & Sondergeld, 2015). The researcher claimed that pre-service elementary teachers experienced a void in science elementary content knowledge and experience. This non- experience is one of the factors that contribute to low self-efficacy belief, since teachers do not have a reference that backs up their vision of themselves as effective science teachers. As a result of a science content course, Knaggs and Sondergeld (2015) noticed that pre-service teachers had a higher level of self-efficacy and science content knowledge. Therefore, it is important to provide pre-service teachers with authentic experiences in the class context.

Based on Bandura's four sources of self-efficacy, peer support has an ongoing effect on self-efficacy beliefs in teaching a subject (e.g. science). Bursal (2010) claimed, as a result of a study on 112 pre-service elementary teachers, that the teachers' high school major area impacted their peer support level. Also, teachers with science background were found to have a higher peer support than those of non-scientific background. Moreover, the support from the university professors as well as peers' support impact pre-service self-efficacy beliefs.

2.9- Research on mathematics and science teaching self-efficacy beliefs:

improving self-efficacy beliefs for math in pre-service teachers seems to be an important part of enhancing students' outcomes (Mongillo, 2016). Bates, Latham, and Kim (2011) found that the high level of PMTE correlates with higher grades on math tests of basic math skills. Consequently, Mongillo (2016) inferred that there is a relationship among math self- efficacy and the capacity to comprehend, do, and explain math.

As a result of an investigation conducted by Menon (2015), the researcher concluded that a rich science content course together with effective teaching strategies resulted in increased positive attitudes and confidence to teach science, thus enhancing science self-efficacy beliefs.

Harknes, D'Ambrosio, and Morrone (2007) argued that when teachers are involved in constructivist-based courses, they are interested in the "why" and not the "what". Hence, they started thinking conceptually. Conceptual understanding is thought to provide teachers with best practices, as well as to fulfill the requirements of the

Common Core State Standards. The Common Core State Standards (CCSS) combine the best state standards and instructor practices to develop a more consistent set of learning outcomes in math and language arts for students across the US. The main paradigm shift that the CCSS provides to math curriculum is that it is interested in process rather than product (Mongillo, 2016). Moreover, Harkness, D'Ambrosio, and Morrone (2007) stated that the more students are involved in real-life situation problems, the more they are able to construct their understanding with respect to new experiences and the more motivated they are.

2.10 – Description of the instruments used to measure the self-efficacy beliefs of the pre-service teachers

Since its introduction, the STEBI-B has been used to measure pre-service science teacher self-efficacy (Cakiroglu, Cakiroglu, &Boone 2005; Gencer & Cakiroglu, 2007; Schoon & Boone, 1998; Hechter, 2011; Tosun, 2000; Ginns, Tulip Watters, & Lucas 1995). It has also been successfully implemented in a variety of international settings, including Australia (Mulholland &Wallace, 1996, 2001; Mulholland, Dorman, & Odgers, 2004), South Africa (Kiviet & Mji, 2003; Mji & Kiviet, 2003), Turkey (Tekkaya, Cakiroglu, & Ozkan, 2004; Cakiroglu, et al., 2005; Gencer & Cakiroglu, 2007) and Jordan (Weshah, 2012). Mulholland et al. (2004) studied the efficacy beliefs of 314 science teachers. They concluded that the science course affected the personal efficacy beliefs but not the outcome expectancy. Also, gender and science courses at school did not affect teachers' efficacy beliefs. In the same context, Kiviet and Miji (2003) studied the gender difference in self- efficacy beliefs of 88 men and 112 women in South Africa. They concluded that female teachers were not as well prepared to teach science as their men colleagues. Moreover, Weshah (2011) studied the self-efficacy

beliefs of 106 Jordanian teachers. He argued that two thirds of the participants had external locus of attribution whereas only one third had an internal locus of attribution. This reflects on the use of effective teaching strategies. The ones with internal locus of attribution had higher levels of effective teaching strategies. Yazdi (2014) studied the relation between self-efficacy beliefs and teachers' burnout. She discovered an inverse relation between them and a significant correlation between burnout and the years of experience. In all these studies, the STEBI-B has proven to be a valid and reliable instrument across these diverse populations and has produced similar results. However, Cakiroglu, et al. (2005) noticed that cultural differences might explain observed differences in STEBI-B scores. Previous findings suggest that the STEBI-B is a strong instrument with a high degree of validity and reliability that can be used in a variety of settings.

2.11-Teacher preparation courses

Teacher preparation courses are planned to form the basis for solid pedagogical content knowledge. The worth of mathematics and science teaching at the elementary level relies on the preparation of pre-service elementary teachers with suitable content knowledge and pedagogical content knowledge in addition to positive beliefs about teaching these subject areas (Gresham, 2008).

2.12- Pre-service public school teachers at the national university

The Lebanese University is responsible for preparing secondary, elementary, and pre-school teachers for public schools (Ballout, 2013).

Under decree number 1833 date 16/3/1879, teachers with bachelor degrees and who pass the test administered by the Council of Common Services go back to the Education Department at the Lebanese university for two years as in-service teachers. During these years, teachers are paid and they are automatically assigned by the Ministry of Education and Higher Education (MEHE) to designated public schools on need basis.

2.13- Elementary pre-service qualification in Lebanon at a private university

Preparing pre-service teachers at the selected private university follows the "Pedagogical Core Requirements for Programs Leading to Certification in Teacher Education." (See Appendix N). This preparation entails a variety of courses, such as teaching diverse students, classroom management, and computers in education. During the third year, pre-service teachers are required to register for their Pedagogical Content Knowledge (PCK) courses in all subject areas. Moreover, teachers' preparation follow the standards developed by the Council of Chief State School Officers (NYSED, 2019).

2.14- Alignment between the syllabi of math and science PCK courses at the private Lebanese university and STEM approach

Kelley and Knowles (2016) claimed that due to changes in global security and economic stability, and after many decades of STEM education in the United States (U.S.), a rigorous understanding of STEM education is needed for educators to prepare students for the workforce in the twenty first century. They argued that if STEM is to be taught as usual in a silo fashion where all subjects are bound by strict agendas, content, and end of semester tests, then these barriers will hinder STEM education. Rather, they suggested a framework for STEM education where the basic elements to educate STEM

teachers is “by grounding their conceptual understanding of integrated STEM education by teaching key learning theories, pedagogical approaches, and building awareness of research results of current secondary STEM educational initiatives” (Kelley & Knowles, 2016, p 10).

While comparing both approaches, it is clear that there is an alignment between STEM and PCK courses’ approaches. They both emphasize the use of inquiry while investigating data. Cooperative and collaborative modes of work are required by both approaches. Technology integration in STEM approach and PCK courses is needed as a tool to provide teachers with effective means to explain, experiment and design models while learning the content. The textbooks used for both courses are aligned with the NCTM *Principles and Standards*, the *Next Generation Science Standards* and the constructivist mode of work to build knowledge. STEM approach and PCK courses embrace a constructivist approach entwined with the growth of learning communities. Learning occurs through the participation of the students in designing their learning experiences with their instructors. These experiences are designed to cater for their interests and needs related to the outcome of both courses. Both approaches emphasize the role of students as active learners and the instructors as the facilitators. They co-construct their knowledge while learning. Moreover, by the end of the course, students assess the course and accordingly some shifts in the course content occur. This boosts pre-service self-confidence as collaborators in designing the courses for the coming semesters and as members of learning cohort.

Based on the review of literature, the following chapter will develop the methodology used to answer the questions pertinent to this study.

Chapter Three

Methodology

In this chapter, the research design used in this study will be outlined. It aims at investigating pre-service self-efficacy beliefs in teaching STEM fields. Overall, the design included both qualitative and quantitative data collection methods to address he following research questions:

1. Are there any significant differences between the Lebanese pre-service elementary teachers' personal math self-efficacy beliefs (PMTE) about teaching mathematics before and after enrolling in the PCK math course?
2. Are there any significant differences between the Lebanese pre-service elementary teachers' personal science self-efficacy beliefs (PSTE) about teaching science before and after enrolling in the PCK science course?
3. How did the course contribute to changes in self-efficacy beliefs of pre-service science and math (STEM fields) elementary teachers?
4. Does the baccalaureate branch that the pre-service teachers follow in high school level influence their self-efficacy beliefs after enrolling in the PCK courses?

The following sections explain the methodology used to answer the questions. They include the research design, context and setting, population and sample, methods and procedures, instruments and procedures, piloting, triangulation, validity and reliability, ethics, data collection, analysis procedures, and analysis procedures.

3.1- Research design

the design of this research is the explanatory sequential design, the quantitative data was collected at the beginning, then the qualitative data collection took place to understand in depth the findings of the quantitative data, and finally the quantitative data was gathered at the end of the semester to measure any differences (Creswell, 2015).

3.2- Context and setting

The site is a private university in Beirut where PCK courses are delivered by the education department. It is a “typical” site since it contains the expected elements in a usual university (Merriam & Tisdell, 2016). The context of the study is the PCK courses in math and science (STEM fields) that are part of a set of education courses. These PCK courses include mathematics and science methods with focused field experiences. All pre-service teachers have to teach some of the lessons they prepared as parts of their units.

3.3- Participants

22 Lebanese female pre-service teachers originally participated in the study. They were informed of the nature of the research. One of the students did not complete the questionnaire and consequently this was excluded from the sample. The sample ended up with 21 pre-service teachers. These are students from the same university who took the same number of major courses required by the education department. Participants are in their senior year at the university prior to student-teaching. They are from different tracks at the high school levels (humanities, life science, and economics and social science), and from different kind of schools (public and private). It is

important to note that our sample, except for two, were educated according to the Lebanese curriculum standards. Hence, the notion of STEM education is not clear to them and they are dealing with each subject as a stand-alone material in the STEM silo. This fact agrees with Breiner, Harkness, Johnson, and Koehler's (2012) argument that many educators do not have a clear definition about what STEM is.

The sampling includes participants who are easily available to the researcher (Creswell, 2008; Rovai, Baker, & Ponton, 2013). The aim of using such a sampling is to gain precise understanding and information about the group while studying a small sample (Merriam & Tisdell, 2016)

3.4- Methods and procedures

3.4.1- Instruments

First, a quantitative data collection was done through the use of the Science Teaching Efficacy Belief Instrument STEBI and the Mathematics Teaching Efficacy Belief Instrument (MTEBI) questionnaires at the beginning of the course, as a pre-test (see section 3.4.2), along with a demographic questionnaire to gather some background about the students and to allocate them numbers and pseudonyms for comparison later on. Second, during the qualitative procedures, semi-structured interviews were administered in both courses. Participants submitted reflections in math and science PCK courses, 3 times during the semester. Finally, a quantitative and qualitative data collection was done through the use of the STEBI and MTEBI at the end of the semester as a post-test along with the interviews and the reflections.

Table 3.1

Data Collection methods and purposes

Collection methods	Participant Involvement	Specific Research Purpose
Demographics	All pre-service teachers completed a questionnaire	To assign numbers to each participant and to determine their previous experiences in both math and science prior to university level
Math and Science Teaching Efficacy Belief Instrument(MTEBI) and (STEBI)	All pre-service teachers will complete this instrument on two occasions pre and post.	To collect information on how PSTE and PMTE were at the beginning of the PCK courses and whether they changed at the end of the course.
One-on-one interviews	At the beginning and at the end of the semester, pre-service teachers will meet with the researcher for 10 minutes.	To collect information on how self-efficacy beliefs changed throughout the course, taking into consideration Bandura's 4 sources of self-efficacy (Mastery experience, emotional states, vicarious experiences, and social persuasion)
Reflections	3 times during the semester. At the beginning, midway and towards the end of the semester.	To collect information on how self-efficacy beliefs changed throughout the course.

The selection of the mixed-methods research design is driven by the explanation of quantitative results through the use of qualitative findings (Creswell, Plano, Gutmann, & Hanson, 2003). While using the sequential explanatory mixed methods, the

investigator "collects and analyzes the quantitative data, then collects and analyzes the qualitative data" (Creswell, et al., 2003, p.223). I started by gathering quantitative data using STEBI and MTEBI instruments. Later, I collected qualitative data by first using the interviews with participants to examine the sources that play a major role in changing mathematics and science self-efficacy beliefs of pre-service teachers. As part of the collection of the qualitative data, reflections were used to examine the evolution of the efficacy beliefs during PCK courses. Finally, the STEBI and MTEBI instruments were used at the end of the course to collect quantitative data.

3.4.2- Instruments and procedures:

3.4.2. a - Quantitative Part:

In this part, STEBI (Bleicher, 2004) and MTEBI instruments (Enochs, Smith & Huinker, 2000) were administered at the beginning, as a pre-test, and at the end, as a post test, of the PCK courses. STEBI was first used by Riggs and Enochs (1990). Dr. Riggs responded to my email and informed me that it is for public use nowadays (Appendix J). Dr. DeAnn Huinker emailed me granting her permission to use the MTEBI (Appendix I). STEBI-B uses two subscales: personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). The PSTE contains 13 Likert-type items and the STOE uses 10 Likert-type items formulated to register pre-service level of agreement with a five-point scale (1= strongly disagree to 5 = strongly agree). STEBI-B contains two subscales: the PSTE and STOE. The scores of the PSTE range from 13 to 65 and those for the STOE range from 10 to 50. Both subscales were verified to be valid and reliable by Riggs and Enochs (1990) with Cronbach's α of 0.90

(PSTE) and 0.76 (STOE). Subsequent studies stated similar values (Bleicher & Lindgren, 2005).

STEBI-B admits two subscales: personal science teaching efficacy beliefs (PSTE) and science teaching outcome expectancy (STOE). The PSTE admits 13 Likert-type items, and the STOE admits 10 Likert-type items to document pre-service teachers' agreement or disagreement with a statement on a five-point scale (5 = strongly agree and 1= strongly disagree).

Like STEBI-B, the MTEBI uses two subscales: Personal math teaching efficacy (PMTE) and math teaching outcome expectancy (MTOE). The PMTE is made up of 13 items and the MTOE is made up of eight items. Eight items (2, 3, 5, 6, 8, 9, 15, 17, 18, 19, 20 and 21) are reverse scored. The PMTE scale consists of 13 items (2, 3, 5, 6, 8, 9 11, 15, 17, 18, 19, 20, and 21). The MTOE scale consists of 8 items (1, 4, 7, 10, 12, 13, 14 and 16). Thus, PMTE scale scores range from 13 to 65 while MTOE scores range from 9 to 45. The MTEBI had 23 items like the STEBI- B, but two items were dropped after the validity analysis (Enochs, Smith, & Huinker, 2000). Moreover, the confirmatory factor analysis indicated that the two subscales (PMTE and MTOE) were independent, thus adding to the validity of the instrument (Enochs et al., 2000). MTEBI is a valid and reliable assessment of PMTE and MTOE (Enochs et al., 2000). Enochs et al. (2000) tested the instrument on a sample of 324 pre-service teachers to determine the reliability and validity of the instrument. The reliability coefficient analysis yielded Cronbach's alphas of internal consistency of 0.88 for the PMTE and 0.81 for the MTOE subscales. Cronbach's alpha coefficient (Cronbach, 1951) is considered, in general, as the most suitable reliability indicator for survey research (Drost, 2011). It is a number

between 0 and 1, Cronbach's alpha reliability assesses the degree of internal consistency of an instrument. Hence, the closer the number is to 1, the better the internal consistency of the survey items. Any value above 0.8 indicates good internal consistency. The personal teaching efficacy scale in both subjects (math and science) and the outcome expectancy scale in both subjects were used. The first scale measures the pre-service confidence to teach certain STEM subjects and their beliefs that student learning in specific STEM subjects can be affected by actions of educators.

3.4.2.b- Qualitative Part:

The main aim of this part of the investigation is to look into the experiences of pre-service teachers from a qualitative perspective and to comprehend what major factors shaped their self- efficacy beliefs and the changes that occurred after the PCK courses.

To complement the findings of the quantitative data, semi-structured interviews were used. Students responded to the questions included in both appendices I and F successively at the beginning and near the end of the semester. Merriam and Tisdell (2016) stated that interviews provide the opportunity to understand in depth an individual's perspective. It helps the researcher focus on the story as told by the individual him/herself. The bases for the interview was Zeldin and Pajare's (2000) protocol and the four sources of self-efficacy (Bandura, 1977, 1986). They devised open-ended questions for interview protocol to investigate self-efficacy.

Each interview lasted approximately10-15 minutes after obtaining the consent of the pre-service teachers. Later, the data was entered into an Excel spreadsheet.

Also, pre-service teachers reflected on their experiences during the math and science PCK courses three times during the semester. Students based their reflections on the four questions in appendices G and H. These questions are based on Bandura's four sources of self-efficacy (1977, 1986).

3.5- Qualitative Data Collection

According to Bandura (1986), self-reflections on mastery experiences play a crucial role in evaluating teachers' self-efficacy. For this reason, pre-service teachers were asked to reflect on some of their positive or negative experiences, and about their abilities while experimenting in both courses.

Pre-service teachers in both PCK courses were given time to reflect on their learning experiences. They would study in a safe environment as one of the participants mentioned "I felt safe while I was giving my answer." The teacher encouraged students to synthesize their ideas and to derive the formula as when they were trying to compute Pick's formula. The professor guided her students' discovery rather than gave them the solution as was the case when they were learning at the school level.

Collected data was coded according to the sources of self-efficacy and to determine the themes that go under these categories. The data from the interviews and the reflections were entered again in Excel worksheets to derive common themes. The analyses of the interviews and reflections provided in-depth understanding on the way the pre-service teachers' self-efficacy evolved during PCK courses.

Data were grouped by asking the 4-w questions (why, what, when and where), then alike answers were put together under the same category.

3.5.1- Demographics

A survey instrument to complete routine demographic information about pre-service teachers, their personal and educational background, was used at the beginning of the course (see Appendix A). Numbers and pseudonyms were assigned to the participants for objectivity and to facilitate comparison of the results after using the instruments.

3.5.2- Interview

Data was collected through one-on-one interviews using semi-structured and open-ended questions. During the interviews, my interruption was kept at a minimum. Participants freely discussed and critiqued their experiences in their university courses. Interviews are widely used since they are important tools in collecting data (Yin, 2018). In addition, Yin (2018) claims that "Interviews can especially help by suggesting explanations of key events, as well as the insights reflecting participants' relativist perspectives" (Yin, 2018, p. 118). The conversation was used to investigate the perceived self- efficacy of the educators in math and science before and after completing the PCK courses. Three major objectives guided the investigation of the pre-service teacher personal self -efficacy beliefs. These objectives are (a) to highlight any change in results of PMTE and PSTE beliefs as they relate to the PCK courses; (b) to find out which of the four sources of self-efficacy had a positive influence on growth in PSTE and PMTE beliefs as they relate to the PCK courses; (c) and to understand if there is a relation between PMTE and PSTE beliefs in the PCK contexts.

Bandura's (1977; 1986; 1997) four sources of self-efficacy work as background to direct the data collection in this section of the investigation. These sources are the following: mastery experiences (ME), vicarious experiences (VE), social persuasions (SP), and physiological states (PS). The interview protocol provides the participants with the freedom to tell their stories in their own words. Follow up questions were asked if participants did not mention the effect of any of the previously mentioned sources of efficacy.

Interviews were used to identify whether experiences in the PCK courses led to promoting one of the sources of self-efficacy beliefs. The interview questions were adapted from Usher and Pajares (2006) who studied self-efficacy from different researchers' perspectives. The questions were designed to observe the four conjectured sources of efficacy to understand which one influences positively the experience of the participants.

3.5.3- Reflections:

Qualitative data were also collected through reflections. Chahine and King (2012) posited that teachers need to reflect on their teaching practices in order to enhance their self-efficacy beliefs. Chahine and King (2012) added that reflections are powerful tools to get in-depth information about the experiences of pre-service teachers in the PCK courses. In our case, reflections were guided through the use of questions (see appendix E). They were assigned 3 times during the semester. Pre-service teachers answered questions related to the four sources of self-efficacy beliefs. (e. g. Did your teacher or peer give you positive feedback in your math class? How did you feel about it?)

3.6- Triangulation

The objective of triangulation is to enhance, complete and clarify the results obtained from one method to the results obtained from another method. In this investigation, the triangulation was between three types of instruments: the MTEBI and STEBI-B instruments, the reflections, and the interviews.

3.7- Validity and reliability of the instruments

It determines if the results obtained meet all of the requirements of the research methods. In the quantitative stage, MTEBI and STEBI-B are recognized tools that were validated with previous researchers' factor analyses (Enochs, et al., 2000; Riggs & Enochs, 1990). Reliability of the instrument is reached through repetitive testing, but since not enough time was available before the beginning of the course, previous research testimony about the reliability and validity of these instruments were considered (Bennett, 2016; Enochs et al., 2000; Riggs & Enochs, 1990; Setra, 2017).

3.8- Ethics

Ethical issues were addressed in m any ways. Approval for conducting the study was obtained from IRB. The participants were informed of the purpose of the study, were promised confidentiality, and signed a written consent that they can opt out whenever they feel like it.

3.9- Data analysis

Data analysis was on three levels: the quantitative, qualitative, and both qualitative and quantitative. The demographic survey was given to the participants at the

beginning of the course. STEBI-B and MTEBI, and the interviews were administered at the beginning of the course and towards the end of the course whereas the reflections were submitted three times during the fall semester at fixed intervals. The research is based on the grounded theory since it is interested in the process or how things changed over time (Merriam & Tisdell, 2016). Also, qualitative data was collected through a wide array of documents, such as interviews and reflections. They were analyzed using the constant comparative method of data analysis whereby each part of the data was grouped into categories and compared to the same category to determine similarities and differences (Merriam &Tisdell, 2016, p. 32). While analyzing the data, I kept moving from abstract concepts to concrete data; following Merriam and Tisdell's (2016) suggestions, using both inductive and deductive reasoning.

3.9.1-Quantitative analysis procedure

A t-test on the pre-and post-test scores of participants on the MTEBI and STEBI-B was conducted to compare the total scores for the first and final administrations of the survey. The independent variable is the time of running the pre and posttest, and the continuous dependent variable is the change in the pre-service teaching self-efficacy in both PCK courses.

3.9.2-Qualitative analysis procedure:

Pre-service teachers' feelings, emotions and thought processes that cannot be studied through quantitative procedures were analyzed and interpreted. The analysis of the qualitative data was conducted using the grounded theory methods.

To ensure the in-depth understanding of the data, qualitative analyses of reflections and interviews were conducted. The reflections and interview data support the findings of the STEBI and MTEBI instruments. The research questions and the four sources of self-efficacy (i.e. mastery experiences, vicarious experiences, verbal persuasions and physiological states) directed the formation of themes within the four sources of self-efficacy and the changes that occurred.

3.9.2.i -Qualitative data coding:

Each participant's reflection was coded under the themes from Bandura's (1968, 1977) four sources of Self-efficacy (i. e. mastery experiences, vicarious experiences, verbal persuasions, and physiological states). The structural coding was done at the same time as the descriptive coding to capture as much as possible of the thoughts of the participants.

3.10-Threats to validity:

The validity of this study is under two main threats: external and internal. The external threats are the ability of the researcher to infer correct conclusions from the data and to generalize the findings to populations (Rovai, et al., 2013). The threats to internal validity of this investigation were the selection of the sample and the instrumentation. The instrumentation threat to internal validity occurs when the researcher commits an error. this threat was addressed using the literature to pinpoint recent discussion on the topics of teachers' self-efficacy, STEM approach, and Lebanese education. The selection of a small sample may be a possible threat as the results may not be generalizable to a larger population. However, when we consider the proportionality of the number of

participants to the size of a country as Lebanon, it seems to be logical. Also, the administration of both instruments yielded 42 answers for the MTEBI and 46 answers for the STEBI. As for the interviews, there were 12 answers per teacher per subject. With respect to the reflections, there were four answers per teacher in each of the three reflections submitted throughout the semester. This enriches the discussion and the findings.

In conclusion, the above chapter presented the methodology of the study and the next chapter presents the results. Specifically, the quantitative part used t-test to compare the participants'

Chapter Four

Results

This chapter describes the levels of mathematics and science teaching efficacy beliefs of 21 pre-service teachers who answered the MTEBI and STEBI questionnaires. Of the 21 participants, four teachers were selected according to their scores on the PMTE and the PSTE subscales. Their answers to the interviews and their reflections were studied to explain their math and science efficacy beliefs and the changes that occured as a result of taking math and science PCK courses.

4.1- Quantitative analysis- Data analysis and findings

4.1.1- Pre-and Post STEBI-B

Independent sample t-tests were run on the pre and post-test scores for each subscale. The PSTE and STOE item scores were analyzed separately. The STEBI-B was administered at the beginning of the course and near its end. The PSTE items are: Items 2, 3, 5, 6, 8, 12, 17, 18, 19, 20, 21, 22, 23. The STOE items are: Items 1, 4, 7, 9, 10, 11, 13, 14, 15, 16.

4.1.1. a- Personal Science teaching efficacy beliefs (PSTE)

Table 4.1
PSTE

Tests	Mean	N	Std. Deviation
Pre	3.52	21	.759
Post	3.49	21	.768
Total	3.44	42	.754

Using SPSS for the PSTE, the means were calculated after recoding items 3, 6, 8, 10, 13, 17, 19, 20, 21, and 23. The means of the PSTE items before the course was 3.52 (SD = 0.76) and after the course it was 3.49 (SD = 0.77) (see Table 4.1).

Separate analyses were run on the PSTE items before and after the course to determine if there was a significant difference between their means during the pre-test and the post-test. The mean of the PSTE changed from 3.52 (SD = .759) to 3.49 (SD = .768), so the difference between the two means was 0.03. Therefore, the mean of their personal efficacy beliefs to teach science was lower after the PCK course. The difference between the two scores is statistically not significant at the .954 ($p > .05$) level ($t = .14$ and $Df = 40$). Thus the findings cannot be generalized.

To compare the means for each item of the PSTE before and after the course the following table was completed. The mean difference shows that students gained confidence on the following items: knows how to teach science concepts (Item 5), be effective in monitoring science activities (item 6), will teach science effectively (Item 8), understands science concepts (Item 12), be able to explain how science solutions work (Item 17), be able to answer students' questions (Item 18), will welcome students'' questions(Item 22), and know what to do to make the students understand science (Item 23) (see Table 4.2).

Table 4.2

PSTE before and after the PCK course

			Pre-test		Post-test		Mean difference
			Mean	SD	Mean	SD	
PSTE	2	Will find better ways to teach science.	4.24	1.091	4.10	.944	.14
	3	Will teach science as well as other subjects*	3.14	1.49	3.00	1.378	.14
	5	Knows how to teach science concepts	2.76	1.091	3.29	1.34	-.53
	6	Will be effective in monitoring science activities *	3.33	1.238	3.43	1.248	-.1
	8	Will teach science effectively *	3.52	1.401	3.76	1.261	-.24
	12	Understands science concepts	3.24	1.221	3.29	1.102	-.05
	17	Will be able to explain how science solutions work *.	3.14	1.195	3.38	1.322	-.24
	18	I will typically be able to answer students'' science questions.	3.57	1.076	3.67	1.017	-.1
	19	Will have the skills to teach science*	3.48	1.167	3.29	1.056	.19
	20	will invite the principal to evaluate my science teaching*	3.62	1.465	3.19	1.289	.43
	21	Will be able to help students understand science concepts*.	3.81	1.327	3.48	1.167	.33
	22	Will welcome students' questions	4.33	1.017	4.05	1.024	.28
	23	Know what to do to make the students understand science*	3.62	1.117	3.48	1.123	.14

*recoded items

4.1.1.b- Science Outcome Expectancy (STOE)

As for the outcome expectancy, the following items were included: Items 1, 4, 7, 9, 10, 11, 13, 14, 15, and 16. The mean for the STOE before the PCK course was 3.44 (SD = .325) and after the course it was 3.60 (SD = .489) (see Table 4.4). Hence, there is

a positive influence of the PCK course on the pre-service teachers' beliefs that they can affect the learning of their students in science (see Table 4.3).

Table 4.3
STOE group statistics

Tests	N	Mean	Std. Deviation
Pre	21	3.44	.325
Post	21	3.60	.493

Now, for the STOE, at the significant level of .096, the difference between the two means was -.126 (t= -.126 and Df = 40). Thus the findings cannot be generalized.

To compare the means for each item of the STOE before and after the course, the following table was completed. There was a mean difference for the following items: when a student does better than usual in science it is often because the teacher exerted a little effort (Item 1), students' grades improve due to their teachers' effective teaching (Item 4), If students are underachieving in science it is most likely due to ineffective science teaching (Item 7), the inadequacy of a student's science background can be overcome by good teaching (Item 9), the low science achievement of students can generally be blamed on their teachers (Item 10), When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher (Item 11), The teacher is generally responsible for the achievement of students in science (Item 14), students' achievement in science is directly related to their teachers' effectiveness in science teaching (Item 15) (Table 4.4). Hence, pre-service teachers were more qualified after the PCK course in these specific areas. They expected that in these specific areas, they are more qualified to affect their students' learning.

Table 4.4
STOE

			Pre-test		Post-test		
			Mean	SD	Mean	SD	Df
STOE	1	when a student does better than usual in science it is often because the teacher exerted a little effort	3.76	1.091	3.81	1.250	.66
	4	When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach	3.76	.944	4.14	0.910	-.38
	7	If students are underachieving in science it is most likely due to ineffective science teaching	2.76	1.091	3.48	1.209	-.72
	9.	The inadequacy of a student's science background can be overcome by good teaching.	3.90	0.889	4.05	0.921	-.15
	10	The low science achievement of students can generally be blamed on their teachers.*	2.29	1.007	2.86	1.108	-.57
	11	When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	3.43	0.870	3.48	0.981	-.05
	13	Increased effort in science teaching produces little change in some students' science achievement.	3.19	1.365	2.52	1.250	.67
	14	The teacher is generally responsible for the achievement of students in science	3.52	1.327	3.76	1.091	-.24
	15	Students' achievement in science is directly related to their teachers' effectiveness in science teaching.	3.52	1.030	3.95	1.024	-.43
	16	If parents comment that their child is showing more interest in science at school, it is probably due to their performance of the child's teacher	4.29	0.644	4.00	0.775	.29

Comparing PSTE according to the branches

The mean for the PSTE items for the humanities branch of the pre-service teachers was 2.94 before the PCK course and it became 2.65 after it (see Table 4.5). The

mean for the PSTE of the science branch before PCK course was 3.66 and it became 3.69 (see Table 4.4). The mean for the economics and social branch was 3.64 and it became 3.67(see Table 4.4). Thus the mean for the science and the economics and social branches was greater before and after the PCK courses than the humanities branch mean. The difference in the PSTE means of these two branches before and after the PCK courses was greater than the humanities branch. The humanities branch students scored less after the PCK course. This might be a proof that the grade 12 curriculum reflects on the pre-service teachers' efficacy beliefs in science. Specifically, the humanities branch students were prepared in a less rigorous way than the economics and science branches (see Appendix O).

Table 4.5

	PSTE for humanities Branch			*PSTE for science branch*			*PSTE for economics and social sciences branch*		
Tests	Mean	N	St Deviation	Mean	N	St Deviation	Mean	N	St Deviation
Pre	2.94	4	1.14	3.66	8	.69162	3.64	8	.61254
Post	2.65	4	.48	3.69	8	.82131	3.67	8	.64457
Total	2.80	8	.82	3.67	16	.73365	3.66	16	.60762

Comparing STOE according to the branches

Looking at the STOE of the three branches, the mean for the STOE of humanities branch pre-service teachers was 3.32 before the PCK course and it became 3.42 after PCK course (see Table 4.5). The mean for the STOE of the science branch before PCK course was 3.53 and it became 3.73 (see Table 4.5). The mean for the economics and social branch was 3.40 and it became 3.56 (see Table 4.5). Thus the STOE mean for all the branches became greater after the PCK course,

Table 4.6

	STOE for humanities Branch			*STOE for science Branch*			*STOE for economics and social sciences branch*		
Tests	Mean	N	St Deviation	Mean	N	St Deviation	Mean	N	St Deviation
Pre	3.32	4	.27538	3.53	8	.206	3.40	8	.453
Post	3.42	4	.33040	3.73	8	.492	3.56	8	.604
Total	3.37	8	.28661	3.63	16	.379	3.48	16	.523

In conclusion, all branches scored better after the PCK course on the STOE subscale.

4.1.2- Pre and post MTEBI

For the MTEBI instrument, the following analysis was done. Independent sample t-tests were run on the pre and post-test scores for each subscale. The PMTE and MTOE item scores were analyzed separately. The MTEBI was administered at the beginning of the course and near its end. Each subscale score (PMTE and MTOE) was analyzed separately.

4.1.2. a- Personal Math Teaching Efficacy Beliefs (PMTE)

The PMTE items are Items 2, 3, 5, 6, 8, 11, 15, 16, 17, 18, 19, 20, 21. Using SPSS for the PMTE, and after recoding items 3, 6, 8, 15, 17, 18, 19, 21, the means of the PMTE were calculated. The means of the PMTE before the course was 3.84 (SD = 0.54) and after the course it was 3.93 (SD = 0.65). all 21 participants participated answered the PMTE subscale (see Table 4.6).

Table 4.7

PMTE before and after PCK course

Tests	Mean	N	Std. Deviation
Pre	3.84	21	.549
Post	3.93	21	.652
Total	3.89	42	.597

Separate analyses were run on the PMTE items before and after the course to determine if there was a significant difference between their means during the pre-test and the post-test. The mean of the PMTE changed from 3.84 (SD= 0.54) to 3.93 (SD = 0.65), so the difference between the two means was - 0.09. Therefore, the pre-service teachers' personal self-efficacy beliefs to teach mathematics was higher after the PCK course. The difference between the two scores is statistically not significant (t = -0.473 and Df = 40). Thus the results cannot be generalized.

For the PMTE, to compare the means for each item before and after the course the following table was completed (see Table 4.11). Overall, the mean difference shows that students showed progress on the following items: will teach mathematics as well as other subjects (Item 3), know how to teach math concepts effectively (Item 8), understand mathematical concepts (Item 11), will have the skills to teach mathematics (Item 17), will welcome students' questions (Item 20), and know what to do to make the students appreciate mathematics (Item 21) (see Table 4.7). Also, pre-service teachers showed a better mean score in the PMTE than in PSTE according to the number of items they progressed at. Thus, participants' math personal efficacy beliefs progressed after the PCK course more than their personal science efficacy beliefs.

Table 4.8
PMTE

			Pre-test		Post-test		Mean Difference
			Mean	SD	Mean	SD	Df
	2	Will find better ways to teach mathematics.	4.52	.602	4.43	0.75	.09
	3	Will teach mathematics as well as other subjects*	3.81	1.29	4.00	1.04	-.19
	5	knows how to teach mathematics concepts effectively	3.29	0.90	3.76	0.94	-.47
P							
M	6	Will be effective in monitoring mathematics activities*	4.14	0.66	3.90	0.89	.24
T							
E	8	Will teach mathematics effectively*	4.29	0.90	4.43	0.87	-.14
	11	Understands mathematical concepts	3.67	0.91	4.00	0.84	-.33
	15	Will be able to explain how mathematical solutions work *.	4.24	0.83	3.76	1.49	.48
	16.	Will be able to answer students' mathematics questions	4	.63	.395	.74	.05
	17	Will have the skills to teach mathematics *	2.90	0.83	3.14	1.11	-.24
	18	Will invite the principal to evaluate mathematics teaching *	3.48	1.08	3.62	1.24	.28
	19	Will be able to help students understand mathematical concepts *.	3. 71	1.06	3.57	0.87	.14
	20	Will welcome students' Questions	4.43	0.98	4.67	0.48	-.24
	21	know what to do to make the students appreciate mathematics*	3.48	.98	3.86	0.95	-.38

4.1.2. b- Math Teaching Outcome Expectancy (MTOE)

As for the outcome expectancy, the following items were included: Items 1, 4, 7, 9, 10, 12, 13, and 14. The mean score for the MTOE before the PCK course was 3.72 (SD 0.53) and after the PCK course it was 3.78 (SD = 0.61), with difference of -.06. Hence, pre-service teachers had more confidence that they can affect their students' mathematics learning after the PCK. Their mean difference was Df = -0.06 compared to the mean difference they got on the STOE (Df = -.162), data shows that students' beliefs that they can teach math after the PCK course was more than their beliefs that they can teach science. This can be explained through the interviews and the courses'

requirements. Pre-service teachers mentioned that they had a better experience at the math PCK course than at the science because they attended a math methods course previously (as stated at the interviews). This result contradicts Bursal's (2010) findings that additional courses would not enhance pre-service self-efficacy beliefs to teach.

Table 4.9
MTOE before and after PCK course

Tests	Mean	N	Std. Deviation
Pre	3.72	21	.532
Post	3.78	21	.612
Total	3.75	42	.567

Now, for the MTOE, at the significant level of 0.69, the difference between the two means was –0.336 (t= -.366 and Df = 40). Hence, pre-service teachers had more confidence that they can affect their students' mathematics learning after the PCK course. Their mean difference was Df = -.06.

For the MTOE, to compare the means for each item before and after the course, the following table was completed (see Table 4.10). There was a mean difference for the following items: when a student does better than usual in mathematics it is often because the teacher exerted a little effort (Item 1), the inadequacy of a student's mathematics background can be overcome by good teaching (Item 9), when a low-achieving child progresses in mathematics it is usually due to extra attention given by the teacher (Item10), students' achievement in mathematics is directly related to their teachers' effectiveness in mathematics teaching (Item 13).

Table 4.10
MTOE

		Item	*Pre-test*		*Post-test*		*Mean difference*
			Mean	SD	Mean	SD	
MTOE	1.	when a student does better than usual in mathematics it is often because the teacher exerted a little effort	3.62	1.07	3.71	1.19	-.09
	4.	When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach	4.10	.83	3.67	1.06	.43
	7.	If students are underachieving in mathematics it is most likely due to ineffective mathematics teaching	3.48	1.25	3.48	.87	0
	9.	The inadequacy of a student's mathematics background can be overcome by good teaching.	4.10	.625	4.33	.65	-.23
	10.	When a low-achieving child progresses in mathematics it is usually due to extra attention given by the teacher.	3.14	1.11	3.62	1.02	-.48
	12.	The teacher is generally responsible for the achievement of students in mathematics	3.81	1.08	3.81	1.03	0
	13.	Students' achievement in mathematics is directly related to their teachers' effectiveness in mathematics teaching	3.52	.98	3.71	.96	-.19
	14.	If parents comment that their child is showing mo Mathematics at school, it is probably due to their of the child's teacher.	4	.71	3.90	.94	.10

Comparing PMTE according to the branches

The mean for the PMTE of humanities branch pre-service teachers was 3.44 before the PCK course and it became 3.58 after the PCK course (see Table 4.11). The mean for the PMTE of the science branch before the PCK course was 4.08 and it became 4.25 (see Table 4.11). The mean for the economics and social branch was 3.88 and it became 3.86 (see Table 4.11). Thus the PMTE mean for the science and the economics and social branches was higher than the humanities branch PMTE before and after the

PCK. This might be an indicator that grade 12 curriculum reflects on the pre-service personal self-efficacy beliefs.

Table 4.11

	PMTE for humanities Branch			*PMTE for science branch*			*PMTE for economics and social branch*		
Tests	Mean	N	St Deviation	Mean	N	St Deviation	Mean	N	St Deviation
Pre	3.44	4	.549	4.08	8	.541	3.88	8	.480
Post	3.58	4	.876	4.25	8	.253	3.86	8	.765
Total	3.51	8	.681	4.16	16	.417	3.87	16	.617

Comparing MTOE according to the branches

The mean for the MTOE of humanities branch pre-service teachers was 4.06 before the PCK course and it became 3.69 after the PCK course (see Table 4.12). The mean for the MTOE of the science branch before the PCK course was 3.80 and it became 3.98 (see Table 4.12). The mean for the economics and social branch was 3.85 and it became 3.64 (see Table 4.12). Thus the MTOE mean for the humanities and the social and economics branches was less. The mean for the science branch increased after the PCK course. Looking at the Lebanese curriculum, the science branch students were more prepared in the math subject than their peers in the other two branches. The better increase in MTOE for the science branch is in alignment with Bursal's (2010) finding that students with math and science background had more self-efficacy beliefs after the preparation courses than their colleagues from other school background.

Table 4.12									
MTOE for humanities branch				*MTOE for science branch*			*MTOE for economics and social branch*		
Wave	Mean	N	St Deviation	Mean	N	St Deviation	Mean	N	St Deviation
1	4.06	4	.298	3.80	8	.395	3.52	8	.689
2	3.69	4	.650	3.98	8	.475	3.64	8	.766
Total	3.88	8	.509	3.89	16	.433	3.58	16	.707

Summary:

Even though the mean of the MTOE and PSTE of the humanities branch became less after the PCK course, the PMTE, PSTE, STOE and MTOE mean scores of the science branch increased after the PCK course. The PMTE, PSTE, STOE mean scores of the social and economics branch increased whereas the MTOE mean score decreased after the PCK course. This is in alignment with Bursal's (2010) findings, that the academic preparation at the school level plays a role in the self-efficacy of the pre-service teachers in teaching STEM (math and science) fields.

4.2- Qualitative analysis

The interview and the reflections provided answers for the third research question. They provide in depth-information into PMTE and PSTE, and MTOE and STOE. While looking into the data collected via the interviews and the reflections, they emphasize the importance of the teacher's role in affecting student learning in STEM fields (math and science).

Bandura (1997) theorized that personal efficacy beliefs "…. people's level of motivation, affective states, and actions are based more on what they believe than on what is objectively true." (p. 2). He argued that self-efficacy beliefs control one's

functioning through four main practices that work together. After comparing participants' results to Bandura's (1997) four efficacy domains, each of the areas within the themes was recognized following pre-service teachers' answers.

Referring to Bandura (1986), self-reflection is a main source of efficacy beliefs since it is based in authentic mastery experience. Successes and failures dominate one's efficacy appraisal; good mastery experiences enhance them and bad experiences lower them. Accordingly, pre-service teachers were asked to remember their past experiences in math and science classes. Their feelings towards these experiences, and whether they were good or bad in both subjects were examined (see Appendices G and H). These experiences encompass the entire academic span from elementary to high school and even experiences during the PCK courses.

Pre-service teachers were asked to reflect on changes that might have occurred during the semester in their perceptions of self-efficacy. The interviews were geared toward an in-depth understanding of the participants' perceptions of their mathematics and science abilities and how that outlines their efficacy beliefs to teach math and science. This includes:

a) Their personal beliefs that they can make students get better results in math and science (Items 1 and 4) in MTEBI and STEBI instruments.

b) Their ability to provide students with alternative strategies if they did not understand the concepts (Items 11 in MTEBI and 12 in STEBI)

c) Their ability to find better ways to teach math and science (Item 2 in MTEBI and STEBI).

d) Their ability to affect students' progress by giving extra attention to the student (Items 10 in MTEBI, and 11 in STEBI).

The data of the interviews was coded to determine if the identified themes that emerged fall under any of the self-efficacy domains. Data from the interviews was reviewed several times to ensure that no details were missed. The interview analysis provided in- depth understanding of the way the pre-service teachers' self-efficacy changed during PCK courses.

Data were grouped by asking questions targeting the four domains of Bandura's (1977, 1986) theory. Then the structural coding was used to sort the data according to Bandura's domains of self-efficacy. The four sources led the organization of the qualitative data by following the research questions. The remaining part of the chapter presents the qualitative and quantitative findings.

4.3- Quantitative findings:

There was a significant difference between pre and post- surveys from "uncertain" to "agree", particularly for the items about effective teaching of mathematics and science concepts and understanding enough to teach them.

The mean scores indicate a progressive view of teaching that is characterized by an emphasis on learning by doing, hands-on activities, real life situation problems to learn versus rote learning.

All in all, the findings of this investigation show that the results of studying PCK courses affected mathematics and science efficacy beliefs of pre-service teachers. Because of accomplishing PCK courses, pre-service teachers' PSTE means did not

improve while their STOE, PMTE and MTOE means improved. The use of manipulatives to teach and learn mathematics played a major role in changing the scores of the participants in the pre-service math self-efficacy beliefs.

Pre-service teachers viewed learning mathematics as memorizing formulas and applying them while learning science was just through memorizing the content. After PCK courses completion, they are in favor of using the inquiry techniques where students discover the information and look for patterns to discover the formula (Pick's formula). Even-though the pre-service teachers experienced an increase in their beliefs in their abilities to teach mathematics, they still doubted their abilities to teach science (e.g. PSTE: Items # 3 and 21).

4.4 - Qualitative findings:

The participants in this part of the study were selected according to their PMTE mean scores before the PCK course and according to the difference in their mean scores before and after the PCK course (see Table 4.6). The two pre-service teachers who had the highest mean and the two who had the lowest PMTE means were chosen. Bandura (1997) theorized that people's self-efficacy beliefs "the beliefs in one's capability to organize and execute the courses of action required to produce given attainments" (p.3). According to him, human performance is guided by the four major domains that interact with each other. The four efficacy domains of Bandura (1977) (vicarious experiences, mastery experiences, social persuasions, and physiological states) acted as the major basis under which emerging areas were put.

Table 4.13.

PMTE of participants before and after PCK course

Participants	PMTE Pre-test	PMTE post test
Participant 11 Reema*	4.77	4.81
Participant 17 Nazli*	4.92	4.95
Participant 16 Mary*	3.15	3.69
Participant 21 Amani*	3.00	3.31

*pseudonyms

4..4.1. a- Mastery Experiences: Referring to Bandura (1986), the best source of efficacy data is self-reflection because it is embedded in authentic experience. Successes of these experiences raise efficacy evaluations and failures lower them down.

Mastery experience (Math)

Pre-service teachers were asked to think about their perceptions concerning teaching of math. They were asked to think about their past experiences and their experiences while teaching. They thought about their math education, including their PCK course experiences. During their interviews and throughout their reflections they were asked to remember their past experiences. They all agreed that high grades and students' achievement play a major role in affecting their self-efficacy beliefs (see Table 4.14)

Table 4.14

Factors affecting mastery experiences(math)

Participant	Interviews	Primary Coding
Participant 11 Reema	a) When I taught my lesson, it was a good experience. I love to solve algebra and geometry.	a) Competency and success PCK course
	b) I used to get full marks.	b) Competency and success School
	c) When I explained using manipulatives, I was creative and the students understood better.	c) Students' achievement as a sign of mastery.
Participant 17 Nazli	a) The teacher got us engaged, and to become better.	a) Capability and achievement. School
	b) I taught math and I found the best way that suits my students.	b) Students' achievement as a sign of mastery. PCK course
	c) At the elementary level I had a lot of good grades, I used to like math.	c) Capability and achievement. School
Participant 16 Mary	a) they were bad experiences, no high grades	a) Capability and achievement. School
	b) I would understand, but the tests were difficult	b) Capability and achievement. School
	c) I had negative experiences, she used to lecture, now I will teach using manipulatives and hands on activities	c) Capability and achievement. School
Participant 21 Amani	a) Bad experiences, destroy your abilities, not normal. "This is so silly how could you not get it?"	a) Capability and achievement. School
	b) I never understood math, and they had high expectations and their approach was that I was stupid and how could you not understand it?	b) Capability and achievement. School
	c) When I was teaching, I helped the hyper active students and the students who did not understand and when they were engaged, I now feel happy.	c) Students' achievement as a sign of achievement. School
	d) I used the dice and the alligator video for the less than and greater than and I liked It when I taught it.	d) Capability and achievement. PCK course

All of the four pre-service teachers explained their math experiences, either as students or as pre-service teachers. The ones with low PMTE referred to as Mary and Amani had bad math experiences at school. Nevertheless, they expressed their willingness to teach math using manipulatives and to differentiate their teaching according to the students' needs. As for the participants with high PMTE, who are referred to as Reema and Nazli, they had positive experiences at school and during PCK course. Amani had a bad experience while learning math, and her teacher would put her down through her negative comments. She is now able to empathize with the students and use new ways that were taught during PCK course to make students understand better.

All of the four participants, who had bad or good experiences previously, are now convinced that they can teach better though the use of manipulatives, games, videos, and hands-on activities to help their students.

In their reflections, Reema and Nazli agreed to the use of the manipulatives while working with their students. They emphasized the use of active learning instead of rote learning. Reema mentioned the use of the "pendulum activity" that was modeled to her at the PCK math course, Mary mentioned the use of "chips" to explain probability. Amani expressed that even though she was now confident about the new ways to teach math, she still doubts her qualifications to teach it.

The three reflections that the four participants wrote progressed through the semester. At the beginning, Reema and Nazli liked math and were eager to teach it, while Mary and Amani had their doubts as they had boring and bad experiences at the school level. Near the end of the semester, i.e. in their third reflection, all four

participants, after their math unit planning and teaching, were able to choose the best hands-on activities and manipulatives, e.g. chips, pendulum, geoboards to teach math in their classes.

Mastery experiences (Science)

The participants in this part of the study were selected according to their PSTE mean scores before the PCK course and according to the difference in their mean scores before and after the PCK course. The two pre-service teachers who had the highest means, referred to as Hanadi and Jomana, and the two who had the lowest, referred to as Rawiya and Carmen (see Table 4.14). They were not the same participants as the ones in the math PCK course. This might be related to the school background that they had before the university level.

Table 4.14

PSTE of participants before and after PCK course

Participants	PSTE pre test	PSTE post test
Participant 4 Hanadi*	4.85	4.95
Participant 5 Jomana*	4.46	5.00
Participant 13 Rawiya*	2.46	3.38
Participant 14 Carmen*	1.85	2.85

*pseudonyms

Rawiya and Carmen showed less interesting school experiences than the ones with high PSTE mean scores. Rawiya had a special tutor who helped her understand science and explain one to one to her. Carmen's teacher was very strict and would reduce students' grades if they didn't know the answers. She used "to memorize out of fear not out of love." Their positive science experiences started at the PCK course. Carmen stated "I am doing things with my hands, I like to get conclusions on my own,"

All 21 pre-service teachers were asked the same questions. The four interviewed agreed that the things that affected their self- efficacy beliefs throughout their science education are their level of success during their learning. They are convinced that they can teach science through inquiry, lab experiments and the use of games to make students understand science in a better way. Nevertheless, after the PCK course, all four participants are now convinced that they have the necessary tools to build a science unit that is inquiry-based and they can use labs and games to cater for their students' needs.

Table 4.16
Factors affecting the mastery experiences (science)

Participants	Interviews	Primary coding
Participant 4 Hanadi	a) I used to love science at the elementary level. b) I used to understand scientific experiments c I know now how to use the methods	a) Capability b) achievement. c) achievement.
Participant 5 Jomana	a) They were good experiences were active and interesting b) I taught a lesson, I could see the concept., not only i theory c) I planned the unit, it is inquiry based	a) Capability b) Capability c) Capability
Participant 13 Rawiya	a) I was engage and motivated in science lessons b) The experiences at the PCK course were motivating c) The PCK course instructor gave me all the instructions to build an inquiry base unit, now I have it and I can teach it.	a) Capability b) Capability c) Capability
Participant 14 Carmen	a) Elementary good, secondary no b) even when the teacher is interesting, I am not motivated c) I like to work with my hands but my schooling was rote learning and I did not score well.	a) Capability b) achievement. c) achievement.

In their reflections, Hanadi and Jomana remembered their school experiences and they noted that they would use inquiry- based lesson plans. They would use concrete objects, and would help their students discover living and non-living things using real life objects. As for Rawiya and Carmen, they would boost the students' curiosity through the use of deductive and inductive reasoning that were modeled in their PCK course. Carmen who had a bad experience with memorization at the school level did not agree to start explaining the lesson without giving definitions first and then students would follow these definitions to categorize things between living and non-living things.

While analyzing the three reflections that these participants submitted, there was a progress, specifically in Rawiya and Carmen's reflections. They started writing specific techniques to engage their students. They specified strategies such as "in the last three weeks there were Schumann's inquiry mode, POE method (Predict, observe, and explain), 5Es (Engage, Explore, Explain, Extent, and Evaluate), conceptual change, and (yes, no) questions." Even though they had the lowest PSTE in PCK class, they admitted that the use of these strategies would motivate their students.

4.4.1. b-Vicarious Experiences

Referring to Bandura (1977), vicarious experiences encompass seeing somebody do something whether it was a successful experience or unsuccessful one. Some of the pre-service teachers labeled their experiences at school or during PCK courses as successes or failures.

Vicarious Experiences (Math)

Reema and Nazli, the ones with high PMTE, expressed positive experiences while learning math at the elementary and during PCK course. Reema's mom helped her understand math and Nazli's elementary math teacher and the PCK course teachers helped her like math again, after a bad experience during secondary level. Mary and Amani, the one with low PMTE, had bad experiences at the elementary level and they can still remember the math teacher's screaming all the time. On the other hand, as Amani mentioned, her PCK course teacher is the only one who understands math and can teach it thoroughly,

While reading the experiences that the four participants had as students, it is noticeable that they now can understand math better as a result of the hands-on experiences and the performance of their role model they had, i.e. their math PCK course instructor. They now know "why things work the way they do" and they will be able to explain better for their students (see Table 4.16).

Table 4.17
Factors Contributing to Vicarious Experiences (Math).

Participant	Interviews	Primary Coding
Participant 11 Reema	a) The math teacher was the one who made me enjoy math b) My mother helped me c) I like my PCK course teacher	a) Role model b) Role model c) Role model
Participant 17 Nazli	a) My elementary teacher, the way he taught us it wasn't traditional, b) Elementary teacher helped me like math again. c) The teacher kept telling my mom that I can't concentrate.	a) Role model b) Role model c) Role model
Participant 16 Mary	a) At the elementary level, she used to scream all the time, b) I love math now; I know why I am doing it c) At the university level, she showed us how to get the formula	a) Adult role model b) PCK experiences c) PCK course role model
Participant 21 Amani	a) The blonde elementary used to shout b) the math PCK course teacher is the only one wo knows math. c) I am impressed with what we are doing.	a) Adult role model b) Role model c) Role model

Referring to the three reflections of the four participants, Reema and Nazli enjoyed the use of the pendulum activity for STEM education. They integrated the four subjects to measure time and length. Mary and Amani, liked the way their PCK course teacher used Pascal's triangle and now they can understand conceptually the reason behind mathematics. All four participants agreed that to teach math later on, the experiences that were modeled in their PCK course math encouraged them to plan for their math lessons in the future.

Vicarious Experiences (science)

While reading the science experiences that these participants had, I noticed that pre-service teachers mentioned that they used to memorize science out of fear of the teacher not out of love. During their PCK course, they liked the investigation and the inquiry- based learning as well as the lab sessions that the instructor conducted. They were building knowledge with their instructor/role model and not merely through looking at it. As a matter of fact, the instructor's way of teaching motivated the pre-service teachers. In fact, the pre-service teachers stated that even if they were not going to teach science, they now knew how to explain to the students through inquiry. The effect of the PCK course instructor is obvious in the change in their attitude towards science teaching/learning because now they are interested in the lab sessions and they would avoid giving their students lessons to memorize (see Table 4.17).

Table 4.18

Factors contributing to vicarious experiences (science)

Participant	Interviews	Primary Coding
Partcipant 4 Hanadi*	a) Elementary science teacher, the lesson was interesting we go to the lab, b) We know now what he is talking about. c) We discovered the lesson using inquiry	a) Adult role model b) PCK inquiry c) PCK experiences
Participant 5 Jomana*	a) It was a science teacher almost all of the grades and they were almost all interesting. b) At G5 she was using interactive methods and I liked it . c) Now science is related to our everyday life and not just memorization.	a) Adult role model b) Adult role model c) PCK course
Participant 13 Rawiya*	a) G4 science teacher, she was knowledgeable b) I love it when he gave us many things on board and we would divide categories living and non-living things and we would categorize them c) I like it, now we are working with our hands	a) Adult role model b) PCK teacher as role model c) PCK experiences
Participant 14 Carmen*	a) The teacher was very strict and if we don't know the definition and she used to reduce grades and I used to memorize out of scare and not out of love b) at the secondary level, she used to threaten us and I hated it c) I still hate science even with a good teacher at the PCK course	a) Adult role model b) Adult role model c) PCK course

*Pseudonyms

Referring to the 3 reflections of the four participants (see Table 4.17), I noticed that Carmen had a turning point in her science experience. She would use the strategies that her PCK instructor modeled in the classroom, like cooperative work and class discussion as opposed to the rote learning strategies she used to experience at school. Jomana would explain in details the way the PCK period would progress. As for Rawiya and Carmen, and even if Carmen was not going to teach science, they argued that the modeled strategies in their PCK course led them to change their views towards science

teaching. According to them, they can now relate science experiences to everyday life and would not teach to the test as they used to do at school.

4.4.1. c-Physiological states

Bandura (1977, 1986) stated that the physiological state is an emotional awakening encouraged by a certain situation, such as math or science situations. He added that different individuals have different responses, negative, positive or neutral. In the table below, the reactions of the students varied between the ones they had in Lebanon or outside Lebanon. Also, pre-service teachers felt that they belong to the class, in contrast to their feelings when they were at school (see table 4.18).

Physiological states (Math)

Reema and Nazli's physiological states varied during school years. They had good experiences at school. Reema lacked content knowledge in space geometry but the PCK course encouraged her to teach math. She had a negative incident at the beginning of her course, but she knew that it was a lesson learned and she had to learn to act differently with the students. Nazli was a new student in Lebanon, and even when her friends would criticize her, she would work hard to catch up with them. Mary and Amani expressed a great change in their sense of belonging to math classes. Mary felt "left out" and Amani used to feel that her math abilities were destroyed due to negative teachers' comments. Mary's teacher would not help her understand math and Amani's teacher used to shout at her instead of helping her. Both of them agreed that they liked math now with the use of the manipulatives such as skittles and geoboards (see Table 4.18).

Table 4.19
Factors contributing to physiological states (math)

Participant	Interviews	Primary Coding
Participant 11 Reema*	a) They used to mess up the information about space and geometry and b) I love teaching math and I know it is a lesson learned c) In the PCK course I was encouraged to teach math	a) Fear of failure b) Teacher success c) Teacher success
Participant 17 Nazli*	a) My math experiences lack test anxiety, b) good math experiences, they would help you improve c) in Lebanon, they used to criticize me and I was new and I worked hard	a) Teacher success b) Teacher success c) Sense of belonging.
Participant 16 Mary*	a) I didn't understand and the teacher would not help me. I was left out b) the skittles and the manipulatives, they make me understand math c) I lost hope and I could not do better	a) Sense of belonging. b) Teacher success c) Pre-service fear of failure
Participant 21 Amani*	a) The teacher used to scream and say: "how could you not understand this?" It destroyed my abilities b) when I taught math and students understood, now I feel happy c) When I used the geoboard to explain math, I feel I achieved something	a) Sense of belonging. b) Teacher success c) Teacher success

*pseudonyms

Referring to the reflections of the four participants, their reflections progressed throughout the semester in a positive way. Reema and Nazli, who had good math experiences were eager to learn math and they had positive feelings towards learning/teaching math. Mary and Amani, who had negative feeling towards math started changing their feelings towards the subject. While Mary mentioned the importance of the positive presence of the PCK course instructor, Amani discussed the high level of motivation that she had through the use of hands-on experiences. They all agreed that they had positive feelings now towards math, even if they were not to teach it.

Physiological states (science)

The participants who had the highest/lowest PSTE mean scores were not the same. This is why I am dividing the tables into math and science subjects. Also, the participants' experiences varied according to the subject and were influenced by their physiological state. If one is faced with a situation that would arouse fear in him/her, s/he would avoid this situation. Math anxiety and math-phobia are well-determined terms in math learning.

Also, in science subjects, there are students who hate science and are not interested. They try to avoid situations where they have to learn or teach it. Hanadi and Jomana had positive feelings towards science during their elementary as well as during their PCK course. Both of them had positive feedback in different forms. This boosted their confidence to teach science. While Rawiya's feelings towards science changed and she was willing to work hard to teach the subject, Carmen's feelings remained the same. Carmen's PCK instructor made her hate science as usual and this might be due to the fact that "he reduced grades because of plagiarism." Rawiya and Carmen were pushed by their PCK course teacher to work harder, but their reactions were different. Rawiya agreed to do her best while Carmen chose to step out of teaching science. Three out of four participants claimed that if they were taught the same way as in the PCK course, they would have liked the material. They were willing to teach science in an active way, to encourage their students, and to use the experiments they learned in PCK course to explain science in an interesting way to motivate their students (see Table 4.19).

Table 4.20

Factors contributing to physiological states (science)

Participant	Interviews	Primary Coding
Partcicipant 4 Hanadi*	a) Certificate of good accomplishment b) We would work together c) I like learning through experiences	a) Teacher success b) Peer support c) Peer support
Participant 5 Jomana*	a) In PCK course, I got a positive feedback b) The PCK instructor comments made me feel confident c) If we were taught that way I would have liked science more and more	a) Teacher success to motivate them. b) Teacher success c) Teacher success
Participant 13 Rawiya*	a) The experiences were a push for me b) We are applying inquiry in our teaching c) I had a positive feedback,	a) Teacher success b) Teacher success c) Teacher success
Participant 14 Carmen*	a) The instructor made me hate science more, b) He gave me a lot of feedback c) I hate it.	a) fear of failure b) fear of failure c) fear of failure

*Pseudonyms

Pre-service teachers in this study had positive as well as negative role models in math and science courses. At some point, the positive experiences they had, specifically in both math and science courses, led them to have a positive attitude towards teaching these subjects later on. They would use the same procedures and activities (example: geoboards, games). Students who experienced negative instances in their learning, such as one student whose science teacher used to ask her “how come you did not get it?” led her to flee science teaching and she hated science throughout her education. Also, she would not teach science, even after she was introduced to interesting ways in teaching the subject during PCK course. Two out of four participants had a lot of feedback during

PCK course. One of them decided to work harder whereas the other one considered it as a challenging situation that she would avoid for the rest of her life. The same experiences during science PCK course stimulated pre-service teachers to like the subject and to look back at their past experiences and to understand the new ways to help them teach in the future. Others looked with resentment at their past experiences and knew now that they didn't learn the subject because their teachers were not catering for their needs properly.

Referring to the reflections, I noticed that Hanadi would start hers by saying "no other class is like the PCK science class." She mentioned that she was "bad" in science, then at the PCK course, her instructor encouraged her and from that moment she "felt proud, engaged, and interested in science." During her third reflection, she mentioned that "there is a certain ambiance in the class of mutual respect and a drive for innovation." She would use the same techniques and would enjoy teaching science. Jomana's state of mind progressed from "I don't see myself as a good science teacher" in her first reflection to "I got positive feedback during the course that boosted my self-confidence and made me feel confident to teach science." The progress in her situation led her to think about herself as a science teacher capable of using the same techniques that the PCK course instructor used.

Rawiya and Carmen's progress can be depicted throughout their reflections. Their first reflections started with hating the subject, and progressed to "it was a safe environment", "I can ask questions." Carmen still hates science, but if she were to teach science, she would provide her students with "positive feedback, just like my PCK course teacher."

4.4.1. d-Social persuasion:

Bandura (1977, 1986) theorized that social persuasion affects the self- efficacy beliefs of a person and stimulates the performance of a task. Positive social persuasion increases self-efficacy and negative social persuasion lowers it. Although it is an important factor, mastery experiences affect self-efficacy in a stronger way as they stem from authentic experiences (Setra, 2017).

Social persuasion (MATH)

Reema and Nazli's math teachers used to encourage them. They used to like math and they were encouraged to solve math problems. Whereas Mary and Amani's teachers used to make them feel ashamed that they did not understand math and they would feel embarrassed to ask questions. Nevertheless, the PCK course instructor helped them accept and understand math. Now, Amani thinks that if she teaches math, then "it will not be a bad experience".All four participants are now convinced that they can teach math as a result of the positive feedback.

Table 4.21
Factors contributing to social persuasion (math)

Participant	Interviews	Primary Coding
Participant 11	a) I liked PCK math course b) my mentor helped me develop the lesson plan	a) Instructor feedback b) Individual feedback
Reema*	a) Verbal encouragement.	a) Teacher's feedback
Participant 17Nazli*	b) the PCK instructor gave me positive feedback a) I hated math because the teacher used to scream and give us negative feedback	b) instructor's feedback a) Teacher's feedback b) Instructor's feedback
Participant 16 Mary*	b) I started to like it because I had a lot of positive feedback	a) Teacher's feedback b) Instructor's feedback
Participant 21 Amani*	a) I hate elementary math because the teacher would shout b) Now, the PCK instructor helped me understand math	

Referring to the reflections that the pre-service teachers provided. Reema and Nazli used to like math and they were convinced to use the same techniques their math PCK course instructor used to encourage them work harder. As for Mary, she mentioned that she used to hate math during her first reflection but throughout her second and third reflections, she stated that she was comfortable in her math PCK course due to her instructor's positive feedback. Amani was engaged in her PCK classes but still couldn't perceive herself as a good math teacher. In her second reflection she mentioned that her hate towards math was because it used to be "an abstract subject that I can't relate to." Later, she expressed her willingness "I will do my best to teach students, and I think that STEAM is a good approach to teach, where many subjects were related." She changed greatly during her reflections from complete hatred of the subject to analyzing the strategies and manipulatives through which she can cater for the needs of her students due to her teachers and peers' positive feedback.

Social persuasion (Science).

Hanadi and Jomana expressed their confidence in teaching a science unit. Jomana mentioned that she did her first unit plan and she did not think that she could do it. Their science PCK instructor would give them feedback to enhance their unit plans and they would work accordingly. Three out of four participants are now convinced that they can plan a science unit and can teach it. Only Carmen, who used to dislike science throughout her education years, did not like labs and did not like to be challenged while learning science.

Table 4.22
Factors contributing to social persuasion (science)

Participant	Interviews	Primary Coding
Partcicipant 4 Hanadi*	a) I don't like science b) During the PCK course, the teacher would comment and would tell me what my mistakes are	a) Individual feedback b) Instructor feedback
Participant 5 Jomana*	a) The elementary teacher would give me a lot of positive feedback b My PCK course instructor encouraged me.	a) Teacher's feedback b) Individual feedback
Participant 13 Rawiya*	a) The teacher used to give me positive encouragement, b) The PCK teacher gave me a positive feedback	a) Teacher's feedback b) Teacher's feedback
Participant 14 Carmen*	a) The teacher would threaten us and I hated it b) Very boring and even at the lab I did not feel entertained	a) Teacher's feedback b) Individual feedback

*Pseudonyms

Referring to Jomana and Hanadi's reflections, they used to look at science as just rote learning, but due to the positive impact of the PCK course teachers, they were able to avoid misconceptions that were built through rote learning. Even though the last two participants, Rawiya and Carmen, used to have negative feelings towards science, they mentioned that the PCK course teacher "offers support to all teachers, he answers the questions in a timely manner." They stated that the positive feedback that they got "boosted their self-confidence." Thus, there was a difference in their self-efficacy levels during their reflections.

The findings derived from the interviews suggest a change in pre-service self-efficacy beliefs. Three out of four participants changed their attitudes towards math and science experiences as a result of the PCK course experiences. Previous research

findings are in alignment with the findings in this study (Bursal, 2010; Ekhoff, 2017; Prentiss Bennett, 2016; Setra, 2017).

In conclusion, the above chapter showed the quantitative and qualitative results of the study. The quantitative part included all participants whereas the qualitative one referred only to four participants in STEM fields. The next chapter presents the discussion of the results.

Chapter Five

Discussion

This chapter includes the discussion of results by comparing the findings of this study to the ones in chapter two.

5.1- Overview:

The study was designed to examine the changes that occur to pre-service teachers' self-efficacy beliefs in teaching STEM fields at the elementary level before and after the PCK courses. A mixed method approach, MTEBI and STEBI instruments were used to measure changes in the self-efficacy beliefs of pre-service teachers at a private university in Beirut.

In my experience as a mathematics teacher, a trainer, and as a STEM graduate student, I was introduced to many teachers who were working with different sets of beliefs about their mathematics and science abilities to teach both subjects. Some believed that they can teach math and science effectively and others doubted their abilities to teach those subjects.

The results of the questionnaires, the reflections, and the interviews indicated that the answers of the participants differed from the pre to the post phases. Participants had a positive gain in their self-efficacy beliefs. They understood science and math concepts through role playing, simulations and lab work. Pre-service teachers selected resources for elementary science and math teaching through discussions. They progressed in their approaches to teaching math and science and began to develop as reflective science and math teachers through reflections. Participants understood the ideas of inquiry based

learning, problem solving and critical thinking through lab activities and hands-on experiences. They viewed their instructors as facilitators of learning. This is in agreement with the literature when Menon (2015) argued that as a result of a science methods course, pre-service teachers had positive shifts in their self- confidence to teach the subject. The use of active learning experiences and teaching models had positive impact on pre-service teachers (Menon, 2015).

Even though the personal self-efficacy beliefs in science (PSTE) were not affected in a positive way, some pre-service teachers changed their responses from "Uncertain" to "Agree" on the PSTE subscale in the STEBI instrument (see Table 4.3). This is in agreement with the literature where Eckhoff (2017) argued that there is a need to provide pre-service teachers at the university with rigorous information and a supportive environment to develop inquiry-based and integrated STEM experiences. Also, Prentiss Bennett (2016) concluded that pre-service teachers need more support to increase their beliefs that they can teach STEM fields effectively. The results of the pre-service teachers according to the branches of grade 12 showed that there was an increase in the means of the PSTE of the science and the economics and social branches, whereas the humanities branch showed no positive change in the pre-service personal self-efficacy beliefs (see Table 4.7). This is in agreement with Bursal's (2010) findings, where Turkish pre-service teachers with mathematics/ science high school majors had higher PSTE scores than the ones with other majors.

Moreover, PMTE subscale indicates that the teachers' self- efficacy beliefs improved after the PCK course (see Table 4.9). Many pre-service teachers changed their answers from "Uncertain" to "Agree" or "Strongly Agree", specifically on the items

about teaching mathematics effectively and understanding math concepts (see Table 4.11). This is in agreement with the literature when Setra (2017) argued that the pre-service teachers' math efficacy beliefs increase as a consequence of a math methods course. As for the PMTE results according to the branches, the humanities and science branches showed an improvement in the pre-service teachers' PMTE mean scores (see Tables 4.15), whereas there was a decrease in the PMTE of the economics and social branch (see Table 4.15). This is in contrast with Bursal's (2010) findings that teachers with math and science background had higher positive changes in their PMTE than their colleagues with other majors.

Concerning the participants' MTOE, results indicated that their beliefs that they can teach math effectively were influences positively by the PCK course (see Table 4.16). This is reflected in the literature where Mongillo (2016) argued that there is a positive correlation between levels of self-efficacy beliefs and the ability to solve and do math. Looking at the branches of grade 12, the teaching beliefs (MTOE) of the science and the economics and social branches were affected positively by the PCK course, whereas the humanities branch's mean decreased after the PCK course (see Table 4.16). This can be depicted in the literature where Bursal (2010) argued that the math efficacy beliefs of the teachers with math high school background were influenced more by the teacher preparation program than the ones with other high school backgrounds.

Also, the STOE of the pre-service teachers were influenced positively by the PCK course. This is in agreement with Wu and Albion's (2019) and Nadelson et al. (2013) arguments in the literature. They stated that pre-service teachers were more confident in teaching STEM fields as a result of scaffolding and hands-on learning. Also,

Tessier (2010) argued that as a result of using inquiry-based laboratories in teacher education programs, pre-service teachers will have more confidence to use them later with their students. In the same line of thought, Shahzad (2017) argued that positive teachers' self-efficacy beliefs impact students' achievement. All branches had a positive mean change in their self-efficacy beliefs as a result of enrolling in the PCK courses.

The third question in this study was How did the course contribute to changes in self-efficacy beliefs of pre-service science and math (STEM fields) elementary teachers? Once the levels of the participants' self-efficacy beliefs were determined, the qualitative part described the changes that occur to their beliefs as a result of enrolling in the PCK courses. During the interviews and in their reflections, three major components were studied: Their past experiences, their abilities to teach effectively to help students understand, and their beliefs that they can succeed in teaching math and science. Pre-service teachers described their science experience at the PCK courses as an "eye opening" experience. Most of the participants, specifically the four chosen ones, used to memorize science and hated rote learning. They have now the abilities to build an inquiry-based unit plan to motivate and interest their students. They used to memorize science out of fear not out of love, but since they like working with their hands, they can categorize living and non-living things, and they can design science experiences related to everyday life. Even the one with the lowest score mentioned that "I got a lot of feedback and now I have to work harder." These findings are consistent with the work of Nadelson et al. (2013), Wu and Albion (2019), and Prentiss Bennett (2016) who argued that for pre-service teachers to feel confident about their abilities to teach STEM, they

need to acquire necessary content knowledge and experiences of STEM during teacher preparation courses.

For the math PCK course, two out of four participants had previous bad math experiences that hindered their abilities. Nevertheless, they now believe that they can empathize with hyper active students and can engage unmotivated ones. The two participants with the lowest PMTE scores loved math and they described their PCK instructor as “the only one who knows math, because she explains the “whys”.” Even though they did not understand math at the school level, the PCK course changed their beliefs and they were impressed with their own performance because they achieved something when they explained math for the first time. This is in alignment with Briley’s (2015) argument that there is a significant relationship between math beliefs and teaching efficacy beliefs. Participants now think that they can help their students understand math conceptually instead of procedurally. This argument aligns with the literature where Setra (2017) argued that the participants’ experiences during their preparation courses boosted their self-confidence about teaching math conceptually in their future classrooms. All four pre-service teachers mentioned that they believe now that they can teach math through the use of hands-on experiences and manipulatives. These strategies were modeled in the PCK class to motivate students and to increase their confidence levels as future math teachers. These findings are in alignment with Setra’s (2017) and Mongillo’s (2016) findings. They argued that the use of hands-on materials influenced positively pre-service self-efficacy beliefs and improved their mathematical content knowledge.

5.2- Discussion and conclusion

Bandura (1986) theorized that past experiences affect a person's efficacy beliefs. These past experiences in math and science courses influenced the participants' view to these subjects. Past experiences influenced the way they feel towards these STEM fields, but they changed their views after the PCK courses. Pre-service teachers with different past experiences in both STEM fields are willing to teach like their PCK instructors.

The findings of the study suggest that the PCK course had positive influence on pre-service teachers in math more than in science. Their PMTE, MTOE and STOE increased. These findings are in alignment with previous research findings (Bursal, 2010; Eckhoff, 2017; Prentiss Bennett, 2016; Setra, 2017).

Through the interviews and the reflections, the reason for a lower STOE after PCK science course was explained. At the beginning of the course pre-service personal level beliefs were higher than at the end due to a plagiarism incident that served as a learning experience. Nevertheless, pre-service teachers liked the course and are willing to teach science based on their PCK experiences in class.

Moreover, participants who used to hate math understood reasons for their actions. In contradiction to their math teachers' opinions, they were not wasting time. They were visual or kinesthetic learners. This was a turning point in their personal beliefs towards math. The same applies for science. Participants who hated science due to rote learning were willing to help their students understand it via the use of laboratories and experimentation. Wu and Albion (2019) argued that it is important to

expose pre-service teachers to a variety of experiences during their preparatory courses with an intent to maximize their ability to teach STEM in their future classes.

Referring to instructional strategies, participants felt the need to use “real life experiences” and “hands-on” experiences in both STEM fields. For instance, they would explain areas through Pick’s formula and living and non-living things through induction reasoning. This is in alignment with STEM approach, the National Council of Teachers of Mathematics (NCTM) and the National Generation Science Standards (NGSS). They emphasize that students construct their learning through experimentation and the use of real life situations.

The four participants argued that their learning experiences in STEM fields were based on “rote learning” and “study to the grade.” Their learning experiences were subject to passing from one grade to the other with all the misconceptions that they did not know existed until they were discovered through PCK course strategies. In alignment with Setra’s (2017) findings, pre-service teachers changed their attitude towards STEM fields. They experienced a “safe environment” where their self-confidence increased. Even for the participants who felt unease due to a lack of content knowledge in their past learning experience, they felt that they now have the needed strategies and can work on the content to teach effectively (Menon, 2015).

Research indicated that teaching conceptually increases pre-service teachers’ efficacy beliefs (Menon, 2015). Teaching STEM fields conceptually is one of the PCK courses’ objectives. In this study, participants feel confident that they can explain STEM fields conceptually and show their students the reason behind a math formula. Also, they would use strategies modeled in science PCK classes, such as the 5E (Engage, Explore,

Explain, Extent, and Evaluate) model, to allow their students time to inquire about a scientific issue and to use research-based pedagogies (see Appendices M and N).

Research indicated the importance of students' engagement while learning a subject (Menon, 2015; Setra, 2017). Pre-service teachers in this study stated their interest in math while at the school level they hated it. Going to the science laboratory and working with their hands involved and engaged them (see Table 4.21). They are more confident that they can explain STEM fields based on their PCK experiences.

Bandura (1977) theorized that mastery experience is a major indicator of self-efficacy increase. An individual would be involved in successful situations and would flee failing ones. In this study, pre-service teachers expressed their confidence in teaching the unit plans they prepared in the course (see Table 4.18). After they explained their unit plans, they felt happy and confident that they can do it again.

5.3- Implications of the study

Research indicated that past experiences influence teachers' beliefs (Bursal, 2010; Menon, 2015; Setra 2017). The strategies used in the PCK courses increased their beliefs that they can teach math and science even when they had bad past experiences at the school level. This is in alignment with Menon's (2015) findings that the pedagogy-rich experiences during teaching preparation methods help teachers see themselves as effective instructors. Also, the modeled experiences help teachers envision themselves teach their students according to how they were taught at the PCK courses (Menon, 2015; Setra 2017).

Research indicated that math efficacy beliefs is one of the important elements in teachers' preparation courses. It helps teachers believe that they can teach STEM fields effectively (Eckhoff, 2017; Bursal 2012). Eckhoff (2017) deduced that it is important to use multimodal experiences and inquiry-based teaching to enhance students' learning experiences. Pre-service teachers need to engage students to construct their own learning in order to build their own products (Mackrell & Pratt, 2017). Constructionism emphasized the importance of emotions to engage students in an activity where their emotions, feelings and actions are open to study and critique (Mackrell & Pratt, 2017).

Even though the PCK courses were not designed to affect the pre-service teachers' efficacy beliefs, they explained that the experiences they had while explaining their lessons for the first time in class changed their beliefs as future teachers. They saw themselves as effective teachers who can teach conceptually. Moreover, the positive feedback given by their PCK course teachers affected their teaching beliefs as math efficacy beliefs increased while science efficacy beliefs decreased. This was due to negative feedback given by the science PCK faculty member.

Prentiss Bennett (2016) emphasized the importance of professional development. Although pre-service teachers showed an increase in their identity as math and science teachers, it is questionable whether this will continue throughout their career.

5.4- Limitations of the study

There are a few limitations to this study. The first one is that the researcher was the only one who gathered the quantitative and qualitative data. Through this process, I

tried my best to understand the participants' answers through their own points of view and to keep my interference at the minimum level.

The second limitation was the sample. In this study, the sample was a convenient sample of elementary pre-service teachers form one private university in Beirut. The findings of the study cannot be generalized to larger population as they were initially 21 participants and during the qualitative part they were only four participants. Also, the pre-service teachers were all females, thus limiting the generalizability of the findings to larger populations.

The third limitation was the variety in the location and the participants. Due to a lack in ethnicity, gender and setting variety, the findings of this study cannot be generalized to other populations that have different gender, ethnicity or settings. The findings cannot be generalized to other populations that cannot be compared to the one chosen from one private university in Beirut.

5.5- Future study

Referring to the findings of this investigation, it is still unknown whether the changes that happened during this semester will continue with the teachers as they go to the field work.

Even though the self-efficacy beliefs for pre-service teachers were studied since Bandura theorized the notion more than four decades ago. There is still a need to study in-depth, in private and public universities, and in different cities in Lebanon other than Beirut, the changes in pre-service efficacy beliefs.

Future research should take into consideration a greater number of participants with different genders and educational backgrounds to better understand self-efficacy beliefs of pre-service teacher as a major element in teacher preparation programs. Another research could be conducted on whether the positive changes in teachers' efficacy beliefs continue throughout their teaching career, specifically with the growing interest in teachers' burnout (El Helou, Nabhani & Bahous, 2016; Yazdi, 2014).

Future research on pre-service efficacy beliefs in STEM education would be a pioneer study, especially that STEM education is still in its infancy stages in Lebanon. Future research connected to students' achievement in STEM would be valuable as teachers' self-efficacy is related to students' achievement (Prentiss Bennet, 2016).

5.6- Concluding remarks

Pre-service teachers' beliefs concerning their abilities to teach STEM fields effectively are corner stones for teaching STEM (Prentiss Bennett, 2016). They need to have a strong foundation in these fields through solid instructions and experimentations during university preparatory courses. Therefore, a well-prepared instructional course might help pre-service teachers influence their students' achievement better later on (Wu & Albion, 2019)

The findings of this study might help curriculum designers in Lebanon consider STEM education while studying its benefits in constructing students' knowledge. It is vital for Lebanon to start preparing teachers and students with needed 21st century skills to compete in a quick economical changing universe. If pre-service teachers acquire

content knowledge to build their confidence in teaching STEM fields, then they will be essential changing factors of the economy on the long run (Dierking & Fox, 2013).

A study like this one is only the start of the research needed to revisit the effects of PCK courses on teaching practices of teachers in STEM fields once they are in their classrooms. It is a challenging endeavor, especially that STEM education is limited in Lebanon and the curriculum dates back to 1997. Prentiss Bennett (2016) voiced that a fragmented curriculum influences negatively pre-service teachers' efficacy beliefs to implement STEM. Teachers' preparation courses in elite universities in Lebanon encompass some elements of STEM approach but lack the adoption of a specific framework to follow while preparing pre-service teachers.

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Appendices

Appendix A

Student Information

The information you are giving is used for research purpose only. Your identity will remain anonymous throughout the procedure. Check or circle the correct answer as needed.

Personal Background:

Number: …….

Demographic Information:

Gender: ……. Male

…… Female

Age: ……. Years

Major: …….. Minor: ……..

Educational Background/ Self:

Type of school you were enrolled at: private public semi-private

High school branch

The branch you graduated at: General science science economics and sociology

Humanities

Reasons for choosing this branch:
……

School setting: urban rural suburban other:

Most prevalent type of learning experience in math classes:

1. Delivery of instruction:

Structured	Unstructured
Lecture	student identified project
Teacher demonstration	discovery learning center

Rote memorization	reflective thinking / learn
Questions with one answer	open-ended question
Assigned seatwork	cooperative groups
Timed tests	portfolios

2. Materials used

Structured	Unstructured
Paper and pencil	paper and pencil
Practice worksheets	practice worksheets
Calculator	Calculator
Manipulatives	Manipulatives

Educational Background/ family:

Mother educational level	Father educational level:
Some high school, no diploma	Some high school, no diploma
High school diploma	High school diploma
Some college	Some college
Bachelor's degree	Bachelor's degree

State an example of a positive and a negative math experience that you had, determine the reasons that made it so:

Positive experience negative experience

State an example of a positive and a negative science experience that you had, determine the reasons that made it so:

Positive experience negative experience

Institutional Review Board
Lebanese American University
31 AUG 2018
APPROVED

Appendix B

Number: -------

Mathematics Teaching Efficacy Beliefs Instrument (MTEBI)

(Used with permission from Dr. Huinker D.M.)

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA	A	UN	D	SD
Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

Item #	Items	SA A UN D SD
1	When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.	SA A UN D SD
2	I will continually find better ways to teach mathematics.	SA A UN D SD
3 *	Even if I try very hard, I will not teach mathematics as well as I will most subjects.	SA A UN D SD
4	When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SA A UN D SD
5	I know how to teach mathematics concepts effectively.	SA A UN D SD
6 *	I will not be very effective in monitoring mathematics activities.	SA A UN D SD
7.	If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.	SA A UN D SD
8. *	I will generally teach mathematics ineffectively	SA A UN D SD
9.	The inadequacy of a student's mathematics background can be overcome by good teaching.	SA A UN D SD
10	When a low-achieving child progresses in mathematics it is usually due to extra attention given by the teacher.	SA A UN D SD

11	I understand mathematics concepts well enough to be effective in teaching elementary mathematics.	SA A UN D SD
12.	The teacher is generally responsible for the achievement of students in mathematics.	SA A UN D SD
13	Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.	SA A UN D SD
14.	If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.	SA A UN D SD
15*	I will find it difficult to use manipulatives to explain to students why mathematics works.	SA A UN D SD
16	I will typically be able to answer students' mathematics questions.	SA A UN D SD
17 *	I wonder if I will have the necessary skills to teach mathematics.	SA A UN D SD
18.*	Given a choice, I will not invite the principal to evaluate my mathematics teaching.	SA A UN D SD
19. *	When a student has difficulty understanding a mathematics concept, I will usually be at a loss as to how to help the student understand it better.	SA A UN D SD
20.	When teaching mathematics, I will usually welcome student questions.	SA A UN D SD
21.*	I do not know what to do to make the students appreciate mathematics.	SA A UN D SD

APPENDIX C

Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) Scoring Instructions Step 1. Item Scoring: Items must be scored as follows: Strongly Agree = 5; Agree = 4; Uncertain = 3; Disagree = 2; and Strongly Disagree = 1.
Step 2. The following items must be reversed scored in order to produce consistent values between positively and negatively worded items. Reversing these items will produce high scores for those high and low scores for those low in efficacy and outcome expectancy beliefs.

Item 3 Item 17
Item 6 Item 18
Item 8 Item 19
Item 15 Item 21

In SPSSx, this reverse scoring can be accomplished by using the recode command. For example, recode ITEM3 with the following command:

RECODE ITEM3 (5=1) (4=2) (2=4) (1=5)

Step 3. Items for the two scales are scattered randomly throughout the MTEBI. The items designed to measure Personal Mathematics Teaching Efficacy Belief (SE) are as follows:

Item 2 Item 11 Item 18
Item 3 Item 15 Item 19
Item 5 Item 16 Item 20
Item 6 Item 17 Item 21
Item 8

Items designed to measure Outcome Expectancy (OE) are as follows:

Item 1 Item 9 Item 13
Item 4 Item 10 Item 14
Item 7 Item 12

<u>Outcome expectancy</u>

---

1. When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort. SA A UN D SD

4. When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach. SA A UN D SD

7. If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching. SA A UN D SD

9. The inadequacy of a student's mathematics background can be overcome by good teaching. SA A UN D SD

10. when a low-achieving child progresses in mathematics it is usually due to extra attention given by the teacher. SA A UN D SD

12. The teacher is generally responsible for the achievement of students in mathematics. SA A UN D SD

13. Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching. SA A UN D SD

14. If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher. SA A UN D SD

Appendix D

Number: ----------

STEBI-B FINAL INSTRUMENT

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

Dr Riggs stated that there is no need for her consent

SA	A	UN	D	SD
Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

Item #	Item	SA A UN D SD
1	When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	SA A UN D SD
2	I will continually find better ways to teach science.	SA A UN D SD
3	Even if I try very hard, I will not teach science as well as I will most subjects.	SA A UN D SD
4	When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SA A UN D SD
5	I know the steps necessary to teach science concepts effectively.	SA A UN D SD
6	I will not be very effective in monitoring science experiments.	SA A UN D SD
7	If students are underachieving in science, it is most likely due to ineffective science teaching.	SA A UN D SD
8	I will generally teach science ineffectively.	SA A UN D SD
9	The inadequacy of a student's science background can be overcome by good teaching	SA A UN D SD
10	The low science achievement of students cannot generally be blamed on their teachers.	SA A UN D SD
11.	When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	SA A UN D SD
12.	I understand science concepts well enough to be effective in teaching elementary science.	SA A UN D SD

13	. Increased effort in science teaching produces little change in some students' science achievement.	SA A UN D SD
14.	The teacher is generally responsible for the achievement of students in science.	SA A UN D SD
15.	Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	SA A UN D SD
16.	If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	SA A UN D SD
17	I will find it difficult to explain why science experiments work.	SA A UN D SD
18	I will typically be able to answer students' science questions.	SA A UN D SD
19	I wonder if I will have the necessary skills to teach science.	SA A UN D SD
20.	Given a choice, I will not invite the principal to evaluate my science teaching.	SA A UN D SD
21.	When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand it better.	SA A UN D SD
22.	When teaching science, I will usually welcome student questions.	SA A UN D SD
23.	I do not know what to do to make the students appreciate science.	SA A UN D SD

APPENDIX E

Science Teaching Efficacy Beliefs Instrument (STEBI) Scoring Instructions Step 1. Item Scoring: Items must be scored as follows: Strongly Agree = 5; Agree = 4; Uncertain = 3; Disagree = 2; and Strongly Disagree = 1.
Step 2. The following items must be reversed scored in order to produce consistent values between positively and negatively worded items. Reversing these items will produce high scores for those high and low scores for those low in efficacy and outcome expectancy beliefs.

Item 3	Item 17
Item 6	Item 19
Item 8	Item 20
Item 10	Item 21
Item 13	Item 23

In SPSSx, this reverse scoring can be accomplished by using the recode command. For example, recode ITEM3 with the following command:

```
RECODE ITEM3 (5=1) (4=2) (2=4) (1=5)
```

Step 3. Items for the two scales are scattered randomly throughout the STEBI. The items designed to measure Personal Science Teaching Efficacy Belief (SE) are as follows:

Item 2	Item 12	Item 21
Item 3	Item 17	Item 22
Item 5	Item 18	Item 23
Item 6	Item 19	
Item 8	Item 20	

Items designed to measure Outcome Expectancy (OE) are as follows:

Item 1	Item 10	Item 15
Item 4	Item 11	Item 16
Item 7	Item 13	

Item 9 Item 14

Outcome expectancy

1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	SA A UN D SD
4. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SA A UN D SD
7. If students are underachieving in sciecne, it is most likely due to ineffective science teaching.	SA A UN D SD
9. The inadequacy of a student's science background can be overcome by good teaching.	SA A UN D SD
10. The low science achievement of students cannot generally be blamed on their teachers.	SA A UN D SD
11. When a low-achieving child progresses in science, it is usually die to extra attention given by the teacher.	SA A UN D SD
13. Increased effort in science teaching produces little change in some students'' science achievement.	SA A UN D SD
14. The teacher is generally responsible for the achievement of students in science.	SA A UN D SD
15. students' achievement in science is directly related to their teachers' effectiveness in science teaching .	SA A UN D SD
16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	

Appendix F

Reflection: PCK course: Math

Open ended questions:

1. Think about the concepts that were discussed in the past three weeks. How would you characterize your state of mind through the math sessions? Were they more positive or negative feelings? Why?

2. Did your teacher or peer give you positive feedback in your math class? How did you feel about it?

3. Identify some of the concepts that were discussed in the classroom, and if given opportunity, how would you teach them in your classroom? If you were to teach them in the future in an elementary classroom, what would you do the same or differently?

4. Identify some of the teaching strategies that were modeled in your math class to teach a certain topic. Given the opportunity, what specific strategy would you use? Why?

Appendix G

Reflection: PCK course (science)

Open ended questions:

1. Think about the concepts that were discussed in the past three weeks. How would you characterize your state of mind through the science sessions? Were they more positive or negative feelings? Why?

2. Did your teacher or peer give you positive feedback in your science class? How did you feel about it?

3. Identify some of the concepts that were discussed in the classroom, and if given opportunity, how would you teach them in your classroom? If you were to teach them in the future in an elementary classroom, what would you do the same or differently?

4. Identify some of the teaching strategies that were modeled in your science class to teach a certain topic. Given the opportunity, what specific strategy would you use? Why?

Appendix H

INTERVIEW PROTOCOL

You are asked to participate in this interview in order to help me understand how you feel about mathematics and mathematics teaching and learning in general.

1. Could you please remember your math experiences (the four operations) at the elementary level, were they good or bad experiences, and how did you feel about them?

2. Do you remember specifically the classroom teacher who was involved in the experience? Give me examples

3. From you own point of view, what are the main reasons that made you feel that way about the experience? Give me examples

4. Did that teacher give you verbal encouragement as feedback? Give me examples

5. Do you recall a peer or a teacher (former or present) whom you consider a role model in your math experiences to this day? Give me examples

6. What are your feelings towards math? Towards specific areas within math? Give me examples

7. Do you recall a positive experience in math as a student or as a student-teacher? Example, teaching a lesson? Give me examples

8. Could you share the experience and describe what part influenced your mathematics teaching capability positively? Was it a classroom experience or a field experience?

9. Did you plan the idea of the lesson by yourself or someone modeled it for you? (Peer or teacher)? Give me examples

10. Did you get any positive feedback about the lesson that made you feel good? Did that indicate that it was a positive teaching experience for you?

11. How do you think those experiences add to your overall feeling about math and about math teaching in particular? Give me examples

12. Is there any particular experiences in the PCK course that made your feelings about past experiences better? Give me examples

Institutional Review Board
Lebanese American University
31 AUG 2018
APPROVED

Appendix I

INTERVIEW PROTOCOL

You are asked to participate in this interview in order to help me understand how you feel about science and science teaching and learning in general.

1. Could you please remember your science experiences at the elementary level, were they good or bad experiences, and how did you feel about them?

2. Do you remember the individual who was involved in the experience?

3. From you own point of view, what are the main motives that made the experience so? Give me examples

4. Did that individual give you verbal encouragement as feedback? Give me examples

5. Do you recall a person who you consider as a role model among peers or teachers in you science experience? Give me examples

6. What are your feelings towards science? Towards specific areas in science? Give me examples

7. Do you recall a positive experience in science as a student or as a student-teacher? Example, teaching a lesson? Give me examples

8. Could you share the experience and describe what part influenced your science teaching capability positively? Was it a classroom experience or a field experience?

9. Did you plan the idea of the lesson by yourself or someone modeled it for you? (Peer or teacher)? Give me examples

10. Did you get any positive feedback about the lesson that made you feel good? Did that indicate that it was a positive teaching experience for you?

11. How do you think those experiences add to your overall feeling about science and about science teaching in particular? Give me examples

12. Is there any particular experiences in the PCK course that made your feelings about past experiences better? Give me examples

Institutional Review Board
Lebanese American University
31 AUG 2018
APPROVED

Appendix J

Approval to use MTEBI

Re: Use of MTEBI instrument

DH

DeAnn M Huinker <huinker@uwm.edu>
Mon 7/9, 3:35 PM
Hanan Shehab

Inbox

> You forwarded this message on 7/9/2018 6:54 PM

Hanan,

Yes you have my permission to use the MTEBI.

Best to you in your research and professional endeavors.
DeAnn Huinker

> On Jul 9, 2018, at 5:50 AM, Hanan Shehab <hanan.shehab@lau.edu> wrote:
>
> Dear Dr. huinker
> Hope my email finds you well.
> I am working under the supervision of Dr. Mona Majdalani on a research paper concerning pre-service teachers' self-efficacy.
> I am wondering if it might be possible for me to use the MTEBI revised that was used in your article :
> Establishing factorial validity of the mathematics teaching efficacy beliefs instrument(2000)
> Regards

Dr. DeAnn Huinker, Mathematics Education
Professor, Department of Curriculum and Instruction
Director, Center for Mathematics and Science Education Research (CMSER)
Board of Directors, National Council of Teachers of Mathematics (NCTM)
Principal Investigator, *Strong Start Math* and *Transforming Fraction Teaching and Learning*
University of Wisconsin-Milwaukee

Appendix K

Consent to use STEBI

From: Iris Riggs <IRiggs@csusb.edu>
Sent: Wednesday, May 23, 2018 5:01 AM
To: Hanan Shehab
Subject: Re: use of instruments for self- efficacy

Hello Hanan,

You are welcome to use the STEBI. It is public domain. Best wishes for your research.

Sadly, Dr. Enochs has passed away.

Iris Riggs

Dr. Iris M. Riggs
Department of Teacher Education and Foundations
CSU San Bernardino
(909) 537-5614

From: Hanan Shehab <hanan.shehab@lau.edu>
Sent: Tuesday, May 22, 2018 8:28 AM
To: Iris Riggs
Subject: use of instruments for self- efficacy

Dear Dr Riggs
Hope my email finds you well
I am writing my thesis paper about personal self- efficacy of pre-service Lebanese teachers at a private university in Beirut after completing their preparatory courses and their pedagogical content knowledge course.
My name is Hanan Shehab and I am a masters graduate at the Lebanese American University -Beirut

I need your consent, as well as Dr Larry Enochs , to use : the Science Teaching Efficacy Belief instruments.

Thank you for your help

Appendix L

Part of the science syllabus of the PCK course

COURSE TYPE

Required

COURSE LEARNING OUTCOMES

At the completion of this course, the student will be able to:

- Explain (qualitatively) a range of phenomena using the core explanatory framework in each of the following domains: matter; force and motion; electricity and magnetism; heat, temperature and energy; diversity of living things.
- Design, carry out and report the results of a simple scientific investigation.
- Evaluate the reliability of popular science news reports using ideas about the nature of science
- Provide a rationale for the main goals of science education using the concept of scientific literacy
- Identify and remediate a number of typical science misconceptions present among elementary grade students.
- Plan an instructional unit that applies an inquiry approach to learning science.

In addition, the course will allow the participants to

1. Develop pedagogical content knowledge relevant to the teaching of science at the elementary level
2. Deepen their understandings of nature of science and identify effective ways of guiding elementary students to develop their understandings of nature of science
3. Explore how elementary students develop understandings of science concepts
4. Deepen their understandings of what a curriculum is
5. Develop an understanding and appreciation of methods of effective science teaching that focus on inquiry, problem solving and critical thinking
6. Teach a full science lesson at the cooperating school and reflect on their teaching experience
7. Become familiar with appropriate and effective selection, development and use of resources for effective science teaching and learning at the elementary level
8. Begin to develop a personal approach to the teaching of science
9. Begin to develop as a professional and reflective teacher

Methods used in the course:

1. Teaching/Learning Method
2. Inquiry-based learning
3. Reflective discourse

4. Discussions
5. Project-based learning
6. Role-playing
7. Simulations
8. Lab work

Appendix M

Part of the syllabus of the Mathematics PCK course

After completing this course students should be able to:

CLO 1. Examine personal assumptions, beliefs and values about elementary school mathematics instruction and their effective teaching in grades 1-6.
CLO 2. Examine and evaluate mathematics curricula for effective instructional strategies, authentic assessments, diversity and accommodations for diverse learners.
CLO 3. Demonstrate a better understanding of the nature of mathematics and its interrelatedness with the world around us.
CLO 4. Plan, implement, assess and reflect on an instructional unit.
CLO 5. Identify and remediate a number of typical math misconceptions present among elementary grade students

Students will be assessed on the following criteria

Course Learning Outcomes	Evidence
Examine personal assumptions, beliefs and values about elementary school mathematics instruction and their effective teaching in grades 1-6.	Unit Plan, Practicum, Reflections, etc.
Examine and evaluate mathematics curricula for effective instructional strategies, authentic assessments, diversity and accommodations for diverse learners.	Scope and Sequence work and lesson plans
Demonstrate a better understanding of the nature of mathematics and its interrelatedness with the world around us.	Resource kit
Plan, implement, assess and reflect on an instructional unit.	Unit plan and reflections
Identify and remediate a number of typical math misconceptions present among elementary grade students	In-School, Resource Kit, NCTM Activity

Appendix N

Pedagogical Core Requirements for Programs Leading to Certification in Teacher Education

Certification Area Code

01. Early Childhood Education	12. Teaching the Career Field[1]
02. Childhood Education	13. Teaching a Specific Career and Technical Subject
03. Middle Childhood Education	14. Library Media Specialist
04. Adolescence Education	15. Educational Technology Specialist
05. Teaching a Special Subject	16. Bilingual Education Extensions[2]
06. Teaching Students with Disabilities	17. Bilingual Education Extensions[3]
07. Teaching Students Who are Deaf or Hard-of-Hearing	18. Grades 5 and 6 Extensions
08. Teaching Students Who are Blind or Visually Impaired	19. Grades 7 through 9 Extensions
09. Teaching Students with Speech and Language Disabilities	20. Gifted Education Extensions
10. Teaching English to Speakers of Other Languages	21. Coordination of Work-based Learning Programs Extensions
11. Literacy	22. Teaching Students with Severe or Multiple Disabilities Annotations

[1]*Teaching the career field of agriculture or business and marketing.*
[2]*Bilingual education extensions for all with exception of library media specialist and educational technology specialist.*
[3]*Bilingual education extensions for library media specialist and educational technology specialist.*

1. Programs Leading to an Initial Certificate in Classroom Teaching

<u>Childhood Education</u> (grades 1 through 6)

General requirements

The program shall include the following:

(i) human developmental processes and variations, including but not limited to: the impact of culture, heritage, socioeconomic level, personal health and safety, nutrition, past or present abusive or dangerous environment, and factors in the home, school, and community on students' readiness to learn -- and skill in applying that understanding to create a safe and nurturing learning environment that is free of alcohol, tobacco, and other drugs and that fosters the health and learning of all students, and the development of a sense of community and respect for one another;

(ii) learning processes, motivation, communication, and classroom management -- and skill in applying those understandings to stimulate and sustain student interest, cooperation, and achievement to each student's highest level of learning in preparation for productive work, citizenship in a democracy, and continuing growth;

(iii) the nature of students within the full range of disabilities and special health-care needs, and the effect of those disabilities and needs on learning and behavior -- and skill in identifying strengths, individualizing instruction, and collaborating with others to prepare students with disabilities and special needs to their highest levels of academic achievement and independence;

(iv) language acquisition and literacy development by native English speakers and students who are English language learners -- and skill in developing the listening, speaking, reading, and writing skills of all students;

(v) curriculum development, instructional planning, and multiple research-validated instructional strategies for teaching students within the full range of abilities -- and skill in designing and offering differentiated instruction that enhances the learning of all students in the content area(s) of the certificate;

(vi) uses of technology, including instructional and assistive technology, in teaching and learning -- and skill in using technology and teaching students to use technology to acquire information, communicate, and enhance learning;

(vii) formal and informal methods of assessing student learning and the means of analyzing one's own teaching practice -- and skill in using information gathered through assessment and analysis to plan or modify instruction, and skill in using various resources to enhance teaching;

(viii) history, philosophy, and role of education, the rights and responsibilities of teachers and other professional staff, students, parents, community members, school administrators, and others with regard to education, and the importance of productive

relationships and interactions among the school, home, and community for enhancing student learning -- and skill in fostering effective relationships and interactions to support student growth and learning, including skill in resolving conflicts;

(ix) means to update knowledge and skills in the subject(s) taught and in pedagogy;

(x) means for identifying and reporting suspected child abuse and maltreatment, which shall include at least two clock hours of coursework or training regarding the identification and reporting of suspected child abuse or maltreatment, in accordance with the requirements of section 3004 of the Education Law;

(xi) means for instructing students for the purpose of preventing child abduction, in accordance with Education Law section 803-a; preventing alcohol, tobacco and other drug abuse, in accordance with Education Law section 804; providing safety education, in accordance with Education Law section 806; and providing instruction in fire and arson prevention, in accordance with Education Law section 808; and

(xii) means for the prevention of and intervention in school violence, in accordance with section 3004 of the Education Law. This study shall be composed of at least two clock hours of course work or training that includes, but is not limited to, study in the warning signs within a developmental and social context that relate to violence and other troubling behaviors in children; the statutes, regulations and policies relating to a safe nonviolent school climate; effective classroom management techniques and other academic supports that promote a nonviolent school climate and enhance learning; the integration of social and problem solving skill development for students within the regular curriculum; intervention techniques designed to address a school violence situation; and how to participate in an effective school/community referral process for students exhibiting violent behavior.

Program-Specific Requirements

Coursework

The program shall include the following:

(i) processes of growth and development in childhood and how to provide learning experiences and conduct assessments reflecting understanding of those processes; and

(ii) at least six semester hours of study in teaching the literacy skills of listening, speaking, reading, and writing to native English speakers and students who are English language learners at the childhood level, including methods of reading enrichment and remediation. This six-semester-hour requirement may be waived upon a showing of good cause satisfactory to the Commissioner, including but not limited to a showing that the program provides adequate instruction in language acquisition and literacy development through other means.

Field experiences, student teaching and practica

- The program shall include at least 100 clock hours of field experiences related to coursework prior to student teaching and at least two college-supervised student-teaching experiences of at least 20 schools days each.
- The field experiences and student teaching shall cover both childhood education settings, grades 1 through 3 and grades 4 through 6.
- For candidates holding another classroom teaching certificate or for candidates who are simultaneously preparing for another classroom teaching certificate and completing the full field experience for that other certificate, the program shall require such candidates to complete at least 50 clock hours of field experiences, practica, or student teaching with students in childhood education, including grades 1 through 3 and grades 4 through 6.

<u>Middle Childhood Education</u> (grades 5 through 9)

General requirements

The program shall include the following:

(i) human developmental processes and variations, including but not limited to: the impact of culture, heritage, socioeconomic level, personal health and safety, nutrition, past or present abusive or dangerous environment, and factors in the home, school, and community on students' readiness to learn -- and skill in applying that understanding to create a safe and nurturing learning environment that is free of alcohol, tobacco, and other drugs and that fosters the health and learning of all students, and the development of a sense of community and respect for one another;

(ii) learning processes, motivation, communication, and classroom management -- and skill in applying those understandings to stimulate and sustain student interest, cooperation, and achievement to each student's highest level of learning in preparation for productive work, citizenship in a democracy, and continuing growth;

(iii) the nature of students within the full range of disabilities and special health-care needs, and the effect of those disabilities and needs on learning and behavior -- and skill in identifying strengths, individualizing instruction, and collaborating with others to prepare students with disabilities and special needs to their highest levels of academic achievement and independence;

(iv) language acquisition and literacy development by native English speakers and students who are English language learners -- and skill in developing the listening, speaking, reading, and writing skills of all students;

(v) curriculum development, instructional planning, and multiple research-validated instructional strategies for teaching students within the full range of abilities -- and skill in designing and offering differentiated instruction that enhances the learning of all students in the content area(s) of the certificate;

(vi) uses of technology, including instructional and assistive technology, in teaching and learning -- and skill in using technology and teaching students to use technology to acquire information, communicate, and enhance learning;

(vii) formal and informal methods of assessing student learning and the means of analyzing one's own teaching practice -- and skill in using information gathered through assessment and analysis to plan or modify instruction, and skill in using various resources to enhance teaching;

(viii) history, philosophy, and role of education, the rights and responsibilities of teachers and other professional staff, students, parents, community members, school administrators, and others with regard to education, and the importance of productive relationships and interactions among the school, home, and community for enhancing student learning -- and skill in fostering effective relationships and interactions to support student growth and learning, including skill in resolving conflicts;

(ix) means to update knowledge and skills in the subject(s) taught and in pedagogy;

(x) means for identifying and reporting suspected child abuse and maltreatment, which shall include at least two clock hours of coursework or training regarding the identification and reporting of suspected child abuse or maltreatment, in accordance with the requirements of section 3004 of the Education Law;

(xi) means for instructing students for the purpose of preventing child abduction, in accordance with Education Law section 803-a; preventing alcohol, tobacco and other drug abuse, in accordance with Education Law section 804; providing safety education, in accordance with Education Law section 806; and providing instruction in fire and arson prevention, in accordance with Education Law section 808; and

(xii) means for the prevention of and intervention in school violence, in accordance with section 3004 of the Education Law. This study shall be composed of at least two clock hours of course work or training that includes, but is not limited to, study in the warning signs within a developmental and social context that relate to violence and other troubling behaviors in children; the statutes, regulations and policies relating to a safe nonviolent school climate; effective classroom management techniques and other academic supports that promote a nonviolent school climate and enhance learning; the integration of social and problem solving skill development for students within the regular curriculum; intervention techniques designed to address a school violence situation; and how to participate in an effective school/community referral process for students exhibiting violent behavior.

Program-Specific Requirements

Coursework

The program shall include the following:

(i) processes of growth and development in middle childhood and how to provide learning experiences, including interdisciplinary experiences, and conduct assessments reflecting understanding of those processes; and

(ii) at least six semester hours of study in teaching the literacy skills of listening, speaking, reading, and writing to native English speakers and students who are English language learners at the middle childhood level, including methods of reading enrichment and remediation. This six-semester-hour requirement may be waived upon a showing of good cause satisfactory to the Commissioner, including but not limited to a showing that the program provides adequate instruction in language acquisition and literacy development through other means.

Field experiences, student teaching and practica

- The program shall include at least 100 clock hours of field experiences related to coursework prior to student teaching and at least two college-supervised student-teaching experiences of at least 20 schools days each.

- Student teaching shall include both middle childhood settings, grades 5 through 6 and grades 7 through 9.
- For candidates holding another classroom teaching certificate or for candidates who are simultaneously preparing for another classroom teaching certificate and completing the full field experience for that other certificate, the programs shall require such candidates to complete at least 50 clock hours of field experiences, practica, or student teaching with middle childhood students, including experiences in both middle childhood settings, grades 5 through 6 and grades 7 through 9.

Appendix O

Lebanese Curriculum

The four branches of the Lebanese Baccalaureate (grade 12) are: humanities, general science, life science, and finally the economics and social science. Each branch at grade 12 contains different math and science objectives, number of periods, and content. For instance, with respect to the objectives of math, the sociology and economics students of this branch learn math in order to work on data in economics and social science, when it comes to life science these objectives change. Students have to learn math to be able to apply it to problem solving in experiments. The objectives of learning math also differ at the humanities branch. The class has to use math to comprehend data obtained from humanities ("Introduction", n.d.-a). Similarly, the objectives of the science at grade 12 differ according to the branches.

When it comes to the number of math periods for each branch, the humanities branches study math for only 2 periods per week, whereas the other branches study math for 5-6 periods per week. As for the science periods, they also differ at grade 12. The humanities branch studies scientific literacy for 3 periods per week. The economics and social science studies four periods of scientific literacy and 7 periods of physics per week. The general science branch studies 5 periods of physics and four periods of chemistry per week. The life science branch studies 5 periods of chemistry and 6 periods of life science per week ("Introduction", n.d.-b.)

With respect to the math content at grade 12, the humanities branch contains the following topics: interest, functions, statistics and probability. Whereas the economics and social science branch include the following content: groups, equations and inequations, all kinds of functions, integration and derivation, finance math, statistics and probability. The life science contains the following domains: equations and inequations, polynomials, transformation, integrations, trigonometry, statistics and vectors. Thus, a student who was at the economics or life science had a more rigorous background in math than the one enrolled in humanities branch. The content of science at grade 12 differs according to the branches ("Introduction", n.d.-b)

The curriculum that was produced by the Center of Educational Research (CRDP) in 1997 included different content for science according to the branch; i.e. humanities, life science, general science and economics and social ("Biology", 1997; "Chemistry", 1997; "Physics", 1997). With respect to the science content at grade 12, the humanities branch contains the following topics in the following domains: 1) Physics: energy; 2) Biology: nutrition and health, neurobiology human behavior and health; 3) Chemistry: food chemistry, perfumes and cosmetics, current medicinal drugs. On the other hand, the economics and social branches contain the following topics in the following domains: 1) Biology: nutrition and health, neurobiology, human behavior and health, science and economy. 2) Chemistry: food chemistry, perfumes and cosmetics, current medicinal drugs, chemistry and economy, treatment of wastes. The life science branch contains the following topics in the following domains: 1) Physics: mechanics, electricity, optics, atoms and nucleus. 2) Biology: genetics, immunology, neurophysiology, system of regulation and functional unity of the organism, living

things. 3) Chemistry: the gaseous state, chemical kinetics, chemical equilibrium, acid-base reactions, organic chemistry, polymers, soap and detergents, current medicinal drugs. The General science has the following topics in the following domains: 1) Physics: mechanics, electricity, optics, atom, nucleus and universe.2) Chemistry: the gaseous state, chemical kinetics, chemical equilibrium, acid-base reactions, organic chemistry, polymers. ("Physics", 1997), ("Biology, 1997), ("Chemistry", 1997). Thus, a student who is in the general or life science branches had a more rigorous background in math than the one enrolled in humanities or sociology and economics branches. The content of science at grade 12 differs according to the branches. The humanities branch student studies chemistry and biology and does not study physics. On the other hand, the general science student studies physics and chemistry and does not study biology. The science branch student studies all three science branches. The main aim in the general science branch is to have students with a thorough understanding of the math theories and conjectures whereas the main aim at the science branch is to prepare students with a thorough understanding of scientific theories. The economics and social branch uses math and science as tools to solve economic equations, whereas the humanities branch does not require students to delve deeply into these subjects. ("Introduction", n. d.-a)

Appendix P

Elementary pre-service qualification in Lebanon at a private university

Teachers' preparation follow the standards developed by the Council of Chief State School Officers (NYSED, 2019). They are built into the syllabi of all the courses. They are found in four domains, namely: the learner and learning, content knowledge, instructional practice, and professional responsibility. In the first domain, there are three standards: the learner development, the learning difference, and the learning environments. In the second domain, there are two standards: the content knowledge and the application of the content. In the third domain, there are three standards: the assessment, planning for instruction, and instructional strategies. In the fourth domain, there are two standards: the professional learning and ethical practice and the leadership and collaboration. The general requirements for middle childhood education (grades 5 through 9) include several themes, namely: a) human developmental processes and variations, b) learning processes, c) the nature of students within the full range of disabilities, d) language acquisition and literacy development by native English speakers and students who are English language learners, curriculum development, instructional planning, and multiple research-validated instructional strategies for teaching students within the full range of abilities, e) uses of technology, f) formal and informal methods of assessing student learning and the means of analyzing one's own teaching practice, g) history, philosophy, and role of education, the rights and responsibilities of teachers and other professional staff, h) means to update knowledge and skills in the subject(s) taught and in pedagogy, i) means for identifying and reporting suspected child abuse and maltreatment, j) means for instructing students for the purpose of preventing child abduction, and k) means for the prevention of and intervention in school violence (NYSED, 2019).

Also, the program includes in the coursework domain: a) processes of growth and development in middle childhood and how to provide learning experiences, b) at least sixty hours of study in teaching the literacy skills of listening, speaking, reading, and writing to native English speakers and students who are English language learners. Whereas, in the field experience domain, students are required to: a) do at least 100 hours of field experiences related to coursework prior to student teaching and at least two college-supervised student-teaching experiences of at least 20 schools days each, b) include both middle childhood settings, grade 5 through 6 and grades 7 through 9. For candidates who are at the same time preparing for another teaching certificate, the they are required to complete at least 50 clock hours of field experiences, practica, or student teaching with middle childhood students, including experiences in both middle childhood settings, grades 5 through 6 and grades 7 through 9. (NYSED, 2019).