A COMPARATIVE STUDY OF TEACHERS' SELF-EFFICACY FOR TEACHING STEM SUBJECTS AND ATTITUDES TOWARD STEM EDUCATION ACCORDING TO GENDER AT WATTANA WITTAYA ACADEMY, BANGKOK, THAILAND

Sunita Sachdev

I.D. No. 5719528

A Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF EDUCATION
in Curriculum and Instruction
Graduate School of Human Sciences
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ABSTRACT

I.D. No.: 5719528

Key Words: SELF-EFFICACY, STEM SUBJECTS, ATTITUDES, TEACHERS, GENDER, STEM EDUCATION, WATTANA WITTAYA ACADEMY, THAILAND

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Thesis Advisor: ASSOC. PROF. DR. SUWATTANA EAMORAPHAN

The purpose of conducting this research was to determine the level of teachers' self-efficacy when teaching STEM subjects and their attitudes towards STEM education at Wattana Wittaya Academy in Bangkok, Thailand. A second purpose was to determine whether there was a significant difference in teachers' self-efficacy for teaching STEM subjects and attitudes toward STEM education according to gender. This study was conducted from 3 June to 6 June, 2019 at Wattana Wittaya Academy, Bangkok, Thailand. As a source of data collection, the researcher used Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education (T-STEM Questionnaire). The respondents were 67 teachers teaching STEM-related subjects at Wattana Wittaya Academy, Bangkok, Thailand during the 2019-2020 academic year. The data obtained were analyzed by descriptive statistics, means and standard deviations and independent samples *t*-test.

The findings of this study were as follows: Teachers had a high level of self-efficacy for teaching STEM subjects in the following three categories: teachers' STEM teaching self-efficacy and beliefs, teachers' STEM teaching outcome expectancy and teachers' STEM instruction. Teachers had positive attitudes toward STEM education in the following three categories: student technology use in STEM classes, 21st century learning attitudes and teacher leadership attitudes. There was no statistical difference between teachers' STEM teaching self-efficacy for teaching STEM subjects and attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand. Recommendations for practice and future research are provided.

Field of Study: Curriculum and Instruction
Graduate School of Human Sciences
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Student's signature……………………..
Advisor's signature………………….

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LIST OF ABBREVIATIONS

ABC	Affect, Behavior and Cognition
CIE	Cambridge International Examination
EU	European Union
GCE	General Certificate of Education
IGCSE	International General Certificate of Secondary Education
IPST	Institute for the Promotion of Teaching Science and Technology
MISO	Maximizing the Impact of STEM Outreach through Data-Driven Decision-Making
NGO	Non-Governmental Organization
STEM	Science, Technology, Engineering and Mathematics
T-STEM	Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education

CHAPTER I

INTRODUCTION

This chapter presents the background of the study, the statement of the problem, and the research questions with corresponding objectives and hypotheses. It also includes the theoretical and conceptual framework of the study, the scope of the study, and the definitions of terms. This chapter concludes with the significance of the study.

Background of the Study

STEM is an abbreviation of four educational disciplines: science, technology, engineering, and mathematics. As a result of the United States' poor performance in these fields, STEM education was created in the 1990s by the National Science Foundation with the purpose of educating students to ensure the nation could compete on a global level (Hanover Research, 2011). STEM education is generally focused on creating interdisciplinary learning. Since the fields comprising STEM education are deeply linked, STEM takes all four fields and incorporates them into a cohesive learning system, instead of isolating each from the other.

Connecting these four subjects is beneficial to the students and the society, because knowledge in these fields is vital to the future of underdeveloped countries in which understanding of STEM subjects is limited. This knowledge presents opportunities for students who have an elevated level of education in STEM fields (Chesky & Wolfmeyer, 2015). The STEM education system allows students to practically solve real-life problems and acquire more knowledge about the process of solving problems rather than about the finished product.

According to Bandura (1989), gender stereotyping begins in early childhood first through the influence of the parents. A child learns her gender roles through the way her parents try to dress her in certain colors and through the toys her parents select for her. This has had a negative effect on females' self-efficacy for teaching STEM subjects and attitudes toward STEM education. In the last several years, a significant effort has been made to bridge the gap between gender inequalities in science, technology, engineering, and mathematics (UNESCO, 2017).

The gender gap in STEM field participation grows when the student reaches college. Female students rarely pursue STEM majors and are outnumbered five to three by male graduates of STEM fields (Jordan & Carden, 2017). Female students' have a lower level of self-efficacy in STEM fields than male students, as it is generally assumed that STEM subjects are for males. Furthermore, the number of those – males and females alike – studying science and technology decreases at every grade level in Thailand (Boonruang, 2015, January 14). The lack of role models and inadequate encouragement can cause low self-efficacy in women (Litzler, Samuel & Lorah, 2014).

The presence of STEM-educated women teaching STEM classes substantially contributes to higher self-efficacy in female students. Teachers' self-efficacy for teaching STEM subjects and attitudes towards STEM education play an important role in determining students' interest in STEM subjects and in providing equal opportunities to access and benefit from quality STEM education (Bandura, 1997).

Teachers' identification of their STEM teaching self-efficacy and beliefs, STEM teaching outcome expectancy and STEM instruction is significant in understanding the gender differences in teaching STEM subjects. The STEM method of instruction is often not given much consideration; in many schools, teachers often teach different topics without any rational connections between them (Wineburg & Grossman, 2000). This is the main reason why students today find it difficult to make connections between different topics. This leads to less effective science, technology, engineering and mathematical instruction and unproductive STEM teaching outcome expectancy.

STEM education encourages teachers to develop positive views of student technology use, 21^{st} century learning attitudes and teacher leadership attitudes in order to allow students to make associations between different topics. This enables the students to innovate when problem-solving and decision-making. Most other systems of teaching do not utilize a cohesive style of teaching either, including CIE (Cambridge International Examination), one of the world's most famous educational systems. CIE has broken science down into three different groups: biology, chemistry, and physics. Separating these three sciences and teaching them individually inhibits students from making connections between them. However, STEM includes not only biology, chemistry, and physics but also links these sciences to technology, engineering, and mathematics, allowing students to receive an integrated education.

With the rapid integration of technology, which serves as the backbone of today's globalized civilization, it is highly beneficial for researchers to be informed about how attitudes towards student technology use are developed, as positive attitudes can lead to careers in STEM occupations (British Council, 2016). STEM education is important for the future as are 21^{st} century skills, but the gender stereotypes of women in mass media influence the perception of the general public regarding female ability in career aspirations in STEM career fields (UNESCO, 2017).

The United Nations Education, Scientific and Cultural Organization's goals include providing women and girls with equal access to education, health care, career opportunities, and representation in political and economic decision-making processes. The United Nations Education, Scientific and Cultural Organization recognizes gender equality and the empowerment of women as one of its global priorities. Women continue to suffer discrimination and violence in every part of the world. The United Nations' goals include providing women and girls with equal access to education, health care, career opportunities, and representation in political and economic decision-making processes. The accomplishment of these goals will fuel sustainable economies and benefit societies. Below is a list of facts about the lack of female participation in societies around the world.

- In developing countries, about two-thirds of girls have achieved gender equality in primary education.
- In 1990, 74 girls for every 100 boys were enrolled in primary school. By 2012, the enrollment ratios were the same for girls as for boys in Southern Asia.
- In sub-Saharan Africa, Oceania and Western Asia, girls still face barriers to entering both primary and secondary school (United Nations, 2015).

Teachers' self-efficacy for teaching STEM subjects and attitudes toward STEM education are considered to be the single most important in-school factor affecting students' achievement in STEM education. The employment of female STEM teachers has enhanced educational experiences and improved learning outcomes for girls in different contexts across STEM subjects.

Female STEM teachers have a positive impact on girls' performances in STEM education and careers. In contrast, girls' learning experience in STEM education is compromised when teachers hold stereotypical attitudes about gender-based STEM capacity or treat boys and girls unequally in the classroom (UNESCO, 2017).

This research aimed to study comparative of teachers' self-efficacy for teaching STEM subjects and attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand. Self-efficacy emphasizes teachers' STEM teaching self-efficacy and beliefs, teachers' STEM teaching outcome expectancy and teachers' STEM instruction. Attitudes emphasized include attitudes toward student technology use in STEM classes, 21st century learning attitudes, and teacher leadership attitudes.

Statement of the Problem

Too many girls are held back by discrimination, biases, social norm and expectation that influence the quality of education they received and the subject they study (UNESCO, 2017). According to the World Bank, four of every ten STEM graduates are girls (Wadhwa, 2019). In a UNESCO study of female STEM participation in the Asian countries of Cambodia, Indonesia, Malaysia, Mongolia, Nepal, the Republic of Korea and Vietnam, it was found that as level of education rises beyond a Bachelor's degree, the number of female students decreases. Thailand for instance, there were no female contestants in the International Olympiads in informatics or physics in 2014 (UNESCO Bangkok, 2015).

In addition, as the research mentioned above, it is possible that a contributing factor related to the lack of female achievement in STEM is a lack of confidence on the part of female STEM teachers. If female STEM teachers do not project confidence and skill when teaching female student will not be encouraged to pursue STEM fields of study.

In this study, the researcher carried out a study to find out whether there is a significant relationship of self-efficacy for teaching STEM subjects and attitudes towards STEM education at Wattana Wittaya Academy, Bangkok, Thailand to determine if there is difference according to gender.

Research Questions

The main focus of this research was to determine whether or not a comparative difference of teacher's self-efficacy for teaching STEM subjects and attitudes toward STEM education according to gender exists. The following research questions were formulated for this study.

1. What is the level of teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand?
    1.1. What is the level of teachers' STEM teaching self-efficacy and beliefs according to gender at Wattana Wittaya Academy, Bangkok, Thailand?
    1.2. What is the level of teachers' STEM teaching outcome expectancy according to gender at Wattana Wittaya Academy, Bangkok, Thailand?
    1.3. What is the level of teachers' STEM instruction according to gender at Wattana Wittaya Academy, Bangkok, Thailand?
2. What is the level of teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand?
    2.1. What is the level of student technology use in STEM classes according to teachers' gender at Wattana Wittaya Academy, Bangkok, Thailand?
    2.2. What is the level of teachers' 21^{st} century learning attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand?
    2.3. What is the level of teacher leadership attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand?
3. Is there a significant difference between teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand?
4. Is there a significant difference between teachers' attitudes towards STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand?

Research Objectives

The following are the specific research objectives addressed by this study.

1. To determine the level of teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand.
    1.1. To determine the level of teachers' STEM teaching self-efficacy and beliefs according to gender at Wattana Wittaya Academy, Bangkok, Thailand.
    1.2. To determine the level of teachers' STEM teaching outcome expectancy according to gender at Wattana Wittaya Academy, Bangkok, Thailand.
    1.3. To determine the level of teachers' STEM instruction according to gender at Wattana Wittaya Academy, Bangkok, Thailand.
2. To determine the level of teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand.
    2.1. To determine the level of student technology use in STEM classes according to teachers' gender at Wattana Wittaya Academy, Bangkok, Thailand.
    2.2. To determine the level of teachers' 21st century learning attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand.
    2.3. To determine the level of teacher leadership attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand.
3. To determine whether there is a significant difference in teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand.
4. To determine whether there is a significant difference in teachers' attitudes towards STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

Research Hypotheses

Two hypotheses were formulated for this study.

1. There is a significant difference in teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand, at a significance level of .05.
2. There is a significant difference in teachers' attitudes towards STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand, at a significance level of .05.

Theoretical Framework

In order to examine whether a difference in teachers' self-efficacy for teaching STEM subjects and attitudes toward STEM education according to gender exists at Wattana Wittaya Academy, Bangkok, Thailand, this study utilized social cognitive theory and ABC model of attitudes.

Social Cognitive Theory Defined Self-Efficacy

Albert Bandura's social cognitive theory provides the theoretical framework for analyzing how teachers design an effective STEM education. Self-efficacy is a construct that describes how confident teachers believe they are or how much control teachers have over their own behavior and their ability to reach their goal or a given task (Bandura, 1994). Self-efficacy for teaching STEM subjects includes the following: teachers' STEM teaching self-efficacy and beliefs, teachers' STEM teaching outcome expectancy and STEM instruction.

The ABC Model of Attitudes

Improving student achievement in STEM education not only involves teacher knowledge and self-efficacy, but also a desire to participate in a reform of pedagogy and attitudes of STEM teachers. Teachers' attitudes towards STEM education are the critical factor affecting their use of new teaching strategies. The tri-component conceptualization of attitudes employs the ABC model of attitudes (Ellis, 1957). The ABC model consists of affect, behavior and cognition. Teachers' attitudes towards student technology use in STEM classes allows 21st century learning attitudes to be structured in a highly rigid style of STEM education, providing students with new cross-disciplinary (Ohio STEM Learning Network, 2016). Teacher leadership attitudes towards purposeful design can enhance the learning experiences of STEM students.

Conceptual Framework

This is a comparative research study that aims to measure teachers' self-efficacy for teaching STEM subjects and attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand. Figure 1 presents the conceptual framework of this study.

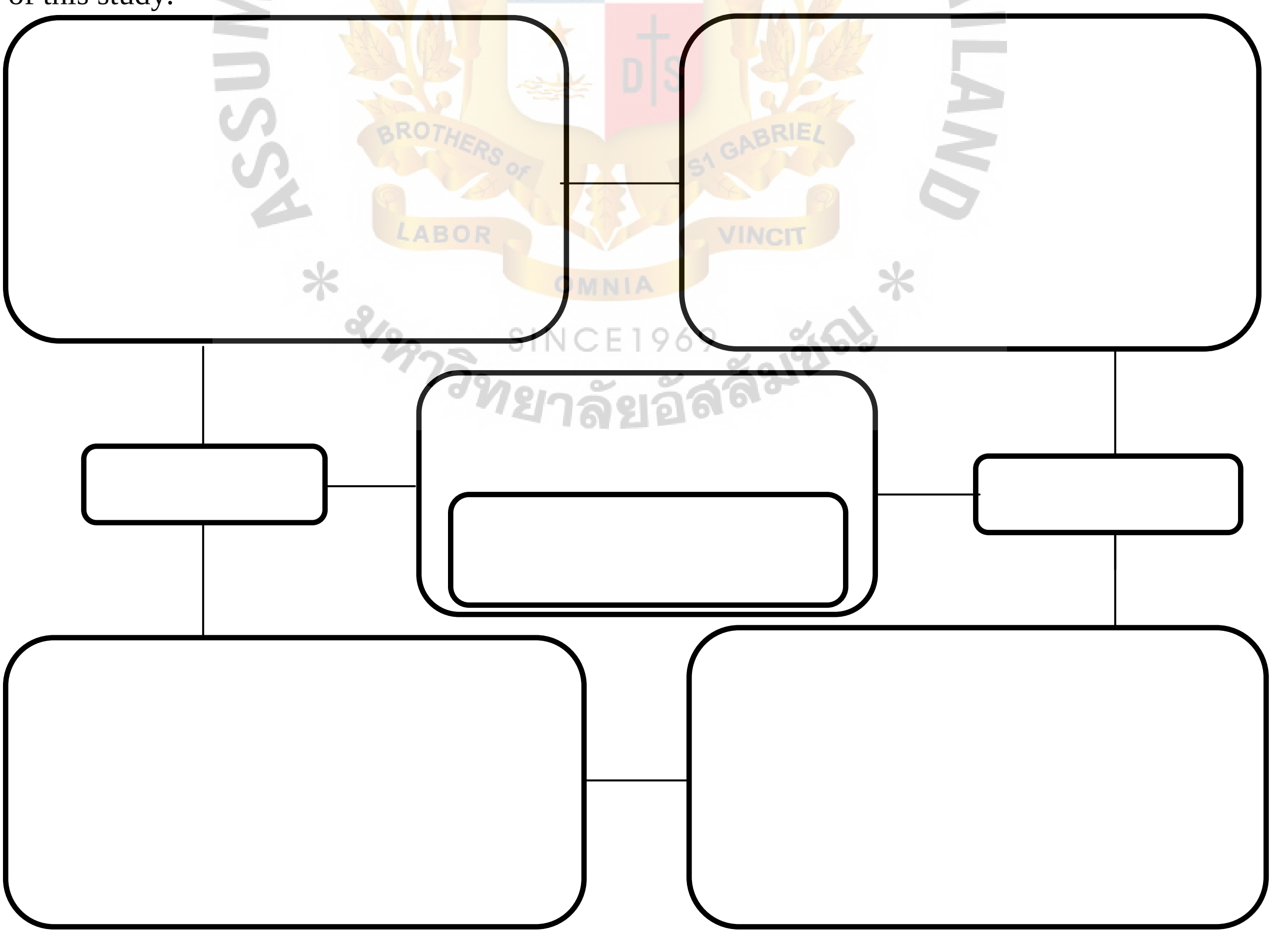

Figure 1. Conceptual framework.

Scope of the Study

The purpose of this study was to investigate the difference in the level of teachers' self-efficacy for teaching STEM subjects and attitudes towards STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand, in the academic year 2018 - 2019. An independent samples *t*-test was used to test whether there is a significant difference between genders.

The population of this study was 67 teachers of STEM subjects at Wattana Wittaya Academy, Bangkok, Thailand. The lack of female role models in STEM at school and workplace feeds disparities. The lack of females in leadership positions in STEM careers is worrisome for female students. According to Bandura (1997), teacher modeling or vicarious experiences in a school environment offers many opportunities, including the ability to develop strong mentoring relationships through teachers' self-efficacy for teaching STEM subjects, which is described as STEM teaching self-efficacy and beliefs, STEM teaching outcome expectancy and STEM instruction measured by the questionnaire research.

STEM education has been described as an innovative approach to learning. According to cognitive behavioral therapy of attitudes known as the tripartite model or ABC model of attitudes, teachers' attitudes towards student technology use in STEM classes, 21st century learning attitudes and teacher leadership attitudes have a positive effect on students' achievement measured by the questionnaire research.

Definitions of Terms

To assure a common understanding of terms used in this study, the following terms are defined.

Attitudes toward STEM education. This refers to a teacher's view of a concept or a tendency to respond positively or negatively towards a certain idea. Teacher's attitudes influence their teaching. A close-ended questionnaire called Teacher Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education are used to measure which is a total of 25 items (see Appendices A and B).

Student technology use. This refers to students' access, evaluation and communication through technology. Technology is rooted in student's lives, and students generally have a positive response towards technology, but the actual use of these devices in academics remains low, despite their increased prevalence. A close-ended questionnaire called Teacher Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education are used to measure starting from Item 52 to 59 (see Appendices A and B).

21st century learning attitudes. This refers to the input of essential skills and knowledge students must master in order to be successful in today's society. The four C' are

- creativity allows student to develop original work and trying new approaches to invention through creative process;
- critical thinking allows student to look at problems in new ways and linking learning across subjects' disciplines and execute real-work problems;
- communication allows students sharing thoughts, ideas and solution to solve problem; and
- collaboration allows students to work together to reach a goal.

A close-ended questionnaire called Teacher Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education are used to measure starting from Item 21 to 31 (see Appendices A and B).

Teacher leadership attitudes. This refers to the ability to achieve challenging goals, as well as to motivate, inspire and direct students and teachers to act towards a vision. A close-ended questionnaire called Teacher Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education are used to measure starting from Item 32 to 37 (see Appendices A and B).

Gender. This refers to the range of characteristics pertaining to and differentiating between masculinity and femininity. Teacher beliefs about male and female students' ability in STEM as well as how teachers treat female and male student in the classroom.

Self-efficacy for teaching STEM subjects. This refers to a teacher's perspective of his or her capabilities are developed through the interpretation of task outcomes the circumstances surrounding task experiences. A close-ended questionnaire called Teacher Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education are used to measure which is a total of 34 items (see Appendices A and B).

Self-efficacy and beliefs. This refers to beliefs a person holds about his or her competence in teaching STEM. A close-ended questionnaire called Teacher Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education are used to measure starting from Item 1 to 11 (see Appendices A and B).

Outcome expectancy. This refers to the monitoring of outcomes and the understanding of the level of performance according to the students' learning goals. A close-ended questionnaire called Teacher Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education are used to measure starting from Item 12 to 20 (see Appendices A and B).

Instruction. This refers to instruction support strategies and behaviors for providing clearly stated learning goals. A close-ended questionnaire called Teacher Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education are used to measure starting from Item number 38 to 51 (see Appendices A and B).

Teacher. This refers to a key person who helps others acquire knowledge; one of the most influential and powerful sources of equality. Teacher teaching STEM related subjects at Wattana Wittaya Academy, Bangkok, Thailand.

Wattana Wittaya Academy. This refers to Wattana Wittaya Academy, Bangkok, Thailand. The first boarding school in Thailand, established in1874. Wattana Wittaya Academy is a private, all-girls preschool to grade 12 school located in the center of downtown Bangkok.

Significance of the Study

This study will contribute to the improvement of teachers' and students' self-efficacy towards STEM education and attitudes. This research will encourage the following:

STEM Teachers

STEM Teachers will benefit from this research by gaining a greater understanding of their self-efficacy and attitudes toward STEM education. Teachers will also be exposed to a more effective teaching method.

STEM Students

The direct recipients of the output of this research are the children who will receive an education allowing them to become functional, productive individuals in society.

This chapter has described the background of the study regarding the importance of STEM education. This chapter includes the statement of the problem: the ever-widening gender gap between male and female students and teacher in STEM related classes and careers. Before examining whether a difference of teachers' self-efficacy teaching STEM subjects and attitudes toward STEM education according to gender exist at Wattana Wittaya Academy, Bangkok, Thailand, the following chapter will provide a review of the literature related to STEM education and the theory of self-efficacy and attitude.

CHAPTER II

REVIEW OF RELATED LITERATURE

In the previous chapter, the researcher discussed the purpose and importance of the study. This chapter will review the literature related to this research within the realm of STEM education, beginning with a general description of STEM education, as well as definitions of self-efficacy for teaching STEM subjects and attitudes toward STEM education especially as they relate to teachers at Wattana Wittaya Academy, Bangkok, Thailand.

STEM Education

After presenting a general overview of STEM education, four topics will be discussed. The first topic involves the challenges faced by STEM education. The second topic discussed is how STEM is different from other types of educational methods. The third topic entails the present situation of STEM education in Thailand. And the last topic describes how STEM education can be successfully implemented.

Overview of STEM Education

Only about 33% of American students in Grade 4 through Grade 8 performed above average in STEM subjects, whereas a little more than a third of the American students in the same grade scored below average in mathematics and science (Hanover Research, 2011).

One-fourth of American students in Grade 12 performed at or below average in mathematics (Hanover Research, 2011). Today's international market is highly competitive, requiring American students to improve their performance in STEM classes if the United

States wants to remain competitive (National Academy of Engineering, 2004). This need resulted in the creation of STEM education.

STEM education is an abbreviation of science, technology, engineering and mathematics. Hanover Research (2011, p. 2) defines STEM education as a broad reform movement in the area of science, technology, engineering and mathematics that seeks to cultivate a STEM-proficient workforce and a STEM-literate citizenry to increase the United States' competitiveness in the global economy." It was further elaborated by Hanover Research (2011, p. 2) that definitions of STEM education utilize "an interdisciplinary approach that aims to cultivate a deeper understanding of each subject through an emphasis on the interrelated nature of science, technology, engineering, and math."

STEM education integrates the study of applied sciences, which covers biology, chemistry, marine biology, physics and science. Secondly, it incorporates technology, including the subjects of computer/information system, game design, developer, [and] web/software developer. Thirdly, STEM education introduces various fields of engineering, including chemical engineering, civil engineering, computer engineering, electrical engineering, general engineering and mechanical engineering. Finally, it involves mathematics and statistics (Hanover Research, 2011, p. 5).

STEM requires students to become familiar with scientific literacy, technological literacy, engineering literacy and mathematical literacy. Hanover Research (2011, p.2), defines scientific literacy as the ability to use scientific knowledge and processes to understand the natural world as well as the ability to participate in decisions that affect it. Technological literacy allows students to know how to use new technologies, understand how new technologies are developed, and have the skills to analyze how new technologies affects our nations, the world, and us. Engineering literacy is defined as the understanding of how technologies are developed via the engineering design process using project-based lessons in manner that integrate lessons across multiple subjects. Finally, mathematical literacy is defined as the ability of students to analyze, reason, and communicate ideas effectively as they pose, formulate, solve, and interpret solutions to mathematical problems in a variety of situations.

As our world continues to shift its dependency from hard labor to technology, it is important for teacher and students to be aware of the number of available positions in STEM careers **(**UNESCO, 2010). As parents and guardians seek guidance as to which field of study to encourage their children towards, STEM education should be a leading choice as these careers are vital to global advancement, including continued infrastructure development and the growth of the techno-economic industry (British Council, 2016). Students who enroll in STEM education get a preliminary education in these four fields of studies at a young age become familiar with the content from the beginning of their academic career and will most likely pursue STEM careers more often than students who have not been exposed to STEM education (Na Ayuthaya, Dejakaisaya & Santanakul, 2015).

As stated in the Hanover Research, the ultimate objective of this curriculum (see Table 1) is to "[e]nsure a STEM-capable citizenry," "[b]uild a STEM-proficient workforce," "[c]ultivate future STEM experts," and "[c]lose the achievement and participation gap."

Table 1

STEM Objectives

Ensure a STEM-capable citizenry	Build a STEM-proficient workforce
This goal seeks a cultivate citizenry that has "the knowledge, conceptual understanding, and critical thinking skills that come from studying STEM subjects." This is important	This goal seeks to adequately prepare a sufficient number of workers to join opening in STEM-related careers, which are expected to increase in coming years. Additionally,

(continued)

(continued)

Ensure a STEM-capable citizenry	Build a STEM-proficient workforce
even for those who never directly enter a STEM-related career.	STEM- related skills are increasing relevant in field not directly related to STEM subject.
Cultivate future STEM experts	**Close the achievement and participation gap**
This goal aims to educate the best STEM experts I the world because they contribute "to economic growth, to technological progress, to our understanding of ourselves, the universe, and to reduction of hunger, disease, and poverty."	This goal aims to increase women and minority participation and interests in STEM fields in order to tap into the country's full potential.

Note. STEM objectives: Reprinted from Hanover Research, 2011, p. 5.

The goal of the STEM system of education is to encourage teachers to develop students who possess a sufficient amount of knowledge in STEM disciplines so they can produce innovative results in their STEM careers (Bybee, 2013). Especially in STEM fields, creativity is of great value. STEM graduates should make up a larger percentage of the work force, so as to enable them to compete worldwide and innovatively solve problems (Kanematsu & Barry, 2016). Sammut (2013) concluded that the concept of integration, which essentially includes the unifying of many different disciplines, is a requirement for producing interdisciplinary students. Integration allows students to connect what they learn and therefore makes their education more meaningful.

Kain (1993) proposes two resolutions for integration either improving student learning and engagement in the present system or replacing the system altogether. If an interdisciplinary educational program like STEM education is implemented in a school in order to improve STEM knowledge and skills, then it should be put into practice in such a way that it is accessible and beneficial to every student. Most of these educational professionals believe that interdisciplinary education increases the student's inquisitiveness and interest in education (Brusinc, 1991).

Thomas Edison, one of history's most prominent inventors, was once asked by a reporter how he was able to persevere in his attempt to create a light bulb after failing 1,000 times. Thomas Edison replied, "I have not failed. I've just found 1,000 ways that won't work." Clearly, Thomas Edison would have been a proponent of STEM education. STEM education builds on Edison's ideology by encouraging students to see their learning as interconnected and to strive for new solutions.

Another famous inventor, Albert Einstein, had this to say: "It's not that I'm smart, it's just that I stay with problems longer." STEM education uses both Edison's and Einstein's philosophies to educate students by allowing and encouraging them to stay with problems longer and permitting them to fail as many times as they need to so they are able to learn through their mistakes. Students' mistakes allow them to learn the process of problem solving and discover original solutions.

As STEM education prepares students well for the challenges and opportunities they will face in the future, it is essential for students to receive a STEM education. Since the introduction of STEM education, high school graduates have been better prepared to study STEM subjects in college. STEM education establishes a creative and rigorous environment, requiring students to think critically and improve their analytic skills and allowing them to increase their level of achievement in other disciplines. STEM graduates are a vital contributor to a country's global status, as they bring value, productivity and innovation to their country's economy (Hanover Research, 2011, p. 11).

Research revealed that in 2018, 1 out of 20 jobs around the world was related to STEM, which is an estimated 2.8 million jobs globally (Smithsonian Science Education Center, 2018). Students who acquire STEM- related skills receive higher salaries than students who do not. Georgetown University Center on Education and the Workforce conducted research which found that 65% of students who have a bachelor's degree in disciplines related to STEM earn more than students who hold a master's degree in other disciplines. The research also concluded that 47% of these bachelor's degree holders make more money than PhD holders from non-STEM disciplines (Engler, 2012).

Challenges Faced by STEM Education

Even though STEM has been widely praised, it also faces many challenges. An article published in *The Atlantic* called "The Myth of the Science and Engineering Shortage" criticized the United States' government for encouraging an increasing number of STEM graduates. Michael S. Teitelbaum, the article's author, wrote that No one has been able to find any evidence indicating current widespread labor market shortages or hiring difficulties in science and engineering occupations that require bachelor's degrees or higher. He goes on to say, most studies report that real wages in many, 'but not all', science and engineering occupations have been flat or slow-growing and unemployment as high or higher than in many comparably-skilled occupations. Teitelbaum warns that if the United States continues to overemphasize the need for STEM graduates, the United States' government would be forced to deploy freezes, cut funds for other program and implement mass layoffs. Despite these criticisms, STEM careers have actually proven to be a big participant in the United States' economy (Teitelbaum, 2014).

The United States' government spends over four point three billion dollar every year on initiatives related to the development of STEM education (Rothwell, 2013). Critics believe that such a large investment could backfire and result in economic loss for the country.

Three problems with STEM have been highlighted by critics: demographic gap, teachers' capabilities, and accessibility.

The demographic gap involves the domination of one gender or race in the workplace (Truscott, 2006). In the case of STEM, Caucasian and Asian males make up the majority of the employees at an average STEM workplace. This problem is highlighted by a 2009 study which concluded that in the United States, only 12% of African Americans and 17% of Hispanic students complete Algebra 1 in high school, whereas 28% of Asian students complete it before high school. The problem is also highlighted by the fact that in 2008, women received only 18% of all STEM degrees. Furthermore, women hold only 25% of STEM jobs in the United States. Critics believe that women and minorities are underrepresented in STEM careers but taking a leading role in teaching (Kelleher, 2011).

STEM education is more complicated than the traditional method of separating subjects, requiring teachers with a high level of knowledge of all STEM disciplines. Research has shown that in the 2007-2008 academic year, 17% of high school STEM teachers did not have the required level of education in the subject they were teaching. In mathematics, the subject in which teachers are least prepared, the percentage rises to 25% (Aud & KewalRamani, 2010).

Most STEM graduates take up jobs that pay well, leaving the graduates who cannot get these jobs to pursue teaching. Students in STEM classes are often not being taught by the best and brightest STEM graduates, leaving the students at risk of receiving an uninspiring, subpar STEM education (Kaminski & Geisler, 2012).

The last significant criticism involves the failure of schools to implement technological advancements. In the United States, only about nine states allow computer science to be considered a math or science graduating credit, and 14 other states fail to possess a high standard for computer science instruction (Association for Computing Machinery, & Computer Science Teacher Association, 2010). All these problems faced by STEM education are of high significance and should be appropriately addressed by each state.

How STEM Education Is Different from Other Programs

STEM education has been actively compared with other methods of education. Two of the most popular educational systems are GCE and IGCSE. STEM education utilizes a different theoretical approach based on existing methods of education (see Figure 2).

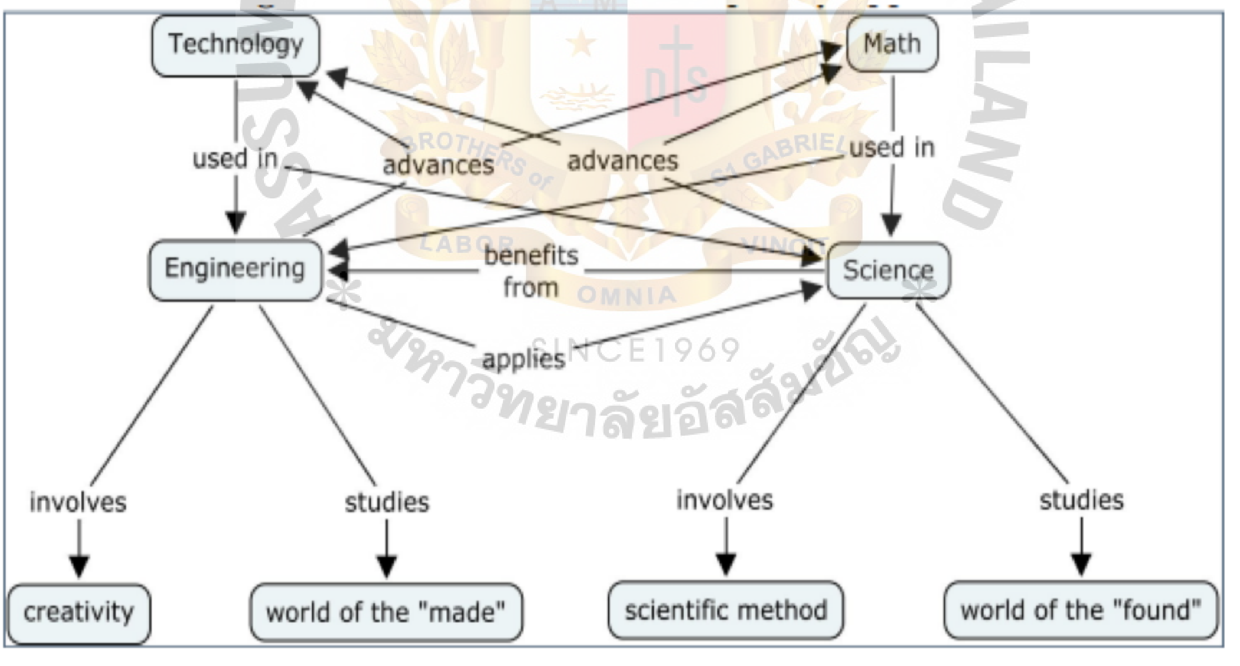

Figure 2. Interdisciplinary approach of STEM: Reprinted from Hanover Research, 2011, p. 9.

GCE, which stands for General Certificate of Education, was formed in 1999 to unify known NGO's and teacher unions in over 100 countries worldwide (Verger & Novelli, 2012). Since its formation, many major global, regional and local groups focused on education, social justice or human rights have joined this association. The aim of GCE is to educate as many students as possible.

IGCSE, which stands for International General Certificate of Secondary Education, is another educational system and one that is similar to GCE. It is the world's most popular qualification for secondary school systems. IGCSE is a qualification which allows students to part take in learning various single subjects and judges their capabilities based on each subject distinctively (Bond & Hughes, 2014). IGCSE uses a traditional type of examination, so students are judged only on this test result. The process of doing the work usually is ascribed little to no value. Its main goal is to identify the smartest students at an early age and then to mentor these students to achieve at a higher level than they could achieve on their own.

A key difference between STEM and these two systems is that STEM education uses a different philosophy of education. In STEM education, failure is considered valuable and students are encouraged to learn from failure. In contrast, GCE is concern only with the end product.

Another difference between STEM and these two systems is that STEM education uses an interdisciplinary style of teaching, combining science, technology, engineering and mathematics into one subject. The other two systems separate subjects. They divide science into three separate subjects: biology, chemistry, and physics. Mathematics has different standards and levels of difficulty. Technology and engineering also divided into many different subjects, such as information and communications technology, computer science, etc. This system does not allow students to make connections between subjects.

STEM education is very different from these more traditional approaches to education. STEM education focuses on enhancing the innovative and creative capabilities of the students. It provides students with cross-disciplinary real-life challenges (Ohio STEM

Learning Network, 2016). A traditional education system has a stronger focus on teaching rather than learning and places a higher emphasis on passing examinations rather than on process of student learning. In a traditional system, students often spend hours memorizing key facts in order to pass the examination rather than actually understanding and making meaning out of the content. The traditional educational system does not allow students to develop their learning skills or realize their true potential, meaning the system fails the students, the teachers and the society (Spooner, 2015).

The Present Situation of STEM Education in Thailand

The Basic Education Core Curriculum of Thailand, which was implemented in 2008, prescribes a certain number of hours of instruction in eight different subjects, which include Thai language; mathematics; science; social studies, religion and culture; health and physical education; arts; occupations and technology and foreign languages. Below is the table created by the Thailand Ministry of Education addressing instructional time that all Thai schools are required to comply with.

Table 2

Basic Core Curriculum Prescribe Framework for Learning Time

	Primary education level						Lower secondary education level			Upper secondary education level
Learning areas	G1	G2	G3	G4	G5	G6	G7	G8	G9	G 10 - 12
Thai Language	200	200	200	200	200	200	120 (3 crs)	120 (3 crs)	120 (3 crs)	240 (6 crs)
Mathematics	200	200	200	200	200	200	120 (3 crs)	120 (3 crs)	120 (3 crs)	240 (6 crs)
Social Studies	200	200	200	200	200	200	160 (4 crs)	160 (4 crs)	620 (4 crs)	320 (8 crs)

(continued)

(continued)

Learning areas	Primary education level						Lower secondary education level		Upper secondary education level	
	G1	G2	G3	G4	G5	G6	G7	G8	G9	G 10 - 12
History	40	40	40	40	40	40	40 (1 crs)	40 (1 crs)	40 (1 crs)	80 (2 crs
Religion, Morality, Civics, Economic and Geogra-phy	80	80	80	80	80	80	120 (3 crs)	120 (3 crs)	120 (3 crs)	240 (6 crs)
Health and Physical Education	80	80	80	80	80	80	80 (2 crs)	80 (2 crs)	80 (2 crs)	120 (3 crs)
Occupation and Tech-nology	40	40	40	80	80	80	80 (2 crs)	80 (2 crs)	80 (2 crs)	120 (3 crs)
Foreign Lang-uages	40	40	40	80	80	80	80 (2 crs)	80 (2 crs)	80 (2 crs)	120 (3 crs)
Total learning time (basic level)	840	840	840	840	840	840	880 (22 crs)	880 (22 crs)	880 (22 crs)	1,640 (41 crs)
Learner develop-ment activities	120	120	120	120	120	120	120	120	120	360
Additional courses activities	Not more than 40 hours for each year						Not more than 200 hours for each year		Not less than 1,600 hours	
Total learning time	Not more than 1,00 hours for each year						Not more than 1,200 hours for each year			Not less than 3600 hours for a total of 3 years

Note. Learning time structure: Reprinted from Basic Core Curriculum p. 25.

The Basic Education Core Curriculum was designed to push students to reach their full potential. This curriculum was created with the intention of producing the physical, intellectual and moral development of Thai students. The overarching goal of this curriculum is to produce responsible and productive members of Thai society. Teachers of this curriculum are encouraged to use a student-centered approach.

STEM education has been recently introduced in Thailand. In March 2016, the Minister of Education took the first step in initiating STEM education in Thailand by appointing board members to research best practices and to develop a STEM curriculum (Ministry of Education Thailand, 2016). Additionally, the British Council Thailand has partnered with the Institute for the Promotion of Teaching Science and Technology and the office of Vocational Education Commission to create a national STEM curriculum (British Council Thailand, 2016).

There is a great need for STEM education in Thailand. Thailand's aging infrastructure requires bright young minds to develop cost-effective structures. Thailand is often dependent on other countries for transportation systems, machinery and electronics, limiting its ability to complete the process of globalization. According to Associate Professor Soranit Silthram, the permanent secretary of the Ministry of Science and Technology, Thailand is experiencing a significant economic shift from low wage jobs to jobs that require creativity and innovation (Akin, 2016).

One obstacle to implementation of STEM education in Thailand is the lack of English proficiency among the Thai population. According to English Proficiency Index in Thailand position 16 out of 21 countries in Asia (English Proficiency Education First, 2019). English proficiency is not required to work in STEM fields, but it is a necessary skill for those in STEM fields who work for international companies. For this reason, it is critical for STEM students to be able to receive instruction in English rather than instruction in Thai. In

Thailand, the language of instruction is Thai, but studying STEM subjects in Thai limits students, as much of the essential STEM vocabulary does not have Thai equivalents. If the rate of English proficiency in Thailand does not increase, Thailand will be unable to compete globally in STEM fields.

Where STEM Education Has Been Implemented

STEM education has been implemented in the following countries, among others: the United States, Canada and Qatar.

As mentioned earlier, the United States is the birthplace of STEM education, which was developed as a result of the disappointing results in STEM-related disciplines at United States' schools. It took some time to properly implement STEM education, but the end result was positive. It was researched by the Department of Commerce that the jobs regarding STEM education were now the highest paying jobs in the country, and had the possibility to offer the highest job growth rate in all 50 states, in 2010. To be more specific 1 in 18 workers in the whole country were STEM graduates who also got paid 26% more than non-STEM graduates, further more because of implementing STEM education, over 17% growth rate in STEM related jobs was expected from 2008 to 2018, compared with an only 9.8% job growth rate for Non-STEM students. STEM career proved to be one of the key reasons of the continued growth and steady economy of USA (U.S. Department of Commerce, 2011). The STEM program was established in Australia in 2009. Its initial focus was on high school students. The success of STEM in Australia is shown by the fact of how so many major universities stood behind the program with greatest amount of support.

Ever since the establishment of STEM education, scholars and teachers have found themselves in an utmost admiration of the things STEM field was capable of achieving. Gradually the brilliance of STEM education spread across the whole world leaving country's officials no choice but to apply this innovative and lucrative educational system in their own states. Some of these countries include the United States, Australia, Canada, Turkey and Qatar.

Canada ranked 12th out of the 16 countries which are involved in STEM education. This ranking puts Canada above the United States by 21.2 %. The peer country that had the greatest amount of STEM graduates was Finland. Out of all the graduates in all of Finland 30% of these students studied STEM education (Conference Board of Canada, 2013).

Qatar is well known for its STEM program. However, they implanted the STEM program through one of their own local program known as, AL-Bairag. AL-Bairag mostly initiates its STEM methods towards high school students. AL-Bairag along with Qatar University Center for Advanced Materials encourages high school students to practice innovative scientific experiment. It enforces students to reach their true potential in STEM related disciplines (UNESCO Dubai, 2017).

Female STEM Participation in Asia

In Asia, only 3 out of 18 countries had an equal or above Female participation in STEM, the Philippines (52 percent), Thailand (51 percent) and Kazakhstan (50 percent)- according to the latest data from UNESCO's Institute for Statistics (researchers in science, technology and innovation). The Nobel laureates in physics, out of 199 only 2 have been women and none from Asia. Lack of female role models in STEM at school and in the workplace feeds disparities (UNESCO Bangkok, 2015).

In Cambodia only 11 percent of female graduates of science programs in year 2011. Female Cambodian student found to give more correct answers compared to male students. However, when female students hesitate to ask questions during the lesson, some female students even wait until the class was over to ask specific questions to their teachers.

Moreover, students would not participate when question asked by teachers and when giving an answer shows a higher level of reluctance, shakiness and anxiety when answering questions (UNESCO Bangkok, 2015).

In Indonesia, the content of teaching and learning materials, particularly textbooks, continues to permeate gender stereotypes in the ways in which they portray the roles of females and males with regards to STEM-related subjects. An image from a Grade 7 science textbook for instance shows students learning science, all of them being male. In another example from a Cambodian Grade 9 science textbook, an image on the central nervous system and the different functions of the brain depicts males as thinking and exercising as opposed to females who are depicted as smelling flowers and tasting food (UNESCO Bangkok, 2015).

In Viet Nam, while male students seemed less confident in presenting in front of the classroom, the number of interactions between teachers and male students were far higher than with female students, averaging at 65 per cent for mathematics and 61 per cent for science (UNESCO Bangkok, 2015).

In Malaysia, the proportion of female graduates in science program in tertiary education in Asia, data shows that as of 2011, this stood at 59 per cent in Malaysia. According to Programme for International Student Assessment 2012 results for instance, boys outscored girls in mathematics by 8 points in Malaysia (UNESCO Bangkok, 2015).

Positive and Negative Impacts of STEM Education

Positive Impacts of STEM Education

Countries within the European Union (EU) are more supportive of STEM education integration and have a higher budget for students to study these fields as the work force for hard labor is generally occupied by immigrants and migrants, who do not hold a sufficient degree to work in other sophisticated fields. This is more or less a success story for STEM education as most of the technological advancements are made within countries such as Germany as well as the United Kingdom. The main aspect which allows scholars to devote their life and time into STEM field is because the government funds most of the citizen's education fees which gives citizens the incentive to not only strive for a bachelors or master's degree but also return the favor by working for STEM field research facilities that are mostly run by the government or have benefits towards the country's reputation and infrastructure.

Negative Impacts of STEM Education

On the other hand, the United States as nation could be facing shortage of work force in other fields as the government focuses too much funding on STEM faculties, as there is a social discrimination that students face to study other less sophisticated fields. Studying STEM education in the 20th century has been compared to being literate in the 19th century (Ossola, 2014, Dec 3). As there is too much initiative for students to focus on STEM field, there is a range of suffering fields such as arts, philosophy, and social sciences. This can also impact the world on a sociological scale as there is a lack of range in types of people if the education system of developed countries focus too much of their work force on STEM career. In terms of sociology, for people to be able to differentiate and be vaster, it is important for governments to back all types of studies so that their population can be diversified. It is not efficient, nationally to intensify particular fields of study such as STEM field, it will diminish the availability of diversity within a nation.

Teachers' Self-Efficacy for Teaching STEM Subjects

Teachers' STEM Teaching Self-Efficacy and Beliefs

STEM teaching self-efficacy and beliefs for teaching STEM subjects is one of the five constructs of psychologist Albert Bandura's social cognitive theory (1989, 1994, 1997), which states that learning takes place in a social context.

Self-efficacy refers to a person's perspective on his or her capabilities.

Reciprocal determinism is the principal idea of social cognitive theory (Bandura, 1997). This theory refers to the interactions between person, environment and behavior, as seen in Figure 3. All perform as interrelating factors which influence each other bilaterally (Bandura, 1978).

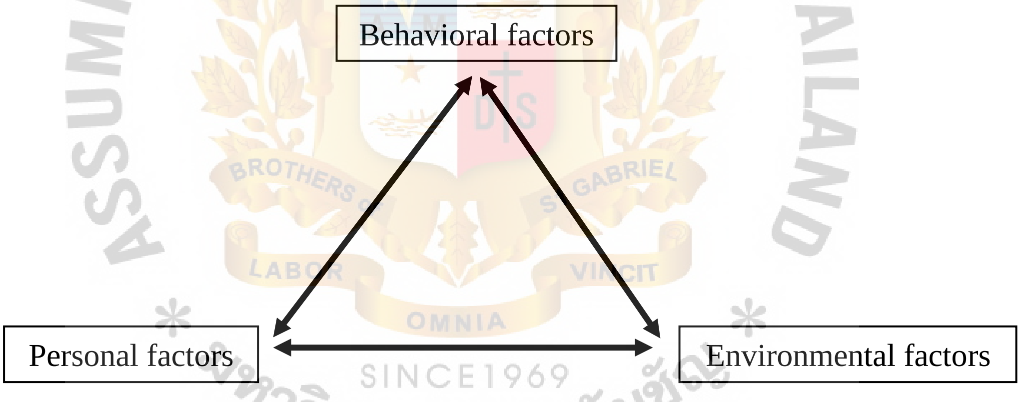

Figure 3. Triadic reciprocal determinism.

The way that people think, believe and feel affects their behavior (Bandura, 1989). Personal factors include "expectations, beliefs, self-perceptions, goals and intentions." The environment does not exert any influence until it is activated by particular behaviors (Bandura, 1989). As an example of the interrelationship between these three factors, teacher performance (behavioral factors) is influenced by how teachers themselves are affected (personal factors) by school strategies (environmental factors).

Bandura (1997) outlines four sources of self-efficacy.

1. Mastery experiences – This refers to direct or past personal experiences, which are the most influential of the four types of experiences. Past performance success tends to enhance STEM teaching self-efficacy and beliefs; teachers are more likely to believe they can do something new if it is similar to something they have already done well (Bandura, 1994). Providing opportunities for teachers to gain mastery through training programs in order to become proficient STEM teachers can increase their self-efficacy in teaching STEM subjects;
2. Vicarious experiences – This refers to social comparison or modeling experiences, which are the second most influential type of experiences. Teachers can observe other teachers as a form of professional development and as a way to improve their own teaching practices. This allows teachers to learn from each other's strength and weaknesses;
3. Support experiences – This refers to feedback or support given following a performance. This feedback might come from administrators, other teachers or students and;
4. Emotional experiences – This refers to a person's response to their circumstances. The impact of negative emotions, such as anxiety and fear, correlates to a lower level of self-efficacy. However, feeling calm and competent contributes to a higher level of self-efficacy.

Teachers' STEM teaching self-efficacy affects their performance in the classroom. Teachers with a lower level of self-efficacy are more likely to perform at a lower level than teachers with a higher level of self-efficacy. Teachers with a higher level of self-efficacy will attempt to challenge themselves to perform better, leading to a higher level of student performance (Butucha, 2013).

A teacher's belief about teaching STEM subjects about his or her ability to implement STEM education is critical, as this belief can determine a teacher's level of success (Lesha, 2017). STEM education represents an innovative, nontraditional approach to teaching, so in order to foster student learning, teachers must use a new approach when implementing STEM pedagogy.

Teachers' STEM teaching self-efficacy and beliefs can be greatly enhanced through their school culture. School leaders and administrators can help teachers improve their self-efficacy by encouraging teachers to take on leadership roles and to take initiative to work together to meet mutual goals. The demand of teaching can be overwhelming because of changes in pedagogy and content knowledge, as well as the responsibilities of creating lesson plans, grading, teaching multiple courses and supervising multiple extracurricular activities, but building a collaborative environment between teachers and school administrators can motivate teachers.

The key to effective STEM education is the teacher's knowledge of STEM pedagogy. Research conducted in 2017 of 154 randomly selected STEM and non-STEM teachers in Thailand found that 85.5% of teachers had never heard of STEM education, 19% could not explain STEM education and 20.53% view STEM as a trans-disciplinary course (Srikoom, Hanuscin & Faikhamta, 2017). It is clear that most teachers have an inadequate knowledge of STEM subjects, of how STEM subjects are interconnected and of STEM pedagogy. If self-efficacy requires knowledge, these teachers' self-efficacy can only be low.

Teachers' STEM Teaching Outcome Expectancy & Teachers' STEM Instruction

STEM instruction has always been considered a central element of pedagogy, as it provides an overall understanding of how content should be taught over the course of study, while teachers' STEM teaching outcome expectancy is the result. As STEM instruction is positively related to STEM teaching outcome expectancy, the researcher has reviewed these two variables together. However, STEM instruction does not rely only on teachers' roles in instructions, but also on student motivation and desire to learn and participate.

Teachers' STEM teaching self-efficacy can have a significant impact on student motivation to achieve higher test scores and engage in content-driven dialogue (Chang & Hu, 2017). As stated earlier, Bandura's social cognitive theory states that students learn better in a social context, which is the argument for what he terms collective efficacy which can be defined as a group's shared belief in its conjoint capabilities to organize and execute the courses of action required to produce given level of attainments (Bandura, 1997, p.477). Teachers and students working together can lead to a higher level of collective efficacy. It is impossible to improve STEM instruction and STEM teaching outcome expectancy without increasing a school's budget (Brown & Kurzweil, 2017). Expenses include technology and tools to support high order thinking, educational games, and lab equipment and supplies, all of which can allow students to participate in more challenging activities in order to develop problem-solving skills through investigation within real world contexts.

The role of communication is essential to effective STEM instruction and STEM teaching outcome expectancy. Use of effective language skills is associated with high self-efficacy for teachers and students (Chang & Hu, 2017). Teachers' and students' communication competence and self-efficacy complement one another. Also, interpersonal communication improves student ability to reason abstractly and quantitatively.

Interpersonal communication in a learning environment is known as STEM instruction, which is affected by the planning of instruction and by classroom procedures which can allow students to provide feedback to one another and critique each other's reasoning without resulting in conflict. Teachers can integrate skills through their interpersonal communication with students through these processes.

Student assessment takes place at the end of the course in order to inform teachers and students about the current level of understanding and skill acquisition. Because written examinations are given more importance than practical assessments such as skill assessments and project-based learning, teachers spend more time teaching scientific knowledge than helping students develop their skills. STEM Instruction results in a theoretical focus rather than a practical focus, presenting an obstacle by limiting student knowledge to facts and theories. STEM teaching outcome expectancy and STEM instruction should be more focused on the development of students' skills rather than on the content to be covered. In this time of globalization and rapid technological change, it is important for teachers to emphasize skills over knowledge.

Students should not be tested based on their ability to memorize the textbook but on their explanation and association of various ideas and concepts. In order to successfully implement STEM teaching outcome expectancy and STEM instruction, teachers must consider other factors including student behavior, socioeconomic status, culture and values. Students can be affected by many factors both inside and outside school, all of which affect their progress.

Teachers' Attitudes Toward STEM Education

Teachers' attitudes are an important factor that can inspire learning. Attitudes are "relatively enduring organization of beliefs, feeling and behavioral tendencies towards social significant objects, group, event or symbols" (Hogg & Vaughan, 2010, p.150). Teachers' attitudes may have an impact on multiple classroom factors including class discipline, peer acceptance and student's academic success. They also impact the instructional strategies and discipline practices used by teachers (Kagan, 1992). Therefore, attitudes influence the academic and social success of STEM students.

Teachers' attitudes may be influenced by many factors, including their gender, their physical environment and their experience. Research reveals a difference in attitude based on gender, such as female teachers' positive attitudes towards children with special needs in their class (Avramidis & Norwich, 2002). Forlin 's research (2001) discovered that male teachers have a more positive attitude than female teachers do when under greater stress and facing difficulties in perceived professional ability. Moreover, a study by Stauble (2009) found that there is a change in attitudes according to other factors such as a negative correlation between teacher attitude and grade level; the higher the grade, the more negative the teachers' attitudes. The same research revealed that teachers who teach mathematics have a more negative attitudes than those who teach language arts and social studies. Understanding how teachers' attitudes are formed and ultimately how they may be changed can lead to increased student academic achievement because teachers' attitudes have an overwhelming impact on students achieve and classroom management (Martin, Yin, & Mayall, 2006).

A commonly used model of attitudes is the Affect, Behavior, Cognitive (ABC) model, which is used to identify the factors that comprise attitudes. The ABC model of attitudes originated from rational emotive behavior therapy created by Dr. Albert Ellis in the 1950s. (David, 2017). A, the affective component, refers to an emotional response to an object that can be measured by physiological responses such as heart rate and galvanic skin response. B, the behavioral component, refers to overt actions, such as a previous experience, which affects the state of readiness to take action towards an object. This can include behavioral intentions and verbal statements regarding behavior. C, the cognitive component, refers to consequences or beliefs, perceptual responses, knowledge and thoughts towards an object.

Student Technology Use in STEM Classes

Many students worldwide now grow up using technology to communicate and interact with society. These students have access to computers and the Internet, allowing them to retrieve information and learn by themselves also termed the “flipped classroom”, this practice takes content and events traditionally given in the classroom and transfer them to the outside the classroom (Kelly, 2015). Touch screen devices have replaced pen and paper in many contexts. Technology can be misused, but teachers can help students exploit the benefits of technology (Chomphuchart, 2017). Because of this shift, schools must meet students where they are, which in terms of how they process information, is ahead of where they used to be. In order engage these students varies form of technology must be used in the classroom on a daily basis.

Attitudes are key factors in whether teachers use information and communication technologies in their teaching practices (Hogg & Vaughan, 2010). There is a variety of technology available to teachers, including eBooks, SMART boards, educational applications, online educational games and videos and interactive educational software, among others. In classrooms around the world, teachers are no longer limited to paper and pencil, but have so many more options to make learning more engaging. However, whether or not teachers make use of the available technology depends on their attitudes towards it.

Peck and Dorricott (1994) identified ten reasons why technology should be used in the classroom:

1. Technology enables students to learn at their own pace and allows teachers to personalize instruction.
2. Technology allows students to practice retrieving, assessing and communicating information.
3. Technology, specifically word processors, improves student writing.

4. Technology supports the use of higher order thinking, including the ability to organize, analyze, interpret, develop, synthesize and evaluate information.
5. Technology encourages students' artistic expression by promoting creative representation of information.
6. Technology enables students to access resources and communicate and collaborate beyond the classroom.
7. Technology presents the opportunity for students to explore real world learning opportunities in a new way.
8. Technology allows students to be more engaged in their learning.
9. Students need to feel confident using technology in order to prepare them for the future challenges and opportunities.
10. Technology allows school to make better decisions regarding the role of the teacher in order to become more effective.

Even though educational technology is not a new concept, it has yet to influence education on a large scale, possibly because using these dynamic, media-rich digital resources will require teachers to change their teaching style and attitudes towards technology (Alrasheedi, 2009).

Technology can greatly benefit students, schools and societies when it is implemented well in education. Teachers need to view their students' technological competence as a benefit and must take advantage of it in order to create a stimulating, engaging classroom environment. Teachers' goal must be to help students find their passion and make meaningful contributions to society and technology is a means to achieving this goal.

21st Century Learning Attitudes

The current educational system must adopt a 21st century learning approach in order to meet the needs of 21st century students. According to Prensky (2001), Today's student has changed completely. Education system can no longer teach them like before. Prensky (2006, p.2) also writes, as educators, we must understand students from 21st century innovations and their behaviors abandoning, Teacher have to create an engaging lesson and allow students to feel in their comfort zone before focusing on the content to be taught.

The International Educational Advisory Board's *Learning in the 21st Century: Teaching Today's Students on Their Terms* report identified these characteristics of Millennials, who are identified as those born between 1980 and 2000: (Villancio, Padilla, & Mangoba, n.d.)

- They like to be in charge;
- They like to have options;
- They prefer being a part of a group;
- They prefer including others;
- They are adept at the use of digital technology;
- They prefer to take risks; and
- They enjoy free time.

In order to engage millennials, these characteristics must be acknowledged and catered to. Moreover, the current educational system must adopt a 21st century learning approach in order to meet the demands of the 21st century.

P21's Framework for 21st Century Learning has identified four 21st century student outcomes: content knowledge and 21st century themes; learning and innovation skills; information, media and technology skills; and life and career skills. Content knowledge includes all core subjects, like English, language arts, foreign languages, mathematics and science. Twenty-first century themes include global awareness, financial literacy and environmental literacy, among others. The four C's of 21st Century skills are

- creativity allows student to develop original work and trying new approaches to invention through creative process;
- critical thinking in 21st century is defined as ability to plan and design problem, solve problem and create an effective solution using a variety of tools and resources;
- communication in a 21st century context refers communication effectively using a variety of digital tools; and
- collaboration in a 21st century context requires the ability to learn and work as a team using social network to diversify and contribute to the learning of others.

21st century learning comprises the learning and innovation skills. Information, media and technology skills are self-explanatory, while life and career skills include flexibility, initiative and social skills, among others.

Teachers must embrace the pedagogical modifications made necessary by the shift from the industrial age to our current information age. In her 2003 book *ICT in Education*, Victoria L. Tinio provides a comprehensive breakdown of the changes in pedagogy from the industrial age to the information age, which are highlighted in Table 3.

Table 3

Overview of Pedagogy in the Industrial versus the Information Age

Aspect	Less ("traditional pedagogy")	More ("emerging pedagogy" for the information society)
Active	-Activities prescribed by teacher	-Activities determined by learners
	-Whole class instruction	-Small groups
	-Little variation in activities	-Many different activities
	-Pace determined by the program	-Pace determined by learners
Collaborative	-Individual	-Working in teams
	-Homogenous groups	-Heterogeneous groups
	-Everyone for him/herself	-Supporting each other
Creative	-Reproductive learning	-Productive learning
	-Apply known solutions to problems	-Find new solutions to problems
Integrative	-No link between theory and practice	-Integrating theory and practice
	-Separate subjects	-Relations between subjects
	-Discipline-based	-Thematic
	-Individual teachers	-Teams of teachers
Evaluative	-Teacher-directed	-Student-directed
	-Summative	-Diagnostic

Note. Reprinted from "ICT in Education" by Victoria L. Tinio., 2013.

Teacher Leadership Attitudes

Teachers serve as school leaders as well as classroom leaders. Teachers can demonstrate leadership outside the classroom in the following ways (Harrison & Killion, 2007)

- Sharing resources with other teachers

  The teacher-leader helps other teachers by sharing resources they have created as well as resources they have found. These resources can include lesson plans, games, manipulatives, songs, visual aids, websites, worksheets, assessments and ideas. Sharing resources allows teachers to make better use of their time. This sharing can encourage other teachers to share their own resources and, in this way, instruction delivered by all of these teachers can be enhanced. Sharing resources allows teachers to make better use of their time by giving them easy access to suitable resources;

- Sharing and demonstrating effective teaching strategies

  The teacher-leader ensures that teachers implement effective, research-based instructional strategies. These teachers have the ability to motivate other teachers and willingly participate in in-house professional development by observing their peers, providing constructive feedback and helping their peers adapt their teaching strategies. These teacher-leaders also welcome observations by their peers. These practices create a community of practice that allows the teachers to learn together in order to enhance student instruction and engagement;

- Sharing curriculum knowledge

  The teacher-leader has a thorough understanding of the relevant standards and curriculum and can be sought out by teachers who have questions about both. The teacher-leader encourages other teachers to understand and follow the standards and curriculum. The teacher-leader has the ability to identify curriculum that aligns with local and national standards;

- Involvement in decision making with administrators and external influences

  The teacher-leader can help administrators identify and solve problems. The teacher-leader is respected as a leader by administration and can communicate effectively with administration;

- Encouraging change

  The teacher-leader encourages change by introducing new ideas, making observations and challenging current practices when needed. The teacher-leader recognizes that growth requires change and;

- Facilitating professional development

  The teacher-leader considers professional development as a necessary continuous pursuit. This teacher contacts educational experts to conduct training relevant to the teachers' needs. The teacher-leader encourages teachers to study books together and to share their own knowledge with their colleagues.

In the classroom, the teacher can serve as a leader by taking responsibility for students' learning. Teachers must know their students and know their students' learning styles in order to make sure that they teach their students effectively (Lauermann, 2013). The teacher-leader believes that if a student has not learned, the teacher has not taught. If a student is struggling with a particular concept, the teacher-leader will take that student aside and teach it to him or her in a different way.

The teacher-leader doesn't teach only content but also recognizes the importance of teaching the traits of good character. This teacher does not use students' ability to memorize as the only indicator of success, but also uses projects, observations, classroom interactions, portfolios and oral communication in addition to written tests to evaluate student progress.

Wattana Wittaya Academy

Wattana Wittaya Academy is Thailand's first boarding school for girls. It was founded by Ms. Edna S. Cole in 1874. The school is located at the end of Sukumvit 19 in the Wattana district of Bangkok. The school vision is to create an education environment for young women under the guidance of Christianity to enhance proper etiquette and academic capability to meet international standards. Wattana Wittaya Academy is a day school from kindergarten through Grade 6 and boarding school from Grade 7 through Grade 12. Wattana Wittaya Academy's motto is "Morality precedes academic knowledge."

The standard dress for all girls is red skirt and white blouse, usually Thursday is dedicated to scouting, the scout uniform is blue uniforms with blue neckerchiefs. The use of accessories is prohibited. All students are prohibited from coloring their hair and having tattoos.

The academic plan and management are according to Thailand's National Education Act B.E. 2542 (A.D. 1999). The current curriculum blends the classics with modern and world perspectives and integrates technology with traditional teaching methods empowering students to make positive changes within the school and the wider community. The classroom environment allows all students to experience education through learning, discussion and collaborative work between teachers and students. The process of learning emphasizes the discipline of passion in reading, research and a life time pursuit of their personal best to become healthy, caring and productive adults.

At present, Wattana Wittaya Academy provides an English Intensive Course for students in the elementary and secondary levels. This program serves students who focuses on strengthen student English through an advanced curriculum and learning environment. The STEM project (iSTEM) was introduced in October 2015. The project aims to create a portfolio to showcase student work. The STEM project operates from early childhood to upper secondary. Student work is uploaded on the school's website as inspiration for others; the uploaded work includes a hotdog solar energy cooker project, a roller coaster project, and a tallest building project, among others. Students are also awarded prizes through a process which allows students and parents to vote for their favorite project. The school also have a facebook page @STEMWWA where school updates student STEM activity, the most recent project is transport lunch box and roof for charity; student make roof from recycle milk box. The reason why the school uses facebook as a platform is to allow students to brainstorm to answering questions related to their projects.

The science teachers at Wattana Wittaya Academy are, at present, teaching science separately from the other STEM subjects. They would like to teach STEM as an integrated subject, but are not sure if they have the required expertise or the necessary time. This is why, in 2017, Wattana Wittaya launched STEM education as a summer school activity for the students. However, the school administrator and ten representative teachers participated in the free seminars yearly organized by The Institute for the Promotion of Teaching Science and Technology (IPST) held at their headquarters in Bangkok, Thailand. Moreover, the school has recently created a STEM department and is looking forward to creating a STEM curriculum from early childhood to upper secondary.

The school is in partnership with EduPark Co, a company that provides tools such as creative toys and educational games and conduct trainings for teachers to learn ways to incorporate creative toys and games in their lessons. Wattana Wittaya

Academy have showcased their computer labs for decades as a critical resource to help students with their education and learning. The use to technology is according to their grade level. The use of technology is lower among student in the lower school level such as kindergarten and lower primary compared to secondary level. A close-ended questionnaire called Teacher Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM

Education (see Appendices A and B) was used to measure level of student technology use is not applicable to all teachers specially the lower level.

In kindergarten to Grade 2, Wattana Wittaya demonstrate the opportunities to use input devices such as mouse, keyboard, remote control. In Grade 3, student uses a variety of media and technology resources for directed and independent learning activities. Students will use technology to work cooperatively and collaboratively. Students will use technology tools such as multimedia authoring, presentation, web tools, digital cameras, scanners for individual and collaborative writing, communication, and publishing activities to create knowledge product. In Grade 3 to Grade 5, student uses technology resources such as puzzles, logical thinking programs, writing tools, digital cameras, drawing tools for problem solving, communication, and illustration of thoughts, ideas, and stories. Student will be able to gather information and communicate with others using telecommunications, with support from teachers. In Grade 6 onwards, student use content-specific tools, software, and simulations such as, environmental probes, graphing calculators, exploratory environments, Web tools to support learning and research. Grade 10 to Grade 12, student will select and apply technology tools for research, information analysis, problem. Student should be able to evaluate the accuracy, relevance, appropriateness, comprehensiveness, and bias of electronic information sources.

CHAPTER III

RESEARCH METHODOLOGY

In the previous chapter, the researcher presented the literature review of STEM education, self-efficacy and attitudes. This chapter will discuss the research design of the study, the population and samples, and the research instrument. This will be followed by data collection for the study, data analysis, and a summary of the study.

Research Design

The research design for this study is a quantitative comparative study of teachers' self-efficacy teaching STEM subjects and attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand. A close-ended questionnaire called Teacher Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education (see Appendices A and B) is the only instrument used in this research study to collect the data. The questionnaire was distributed to 67 teachers teaching STEM subjects for the research.

This instrument measured teachers' self-efficacy teaching STEM subjects and attitudes toward STEM education. For Objective 1, descriptive statistics, means and standard deviations was used to analyze teachers' level of self-efficacy teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand. For Objective 2, descriptive statistics, means and standard deviations was used to analyze teachers' level of attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand. For Objective 3, an independent samples *t*-test was used to analyze the difference between teachers' self-efficacy teaching STEM subjects according to gender at

Wattana Wittaya Academy, Bangkok, Thailand. For Objective 4, an independent samples *t*-test was used to analyze the difference between teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

Population

The total population of this research is 67 teacher teaching mathematics, science and information communication technology teachers of Grade 1 to 6 as well as mathematics, biology, chemistry, physics and information communication technology teachers of grades seven to twelve at Wattana Wittaya Academy, Bangkok, Thailand, during the 2019-2020 academic year.

Sample

A population sampling method was used in this study. The researcher chose to study the entire population of 67 teachers which consist of 17 male teachers and 50 female teachers teaching STEM-related subjects at Wattana Wittaya Academy, Bangkok, Thailand during the 2019-2020 academic year. Below is the Table 4 detailing teachers teaching STEM-related subjects in each department by gender.

Table 4

Total STEM Teachers at Wattana Wittaya Academy Categorized by Department and Gender

Department	Male	Female	Total
Primary	8	23	31
Secondary	9	27	36
Total	17	50	67

Research Instrument

One instrument was used in this study. The questionnaire called T-STEM survey (see Appendices A and B) was used to assess the level of teachers' STEM teaching self-efficacy and attitudes toward STEM education. The overview of measurement application for each variable in different part and items can be seen in Table 5.

Table 5

Overview of Measurement Application for Each Variable and Item Numbers

Variables & measurement application	Item no.	Total
Teachers' self-efficacy for teaching STEM subjects		
Teachers' STEM teaching self-efficacy and beliefs (Self-efficacy and confident related to teaching the specific STEM subject)	1-11	11
Teachers' STEM teaching outcome expectancy (The degree to which the respondent believes in general, student-learning in the specific STEM subject can be impacted by an action of the teacher)	12-20	9
Teachers' STEM Instruction (How often teacher use certain STEM instructional practices)	38-51	14
Teachers' attitudes toward STEM education		
Student technology use in STEM classes (How often student use technology in the classes)	52-59	8
21st century learning attitudes (Attitudes toward student learning opportunities for 21st century skills)	21-31	11
Teacher leadership attitudes (Attitudes toward teacher leadership activities)	32-37	6
Total		59

The questionnaire was designed to determine the impact of STEM programs developed by principal investigator Warwick Arden the following co-investigators Weibe, Ragan and Picart at The Friday Institute for Educational Innovation at the College of Education at North Carolina State University (2012) on teacher efficacy and attitudes. This study is a part of the Maximizing the Impact of STEM Outreach through Data-Driven Decision-Making (MISO) project and received funding from the Golden Leaf Foundation.

The questionnaire (see Appendices A and B) consists of two parts. Part one asks teachers to identify their gender. Part two asks teachers to respond to statements about their STEM teaching self-efficacy and attitudes. Principal investigator Warwick Arden and team of investigators at North Carolina State University developed five versions of the T-STEM questionnaire: one each for teachers of science, technology, engineering and mathematics and one for the elementary teacher. The questionnaire contains seven variables, the following three of which relate to the teacher's specific STEM subject: teaching efficacy and beliefs, teaching outcome expectancy and instruction. The other four variables are student technology use, 21st century learning attitudes, teacher leadership attitudes and STEM career awareness (Arden, Weibe, Ragan, & Picart, 2012).

The researcher made slight modifications to North Carolina State University's T-STEM questionnaire. The researcher adapted the T-STEM questionnaire by removing the specific content area of the following variables: teaching efficacy and beliefs, teaching outcome expectancy and instruction. The last variable, STEM career awareness, is not included, as the researcher perceived it to be irrelevant to the purpose of this study. Finally, the wording of several items was slightly altered.

These subscales utilize a five-point Likert scale, which is presented in Table 5. For four of the variables including teachers' STEM teaching self-efficacy and beliefs, teachers' STEM teaching outcome expectancy, 21st century learning attitudes and teacher leadership attitudes, teachers responded to the statements using a five-point Likert scale from one *(strongly disagree)* to five *(strongly agree)*. For the other two variables, student technology use in STEM classes and teachers' STEM instruction, teachers responded to the statements using a five-point scale from one *(never*) to five *(every time)*, which is presented in Table 6.

The scale of interpretation of Teachers' Self-Efficacy For Teaching STEM Subjects and Attitudes toward STEM Education is displayed in Tables 6 and 7 for means of each item and for the mean of overall items.

Table 6

Interpretation of Teachers' Self-Efficacy for Teaching STEM Subjects Scores of Questionnaire Result

Agreement level	Score	Scale	Interpretation
Strongly agree	5	4.51-5.00	Very high
Agree	4	3.51-4.50	High
Neither agree nor disagree	3	2.51-3.50	Moderate
Disagree	2	1.51-2.50	Low
Strongly disagree	1	1.00-1.50	Very low

Table 7

Interpretation of Teachers' Attitudes Toward STEM Education Scores of Questionnaire Results

Agreement level	Score	Scale	Interpretation
Every time	5	4.51-5.00	Very positive
Usually	4	3.51-4.50	Positive
About half the time	3	2.51-3.50	Neutral
Occasionally	2	1.51-2.50	Negative
Never	1	1.00-1.50	Very negative

Validity and Reliability of the Research Instrument T-STEM Questionnaire

The validity and reliability of all items of the instrument can be found from the questionnaire's original findings. The first two variables under teachers' self-efficacy for teaching STEM subjects, teachers' STEM teaching self-efficacy and beliefs and teachers' STEM teaching outcome expectancy, were adapted from a science teaching efficacy belief questionnaire (Riggs, & Enochs, 1990). Several items of this questionnaire were removed and the wording was modified to use student growth language in place of student achievement language. The last variable under teachers' STEM teaching self-efficacy, teachers' STEM instruction, was built on the item used in the statewide assessment of North Carolina's Race to the Top grant (Corn, 2013)

The remaining three variables, the attitude toward STEM education variables, were developed from the Student Technology Needs Assessment (2005). The 21st century learning attitudes construct was adapted from the Friday Institute's Student Learning Conditions Survey (2010). Finally, each item in the teacher leadership attitudes construct was taken from the North Carolina Department of Public Instruction's Professional Standards for Educators (2012).

The original pilot teacher surveys analyzed by Principal investigator Warwick Arden and team of investigators at North Carolina State University responses from 257 science teachers, 72 technology teachers, 17 engineering teachers, 120 math teachers, and 218 elementary teachers. The results of the reliability test in Table 8 showed the Cronbach's alpha of greater than .8 for all variables, meaning that the measurement of variables is considered good.

Table 8

T-STEM Questionnaire Reliability

Variables	Number of items	Cronbach's alpha
Teachers' STEM teaching self-efficacy and beliefs	11	.90
Teachers' STEM teaching outcome expectancy	9	.81
Teachers' STEM instruction	14	.93
Student technology use in STEM classes	8	.90
21st century learning attitudes	11	.94
Teacher leadership attitudes	6	.87
Total	59	

Collection of Data

The permission from the principal of Wattana Wittaya Academy, Bangkok, Thailand was requested and granted on 3 June 2019. After permission was granted, the researcher distributed the T-STEM questionnaires. All 67 questionnaires were distributed to teachers teaching STEM-related subject. Table 9 provides an overview of the data collection process of this research.

Table 9

Data Collection Process

Date	Task
3 June 2019	Permission granted
4 June 2019	Data collection for primary level
5 June 2019	Data collection for secondary level

Data Analysis

The collected data was analyzed according to the research objectives by using Statistical Package for the Social Sciences (SPSS) software to address the following research objectives.

1. To determine the level of teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand

   Method: Means and standard deviations were used to determine the level of teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

   1.1. To determine the level of teachers' STEM teaching self-efficacy and beliefs according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

   Method: Means and standard deviations were used to determine the level of teachers' STEM teaching self-efficacy and beliefs according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

   1.2. To determine the level of teachers' STEM teaching outcome expectancy according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

   Method: Means and standard deviations were used to determine the level of teachers' STEM teaching outcome expectancy according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

   1.3. To determine the level of teachers' STEM instruction according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

   Method: Means and standard deviations were used to determine the level of teachers' STEM instruction according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

2. To determine the level of teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

   Method: Means and standard deviations were used to determine the level of teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

   2.1. To determine the level of student technology use in STEM classes according to teachers' gender at Wattana Wittaya Academy, Bangkok, Thailand.

   Method: Means and standard deviations were used to determine the level of student technology use in STEM classes according to teachers' gender at Wattana Wittaya Academy, Bangkok, Thailand.

   2.2. To determine the level of teachers' 21st century learning attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

   Method: Means and standard deviations were used to determine the level of teachers' 21st century learning attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

   2.3. To determine the level of teacher leadership attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

   Method: Means and standard deviations were used to determine the level of teacher leadership attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

3. To determine whether there is a significant difference in teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

Method: An independent samples *t*-test was used to determine whether there is a significant difference in teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

4. To determine whether there is a significant difference in teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

   Method: An independent samples *t*-test was used to determine whether there is a significant difference in teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

Summary of the Research Process

The research process of this study is summarized in Table 10.

Table 10

Summary of the Research Process

Research objectives	Source of data	Data collection method	Data analysis
1. To determine the level of teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand 1.1. To determine the level of teachers' STEM teaching self-efficacy and beliefs according to gender at Wattana Wittaya Academy, Bangkok, Thailand	A sample of 67 teacher teaching STEM related subjects at Wattana Wittaya Academy, Bangkok, Thailand	T-STEM Questionnaire	Descriptive statistics mean and standard deviation

(continued)

(continued)

Research objectives	Source of data	Data collection method	Data analysis
1.2. To determine the level of teachers' STEM outcome expectancy according to gender at Wattana Wittaya Academy, Bangkok, Thailand 1.3. To determine the level of teachers' STEM instruction according to gender at Wattana Wittaya Academy, Bangkok, Thailand 2. To determine the level of teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand 2.1. To determine the level of student technology use in STEM classes according to teachers' gender at Wattana Wittaya Academy, Bangkok, Thailand 2.2. To determine the level teachers' 21^{st} century learning attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand 2.3. To determine the level of teacher leadership attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand	A sample of 67 teacher teaching STEM related subjects at Wattana Wittaya Academy, Bangkok, Thailand	T-STEM questionnaire	Descriptive statistics mean and standard deviation

(continued)

(continued)

Research objectives	Source of data	Data collection method	Data analysis
3. To determine whether there is a significant difference between teacher's self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand 4. To determine whether there is a significant difference between teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand	A sample of 67 teacher teaching STEM related subjects at Wattana Wittaya Academy, Bangkok, Thailand	T-STEM questionnaire	Independent samples t-test

CHAPTER IV

RESEARCH FINDINGS

In Chapter III, the researcher explained the research design, the population and sample, the research instrument, followed by data collection, data analysis and a summary of the research process. In this chapter, the researcher presents the finding of the research objectives.

The quantitative study investigated and compared the difference in teachers' self-efficacy for teaching STEM subjects according to gender using three variables: teachers' STEM teaching self-efficacy and beliefs, teachers' STEM teaching outcome expectancy and teachers' STEM instruction. Furthermore, the researcher compared the attitudes toward STEM education according to gender using three variables: student technology use in STEM classes, 21st century learning attitudes and teacher leadership attitudes. The research instrument used in this study was the Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education questionnaire (see Appendices A and B), which is an adapted version of T-STEM developed by North Carolina State University (2012). The questionnaire consists of 59 items. The survey of teachers teaching STEM-related subjects was conducted from 3 June to 6 June 2019. The researcher distributed a total of 67 questionnaires to the target population at Wattana Wittaya Academy, Bangkok, Thailand and the respondents' valid return rate was 100%.

The findings of this study are presented in four sections: research findings of Research Objective 1, research findings of Research Objective 2, research findings of Research Objective 3, and research findings of Research Objective 4.

Research Findings of Research Objective 1

The first research objective was to determine the level of teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand. To address Research Objective 1, data were collected from 34 items from part two of the Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education questionnaire (T-STEM), which includes the following three variables: teachers' STEM teaching self-efficacy and beliefs, teachers' STEM teaching outcome expectancy and teachers' STEM instruction (see Appendices A and B). Table 11 shows the teachers' means and standard deviations of teachers' self-efficacy for teaching STEM subjects.

Table 11

Means, Standard Deviations, And Interpretations of Teachers' Self-Efficacy for Teaching STEM Subjects According to Gender at Wattana Wittaya Academy, Bangkok, Thailand

Variables	Gender	*M*	*SD*	Interpretation
STEM teaching self-efficacy and beliefs	Male	3.44	.80	Moderate
	Female	3.67	.44	High
STEM teaching outcome expectancy	Male	3.65	.59	High
	Female	3.66	.49	High
STEM instruction	Male	2.98	1.03	Neutral
	Female	3.28	.76	Neutral
Overall	Male	3.36	.72	Moderate
	Female	3.54	.45	High

The results in Table 11 show that the overall means of teachers' STEM teaching self-efficacy at Wattana Wittaya Academy, Bangkok, Thailand, was *M* = 3.36 for males, which was interpreted as moderate, and *M* = 3.54 for females, which was interpreted as high.

Research Findings of Research Objective 1.1

Research Objective 1.1 was to determine the level of teachers' STEM teaching self-efficacy and beliefs according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

To address Research Objective 1.1, the Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education questionnaire (T-STEM) was distributed to collect the data of teachers' STEM teaching self-efficacy and beliefs. The items related to teachers' STEM teaching self-efficacy and beliefs are found in part two and consist of Items 1 to 11, which also were related a five-point Likert scale (see Tables 6, Chapter III). Table 12 shows the means, standard deviations and interpretation of teachers' STEM teaching self-efficacy and beliefs according to gender.

Table 12

Means, Standard Deviations, And Interpretations of Teachers' STEM Teaching Self-Efficacy and Beliefs According to Gender at Wattana Wittaya Academy, Bangkok, Thailand

Item	Statement	Gender	*M*	*SD*	Interpretation
1	I am continually improving my STEM teaching practice.	Male	3.88	.60	High
		Female	3.88	.71	High
2	I know the steps necessary to teach STEM classes effectively.	Male	3.47	1.00	Moderate
		Female	3.52	.81	High
3	I am confident that I can explain to students why STEM experiments work.	Male	3.18	1.07	Moderate
		Female	3.68	.76	High
4	I am confident that I can teach STEM classes effectively.	Male	3.47	1.00	Moderate
		Female	3.70	.64	High
5	I wonder if I have the necessary skills to teach STEM classes.	Male	3.18	1.07	Moderate
		Female	3.26	.85	Moderate
6	I understand STEM concepts well enough to be effective in teaching STEM classes.	Male	3.18	1.13	Moderate
		Female	3.64	.85	High

(continued)

(continued)

Item	Statement	Gender	*M*	*SD*	Interpretation
7	Given a choice, I would invite colleagues	Male	3.47	1.17	Moderate
	to be evaluate my STEM teaching.	Female	3.70	.73	High
8	I am confident that I can answer students'	Male	3.35	1.11	Moderate
	STEM questions.	Female	3.70	.61	High
9	When a student has difficulty	Male	3.41	1.12	Moderate
	understanding a STEM concept, I am confident that I know how to help the student to understand it better.	Female	3.74	.72	High
10	When teaching STEM, I am confident	Male	3.59	1.06	High
	enough to welcome student questions.	Female	3.96	.72	High
11	I know what to do to increase student	Male	3.71	1.04	High
	interest in STEM.	Female	3.66	.68	High
	Overall	Male	3.44	.80	Moderate
		Female	3.67	.44	High

The results in Table 12 show that the overall means of teachers' STEM teaching self-efficacy and beliefs at Wattana Wittaya Academy, Bangkok, Thailand, was *M* = 3.44 for males, which was interpreted as moderate, and *M* = 3.67 for females, which was interpreted as high.

Research Findings of Research Objective 1.2

Research Objective 1.2 was to determine the level of teachers' STEM teaching outcome expectancy according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

To address Research Objective 1.2, the Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education questionnaire (T-STEM) was distributed to collect the data of teachers' STEM teaching outcome expectancy. The items related to teachers' STEM teaching outcome expectancy are found in part two and consist of Items 12 to 20, which also were related at a five-point Likert scale (see Tables 5, Chapter III). Table 13 shows the means, standard deviations and interpretations of teachers' STEM teaching outcome expectancy according to gender.

Table 13

Means, Standard Deviations, And Interpretations of Teachers' STEM Teaching Outcome Expectancy According to Gender at Wattana Wittaya Academy, Bangkok, Thailand

Item	Statement	Gender	*M*	*SD*	Interpretation
12	When a student does better than usual in STEM, it is often because the teacher exerted a little extra effort.	Male	3.71	.92	High
		Female	3.78	.73	High
13	The inadequacy of students' STEM background can be overcome by good teaching.	Male	3.82	.95	High
		Female	3.90	.67	High
14	When a students' learning in STEM is greater than expected, it is most often due to their teacher having found a more effective teaching approach.	Male	3.53	.80	High
		Female	3.82	.62	High
15	The teacher is generally responsible for students' learning in STEM.	Male	3.76	.66	High
		Female	3.72	.73	High
16	If students' learning in STEM is less than expected, it is most likely due to ineffective STEM teaching.	Male	3.53	.87	High
		Female	3.42	.81	Moderate
17	Students' learning in my STEM classes is directly related to my effectiveness in teaching.	Male	3.71	.77	High
		Female	3.68	.62	High
18	I think when a low achieving student progresses more than expected in STEM classes, it is usually due to extra attention given by the teacher.	Male	3.65	1.05	High
		Female	3.70	.76	High

(continued)

(continued)

Item	Statement	Gender	*M*	*SD*	Interpretation
19	I think if parents comment that their child is showing more interest in STEM at school, it is probably due to the performance of the child's teacher.	Male	3.41	.87	Moderate
		Female	3.48	.58	Moderate
20	I think if student learning in STEM can generally be attributed to their teachers.	Male	3.76	.83	High
		Female	3.46	.73	Moderate
	Overall	Male	3.65	.59	High
		Female	3.66	.49	High

The results in Table 13 show that the overall means of teachers' STEM teaching outcome expectancy at Wattana Wittaya Academy, Bangkok, Thailand, was *M* = 3.65 for males was, which was interpreted as high, and *M* = 3.66 for females, which was interpreted as high.

Research Findings of Research Objective 1.3

Research Objective 1.3 was to determine the level of teachers' STEM instruction according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

To address Research Objective 1.3, the Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education questionnaire (T-STEM) was distributed to collect the data of teachers' STEM instruction. The items related to teachers' STEM instruction are found in part two and consist of Items 38 to 51, which also were related at five-point scale (see Tables 6, Chapter III). Table 14 shows the means, standard deviation and interpretations of teachers' STEM instruction according to gender.

Table 14

Means, Standard Deviations, And Interpretations of Teachers' STEM Instruction According to Gender at Wattana Wittaya Academy*, Bangkok, Thailand*

Item	Statement	Gender	*M*	*SD*	Interpretation
38	During your STEM instructional classes, how often do your students develop problem-solving skills through investigations (for example, scientific, design or theoretical investigations)?	Male	3.12	1.31	Neutral
		Female	3.32	.99	Neutral
39	During your STEM instructional classes, how often do your students work in small groups?	Male	3.41	1.22	Neutral
		Female	3.68	.86	Positive
40	During your STEM instructional classes, how often do your students make predictions that can be tested?	Male	2.94	1.14	Neutral
		Female	3.30	1.01	Neutral
41	During your STEM instructional classes, how often do your students make careful observation or measurement?	Male	3.06	1.08	Neutral
		Female	3.28	1.08	Neutral
42	During your STEM instructional classes, how often do your students use tools to gather data (for example, calculators, computer programs, scales, rulers, compasses, etc.)?	Male	2.94	1.51	Neutral
		Female	3.14	1.10	Neutral
43	During your STEM instructional classes, how often do your students recognize patterns in data?	Male	2.82	1.28	Neutral
		Female	3.12	.94	Neutral
44	During your STEM instructional classes, how often do your students create reasonable explanations of results of an experiment or investigation?	Male	3.18	1.28	Neutral
		Female	3.34	.82	Neutral

(continued)

(continued)

Item	Statement	Gender	*M*	*SD*	Interpretation
45	During your STEM instructional classes, how often do your students choose the most appropriate methods to express results (for example, drawings, models, charts, graphs, technical language, etc.)?	Male	2.82	1.23	Neutral
		Female	3.18	1.06	Neutral
46	During your STEM instructional classes, how often do your students complete activities with a real-world context?	Male	3.06	1.08	Neutral
		Female	3.28	.94	Neutral
47	During your STEM instructional classes, how often do your students engage in content-driven dialogue?	Male	3.06	1.14	Neutral
		Female	3.36	.94	Neutral
48	During your STEM instructional classes, how often do your students reason abstractly?	Male	2.88	1.05	Neutral
		Female	3.28	.94	Neutral
49	During your STEM instructional classes, how often do your students reason quantitatively?	Male	2.65	1.22	Neutral
		Female	3.26	1.00	Neutral
50	During your STEM instructional classes, how often do your students critique reasoning of others?	Male	3.06	1.19	Neutral
		Female	3.36	.89	Neutral
51	During your STEM instructional classes, how often do your students learn about careers related to the instructional content?	Male	2.76	1.25	Neutral
		Female	3.14	1.01	Neutral
	Overall	Male	2.98	1.03	Neutral
		Female	3.28	.76	Neutral

The results in Table 14 show that the overall means of teachers' STEM instruction at Wattana Wittaya Academy, Bangkok, Thailand, was *M* = 2.98 for males, which was interpreted as neutral, and females was *M* = 3.28, which was interpreted as neutral.

Research Findings of Research Objective 2

The second research objective was to determine the level of teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand. To address Research Objective 2, data were collected from 25 items from part two of Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education questionnaire (T-STEM), which includes the following three variables: student technology use in STEM classes, 21st century learning attitudes and teacher leadership attitudes (see Appendices A and B). Table 15 shows the teachers' means and standard deviations of teachers' attitudes toward STEM education.

Table 15

Means, Standard Deviations, And Interpretations of Teachers' Attitudes Toward STEM Education According to Gender at Wattana Wittaya Academy, Bangkok, Thailand

Variable	Gender	*M*	*SD*	Interpretation
Student technology use in STEM classes	Male	2.83	1.17	Neutral
	Female	3.21	.91	Neutral
21st century learning attitudes	Male	4.28	.65	High
	Female	4.20	.49	High
Teacher leadership attitudes	Male	4.12	.64	High
	Female	4.24	.55	High
Overall	Male	3.74	.63	Positive
	Female	3.88	.44	Positive

The results in Table 15 show that the overall means of teachers' attitudes toward STEM education at Wattana Wittaya Academy, Bangkok, Thailand, was *M* = 3.74 for males, which was interpreted as positive, and *M* = 3.88 for females, which was interpreted as positive.

Research Findings of Research Objective 2.1

Research Objective 2.1 was to determine the level of student technology use in STEM classes according to teachers' gender at Wattana Wittaya Academy, Bangkok, Thailand.

To addressing Research Objective 2.1, the Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education questionnaire (T-STEM) was distributed to collect the data of student technology use in STEM classes. The items related to student technology use in STEM classes are found in part two and consist of Items 52 to 59, which also were related at a five-point scale (see Tables 6, Chapter III). Table 16 shows the means, standard deviations and interpretations of student technology use in STEM classes.

Table 16

Means, Standard Deviations, And Interpretations of Student Technology Use in STEM Classes According to Teachers' Gender at Wattana Wittaya Academy, Bangkok, Thailand

Item	Statement	Gender	*M*	*SD*	Interpretation
52	During your STEM instructional classes, how often do your students use a variety of technologies (for example, productivity, data visualization, research and communication tools)?	Male	2.88	1.40	Neutral
		Female	3.28	1.03	Neutral

(continued)

(continued)

Item	Statement	Gender	*M*	*SD*	Interpretation
53	During your STEM instructional classes, how often do your students use technology to communicate and collaborate with others beyond the classroom?	Male	2.94	1.43	Neutral
		Female	3.14	1.14	Neutral
54	During your STEM instructional classes, how often do your students use technology to access online resources and information as a part of activities?	Male	2.88	1.36	Neutral
		Female	3.20	.99	Neutral
55	During your STEM instructional classes, how often do your students use the same kinds of tools that professional researchers use (for example, simulations, databases, satellite imagery)?	Male	2.59	1.32	Neutral
		Female	3.00	1.12	Neutral
56	During your STEM instructional classes, how often do your students work on technology-enhanced projects that approach real-world applications of technology?	Male	2.53	1.23	Neutral
		Female	3.10	1.01	Neutral
57	During your STEM instructional classes, how often do your students use technology to help solve problems?	Male	3.00	1.36	Neutral
		Female	3.28	.99	Neutral
58	During your STEM instructional classes, how often do your students use technology to support higher-order thinking (for example, analysis, synthesis and evaluation of ideas and information)?	Male	3.00	1.22	Neutral
		Female	3.30	1.14	Neutral
59	During your STEM instructional classes, how often do your students use technology to create new ideas and representations of information?	Male	2.82	1.38	Neutral
		Female	3.40	1.03	Neutral
	Overall	Male	2.83	1.17	Neutral
		Female	3.21	.91	Neutral

The results in Table 16 show that the overall mean score of student technology use in STEM classes at Wattana Wittaya Academy, Bangkok, Thailand, was *M* = 2.83 for males, which was interpreted as neutral, and *M* = 3.21 for females, which was interpreted as neutral.

Research Findings of Research Objective 2.2

Research Objective 2.2 was to determine the level of teachers' 21st century learning attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

To address Research Objective 2.2, the Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education questionnaire (T-STEM) was distributed to collect the data of teachers' 21st century learning attitudes. The items related to teachers' 21st century learning attitudes are found in part two and consist of Items 21 to 31, which also were related a five-point Likert scale (see Tables 5, Chapter III). Table 17 shows the means, standard deviations and interpretations of teachers' 21st century learning attitudes according to gender.

Table 17

Means, Standard Deviations, And Interpretations of Teachers' 21st Century Learning Attitudes According to Gender at Wattana Wittaya Academy, Bangkok, Thailand

Item	Statement	Gender	*M*	*SD*	Interpretation
21	I think it is important that students have learning opportunities to lead others to accomplish a goal.	Male	4.00	1.1	High
		Female	4.08	.60	High
22	I think it is important that students have learning opportunities to encourage others to do their best.	Male	4.24	.90	High
		Female	4.18	.59	High
23	I think it is important that students have learning opportunities to produce high quality work.	Male	4.18	.88	High
		Female	4.20	.63	High

(continued)

(continued)

Item	Statement	Gender	*M*	*SD*	Interpretation
23	I think it is important that students have learning opportunities to produce high quality work.	Male	4.18	.88	High
		Female	4.20	.63	High
24	I think it is important that students have learning opportunities to respect the differences of their peers.	Male	4.53	.62	Very high
		Female	4.26	.63	High
25	I think it is important that students have learning opportunities to help their peers.	Male	4.24	.83	High
		Female	4.32	.74	High
26	I think it is important that students have learning opportunities to include others' perspectives when making decisions.	Male	4.41	.79	High
		Female	4.28	.67	High
27	I think it is important that students have learning opportunities to make changes when things do not go as planned.	Male	4.47	.62	High
		Female	4.16	.73	High
28	I think it is important that students have learning opportunities to set their own learning goals.	Male	4.12	1.1	High
		Female	4.08	.66	High
29	I think it is important that students have opportunities to manage their time wisely when working on their own.	Male	4.41	.50	High
		Female	4.34	.55	High
30	I think it is important that students have learning opportunities to choose which assignment out of many needs to be done first.	Male	4.06	.96	High
		Female	4.18	.66	High
31	I think it is important that students have learning opportunities to work well with students from different backgrounds.	Male	4.53	.80	Very high
		Female	4.20	.63	High
	Overall	Male	4.28	.65	High
		Female	4.20	.49	High

The results in Table 17 show that the overall mean score of teachers' 21st century learning attitudes at Wattana Wittaya Academy, Bangkok, Thailand, was *M* = 4.28 for males, which was interpreted as high, and *M* = 4.20 for females, which was interpreted as high.

Research Findings of Research Objective 2.3

Research Objective 2.3 was to determine the level of teacher leadership attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

To address Research Objective 2.3, the Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education questionnaire (T-STEM) was distributed to collect the data of teacher leadership attitudes. The items related to teachers' leadership attitudes are found in part two and consist of Items 32 to 37, which also were related at five-point Likert sake (see Tables 5, Chapter III). Table 18 shows the means, standard deviations and interpretations of teachers' leadership attitudes.

Table 18

Means, Standard Deviations, And Interpretations of Teacher Leadership Attitudes According to Gender at Wattana Wittaya Academy, Bangkok, Thailand

Item	Statement	Gender	*M*	*SD*	Interpretation
32	I think it is important that teachers take responsibility for all students' learning.	Male	3.35	1.22	Moderate
		Female	3.80	.94	High
33	I think it is important that teachers communicate vision to the students.	Male	4.35	.78	High
		Female	4.26	.56	High
34	I think it is important that teachers use a variety of assessment data throughout the year to evaluate progress.	Male	4.24	.66	High
		Female	4.30	.58	High

(continued)

(continued)

Item	Statement	Gender	*M*	*SD*	Interpretation
35	I think it is important that teachers use a variety of data to organize, plan and set goals.	Male	4.18	.88	High
		Female	4.28	.60	High
36	I think it is important that teachers establish a safe and orderly environment.	Male	4.41	.61	High
		Female	4.40	.67	High
37	I think it is important that teachers empower students.	Male	4.24	1.14	High
		Female	4.40	.70	High
	Overall	Male	4.12	.64	High
		Female	4.24	.55	High

The results in Table 18 show that the overall mean score of teacher leadership attitudes at Wattana Wittaya Academy, Bangkok, Thailand, was *M* = 4.12 for males, which was interpreted as high and *M* = 4.24 for females, which was interpreted as high.

Research Findings of Research Objective 3

Research Objective 3 was to determine whether there is a significant difference between teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

To address Research Objective 3, the Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education questionnaire (T-STEM) was implemented to collect data of STEM teachers' self-efficacy according to gender at Wattana Wittaya Academy, Bangkok, Thailand. The items related to teachers' self-efficacy for teaching STEM subjects are found in part two. Items related to teachers' STEM teaching self-efficacy and beliefs consist of Items 1 to 11. Items related to teachers' STEM teaching outcome expectancy consist of Items 12 to 20. Lastly, items related to teachers' STEM instruction consist of Items 38 to 51. Table 19 shows the independent samples *t*-test used to determine whether there is a significant difference between teachers' STEM teaching self-efficacy according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

Table 19

Result of the Independent Samples t-Test Comparing Teachers' Self-Efficacy for Teaching STEM Subjects According to Gender at Wattana Wittaya Academy, Bangkok, Thailand

Variable	Gender	*N*	*M*	*SD*	*df*	*t*	*p*
Self-efficacy for teaching STEM subjects	Male	17	3.36	.72	65	-1.21	.23
	Female	50	3.54	.45			

Results were analyzed using an independent-sample *t*-test. This analysis failed to reveal significant different between the two groups, t (65) = -1.21; p = .23. The sample means are displayed in Table 19, which shows that male teachers' attitudes toward STEM education which is quite similar to female teachers' attitudes toward STEM education. (for male teachers', M = 3.36, SD = .72; for female teachers', M = 3.54, SD = .45).

Research Findings of Research Objective 4

Research Objective 4 was to determine whether there is a significant difference between teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

To address Research Objective 4, the Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education questionnaire (T-STEM) was implemented to collect data of teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand. The items related to teachers' attitudes toward STEM education are found in part two. Items related to student technology use in STEM classes consist of Items 51 to 59. Items related to 21st century learning attitudes consist of Items 21 to 31. Lastly, items related to teacher leadership attitudes consist of Items 32 to 37. Table 20 shows the independent samples *t*-test used to determine whether there is a significant difference between teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

Table 20

Result of the Independent Samples t-Test Comparing Teachers' Attitudes Toward STEM Education According to Gender at Wattana Wittaya Academy, Bangkok, Thailand

Variable	Gender	*N*	*M*	*SD*	*df*	*t*	*p*
Attitudes toward STEM education	Male	17	3.74	.63	65	-1.21	.33
	Female	50	3.88	.44			

Results were analyzed using an independent-sample *t*-test. This analysis failed to reveal significant different between the two groups, *t* (65) = -1.21; *p* = .33. The sample means are displayed in Table 20, which shows that male teachers' attitudes toward STEM education which is quite similar to female teachers' attitudes toward STEM education. (for male teachers', *M* = 3.74, *SD* = .63; for female teachers', *M* = 3.88, *SD* = .44).

In this chapter, the researcher explained the findings of the study according to the Research Objectives 1 through 4. In the next chapter, the researcher will present the conclusions, discussion and recommendations.

CHAPTER V

CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

In the previous chapter, the findings of the current study of teachers' self-efficacy for teaching STEM subjects and attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand, were reported. This chapter will present the summary of the study and its findings, the conclusions drawn from the findings, and a discussion placing the findings in context of previous research. Finally, this chapter will end with recommendations regarding teachers' self-efficacy for teaching STEM subjects and attitudes toward STEM education for administrators, teachers and future researchers.

Summary of the Study

This study was designed to determine whether there was is a significant difference between teachers' self-efficacy for teaching STEM subjects and attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand, during the 2019-2020 academic year. For this purpose, the following research objectives were addressed.

1. To determine the level of teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand.
    1.1. To determine the level of teachers' STEM teaching self-efficacy and beliefs according to gender at Wattana Wittaya Academy, Bangkok, Thailand.
    1.2. To determine the level of teachers' STEM teaching outcome expectancy according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

1.3. To determine the level of teachers' STEM instruction according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

2. To determine the level of teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

2.1. To determine the level of student technology use in STEM classes according to teachers' gender at Wattana Wittaya Academy, Bangkok, Thailand.

2.2. To determine the level of teachers' 21st century learning attitudes to gender at Wattana Wittaya Academy, Bangkok, Thailand.

2.3. To determine the level of teacher leadership attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

3. To determine whether there was a significant difference in teachers' self-efficacy for teaching STEM subjects according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

4. To determine whether there was a significant difference in teachers' attitudes toward STEM education according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

The study was conducted on a population sample of 67 teachers teaching STEM related subjects at Wattana Wittaya Academy, Bangkok, Thailand. A quantitative questionnaire, Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education (T-STEM), was distributed to teachers to determine their level of teachers' self-efficacy for teaching STEM subjects and attitudes toward STEM education. The questionnaire was distributed and collected from 3 June to 6 June 2019, which was during the first semester of the 2019-2020 academic year. The data was collected from the questionnaire and the researcher compared the responses through the inferential statistical method (i.e., independent samples *t*-test) to determine whether there was a significant difference between teachers' STEM teaching self-efficacy and attitudes according to gender at Wattana Wittaya Academy, Bangkok, Thailand.

Summary of the Findings

This section summarizes the findings from the data collection and analysis. There were four main research objectives.

Research Objective 1

Male teachers' self-efficacy for teaching STEM subjects was found to be moderate, whereas female teachers' STEM teaching self-efficacy was found to be high at Wattana Wittaya Academy, Bangkok, Thailand.

Research Objective 1.1

Male teachers' STEM teaching self-efficacy and beliefs was found to be moderate, whereas female teachers' STEM teaching self-efficacy and beliefs was found to be high at Wattana Wittaya Academy, Bangkok, Thailand.

Research Objective 1.2

Male teachers' STEM teaching outcome expectancy was found to be high, as well as female teachers STEM teaching outcome expectancy was found to be high at Wattana Wittaya Academy, Bangkok, Thailand.

Research Objective 1.3

Male teachers' STEM instruction was neutral to be neutral, as well as female teachers' STEM instruction was found to be neutral at Wattana Wittaya Academy, Bangkok, Thailand.

Research Objective 2

Male teachers' attitudes towards STEM education were found to be positive, as well as female teachers' attitudes were found to be positive at Wattana Wittaya Academy, Bangkok, Thailand.

Research Objective 2.1

Male teachers demonstrated a neutral attitude towards student technology use in STEM classes, as did female teachers at Wattana Wittaya Academy, Bangkok, Thailand.

Research Objective 2.2

Male teachers demonstrated a positive attitude towards 21st century learning attitudes, as did female teachers at Wattana Wittaya Academy, Bangkok, Thailand.

Research Objective 2.3

Male teachers demonstrated a positive attitude towards teacher leadership attitudes, as did female teachers at Wattana Wittaya Academy, Bangkok, Thailand.

Research Objective 3

According to the results from the comparison made by applying a two-tailed independent samples *t*-test, there was no significant difference in male and female teachers' STEM teaching self-efficacy at Wattana Wittaya Academy, Bangkok, Thailand.

Research Objective 4

According to the results from the comparison made by applying a two-tailed independent samples *t*-test, there was no significant difference in male and female teachers' attitudes toward STEM education at Wattana Wittaya Academy, Bangkok, Thailand.

Conclusions

The following conclusions were drawn from the findings.

Research Objective 1

Regarding male teachers' responses, the highest mean (3.63) was found to be related to STEM teaching outcome expectancy, while the lowest mean (2.98) was found to be related to STEM instruction. Regarding female teachers' responses, the highest mean (3.67) was found to be related to STEM teaching self-efficacy and beliefs, while the lowest mean (3.28) was found to be related to STEM instruction. It indicates that teachers understand the great responsibility so that STEM education can take place in line with the goals and objective of the school but concern about manual of technical procedure to carry out STEM instructions.

Research Objective 1.1

Regarding male teachers' responses, the highest mean (3.88) was from Statement 1, which states, "I am continually improving my STEM teaching practice." The lowest mean (3.18) was shared by two Statements, 3 and 5, which state, "I am confident that I can explain to students why STEM experiments work." and "I wonder if I have the necessary skills to teach STEM classes." Regarding female teachers' responses, the highest mean (3.96) was from Statement 10, which states, "When teaching STEM, I am confident enough to welcome student questions." The lowest mean (3.26) was from Statement 5, which states, "I wonder if I have the necessary skills to teach STEM classes." It suggests that Wattana Wittaya Academy STEM teachers practices a student-centered approach. There are many strategies that teachers apply such as posing challenge questions to future student thinking. Teachers are able to identify what can be introduced for promoting a well-oriented student activity.

Research Objective 1.2

Regarding male teachers' responses, the highest mean (3.28) was from Statement 13, which states, "The inadequacy of students' STEM background can be overcome by good teaching." The lowest mean (3.41) was from Statement 19, which states, "I think if parents comment that their child is showing more interest in STEM at school, it is probably due to the performance of the child's teacher." Regarding female teachers' responses, the highest mean (3.90) was from Statement 13, which states, "The inadequacy of students' STEM background can be overcome by good teaching." The lowest mean (3.42) was from Statement 16, which states, "If students' learning in STEM is less than expected, it is most likely due to ineffective STEM teaching." It implies that teachers play a powerful role in shaping and guiding student, at Wattana Wittaya Academy student cannot escape at the end of the classes, student cannot avoid the strong influence teachers have on time. As a boarding school it is a self-contained community. Lower achieving students gets extra help from direct teachers after class hours.

Research Objective 1.3

Regarding male teachers' responses, the highest mean (3.41) was from Statement 39, which states, "During your STEM instructional classes, how often do your students work in small groups?" The lowest mean (2.08) was from Statement 48, which states, "During your STEM instructional classes, how often do your students reason abstractly?" Regarding female teachers' responses, the highest mean (3.68) was from Statement 39, which states, "During your STEM instructional classes, how often do your students work in small groups?" The lowest mean (3.12) was from Statement 43, which states, "During your STEM instructional classes, how often do your students recognize patterns in data?" The findings suggest that STEM teachers did not promote the mathematical practices in their STEM lesson such as reason with models or pictorial representation to solve problems. To able to translate situations into symbols for solving problems is not practiced in the classroom.

Research Objective 2

Regarding male teachers' responses, the highest mean (4.28) was found to be related to 21st century learning attitudes, while the lowest mean (2.83) was found to be related to student technology use in STEM classes. Regarding female teachers' responses, the highest mean (4.24) was found to be related to teacher leadership attitudes, while the lowest mean (2.83) was found to be related to student technology use in STEM classes.

Research Objective 2.1

Regarding male teachers' responses, the highest mean (3.28) was shared by two Statements, 57 and 58, which state, "During your STEM instructional classes, how often do your students use technology to help solve problems?" and "During your STEM instructional classes, how often do your students use technology to support higher-order thinking (for example, analysis, synthesis and evaluation of ideas and information)?" The lowest mean (2.53) was from Statement 56, which states, "During your STEM instructional classes, how often do your students work on technology-enhanced projects that approach real-world applications of technology?" Regarding female teachers' responses, the highest mean (3.40) was from Statement 59, which states, "During your STEM instructional classes, how often do your students use technology to create new ideas and representations of information?" The lowest mean (3.00) was from Statement 55, which states, "During your STEM instructional classes, how often do your students use the same kinds of tools that professional researchers use (for example, simulations, databases, satellite imagery)?". These finding share a common theme; portion of STEM teachers feel they are limited by a lack of resources. This explains why STEM teachers' instructional practice did not integrate technology, despite teachers' acquisition of new teaching ideas. Another reason being that as a boarding school student are limited to access of internet and student do not have their own laptop but a common area making it very easy for teachers to control their student accessibility as well as content.

Research Objective 2.2

Regarding male teachers' responses, the highest mean (4.53) was from Statement 24, which states, "I think it is important that students have learning opportunities to respect the differences of their peers." The lowest mean (4.00) was from Statement 21, which states, "I think it is important that students have learning opportunities to lead others to accomplish a goal." Regarding female teachers' responses, the highest mean (4.28) was from Statement 26, which states, "I think it is important that students have learning opportunities to include others' perspectives when making decisions." The lowest mean (3.00) was shared by two Statements, 21 and 28, which state, "I think it is important that students have learning opportunities to lead others to accomplish a goal." and "I think it is important that students have learning opportunities to set their own learning goals." As a boarding school, Wattana Wittaya Academy student have limited free time as the finding suggest that students are encourage to be competitive across each and every discipline. Supportive staff teachers constantly on hand to ensure that students have crucial life skills.

Research Objective 2.3

Regarding male teachers' responses, the highest mean (4.35) was from Statement 33, which states, "I think it is important that teachers communicate vision to the students." The lowest mean (3.35) was from Statement 32, which states, "I think it is important that teachers take responsibility for all students' learning." Regarding female teachers' responses, the highest mean (4.40) was from Statement 36, which states, "I think it is important that teachers establish a safe and orderly environment." The lowest mean (3.80) was from Statement 32, which states, "I think it is important that teachers take responsibility for all students' learning." It implies that all teachers have leadership quality who educate student in the classroom as well takes advice roles outside of their classroom to assist in functions and take on administrative roles.

Research Objective 3

The findings from Research Objective 3 revealed was no significant difference between male and female teachers' self-efficacy for teaching STEM subjects at Wattana Wittaya Academy, Bangkok, Thailand. Based on the inferential statistical analysis, the overall female teachers' self-efficacy for teaching STEM subjects was slightly higher than that of the male teachers. It indicates that there was no difference in teachers' perspective of his or her capabilities are developed through the interpretation of task outcome according to teachers' gender.

Research Objective 4

The findings from Research Objective 4 revealed was no significant difference between male and female teachers' attitudes toward STEM education at Wattana Wittaya Academy, Bangkok, Thailand. Based on the inferential statistical analysis, the overall female teachers' attitudes toward STEM education was slightly higher than that of the male teachers. It indicates that there was no difference in teachers' view of a concept or a tendency to respond positively or negatively towards a certain idea according to teachers' gender.

Discussion

The results of this study expose several chronic challenges related to STEM teaching and learning. In this section, the researcher looks at STEM teaching self-efficacy and beliefs, STEM teaching outcome expectancy and STEM instruction, student technology use, 21st century learning attitudes and teacher leadership attitudes.

Research Objective 1.1

The research findings revealed that teachers' self-efficacy and beliefs in regards to teaching STEM subjects were positive. Almost all of the participating teachers *strongly agreed* with all the statements regarding their STEM-teaching confidence and understanding of STEM concepts. However, when responding to Statement 5, which says, "I wonder if I have the necessary skills to teach STEM classes," a high number of teachers choose *agree* or *strongly agree*. According to Appropriate STEM Education Design for Kindergarten in Thailand (Na Ayuthaya, Dejakaisaya & Santanakul, 2015) teachers of young children are not confident when teaching STEM because these teachers did not study an integrated STEM course. To effectively teach STEM, STEM teachers need to have science, technology, engineering and mathematics content knowledge and necessary teaching skills.

Research Objectives 1.2 and 1.3

The research findings revealed that teachers believe that effective instruction can help students overcome difficulties. In this section of the questionnaire, no teacher chose *strongly* *disagree* in response to any of the statements regarding STEM outcome expectancy. However, in the STEM instruction section of the questionnaire, the researcher was surprised to find that a significant number of participating teachers indicated that their students are not using scientific skills and tools during STEM instruction. There may be many reasons for this. Teachers might lack training; teachers might have only a poor curriculum to guide them; teachers may not have enough time for projects and activities.

In a study, Srikoom, Hanuscin and Faikhamta (2018) found that teachers are motivated to improve their teaching and are confident in their ability to deliver STEM instruction but find that the time necessary for teaching STEM is not allowed by the curriculum. One solution to the problem of lack of time is to implement a flipped classroom. According to Kelly (2015) who studied the use of a flipped or inverted classroom in three STEM classes, teachers stated having extra class time for the students to work over projects and tasks, and the teacher is open for direct student collaboration and assistance. Teachers is able to create a deeper understanding of the subjects and concepts in the students.

Two STEM instruction activities are especially important: engaging in content-driven dialogue and quantitative reasoning. The ability to reason quantitatively allows students to interpret graphs, whereas allowing students to engage in content-driven dialogue give students the opportunity to process their learning and teachers the opportunity to correct and expand student understanding. These activities are not suitable for large classes, as they require a significant amount of time and opportunity for all student to speak.

Research Objective 2.1

The research findings revealed that the students of the participating teachers use technology about half the time in their STEM classes. The researcher was concerned by the high number of teachers who responded *never* in response to statements about students working on technology-enhanced projects that approach real-world application of technology and about students using technology to help solve problems. One reason the students of the participating teachers may not be using technology to its full extent could be the school's lack of technology. It could also be that teachers lack training necessary to equip them to facilitate their students' technology use or that teachers do not value the use of technology. According to Chomphuchart (2017) are concern about whether or not technology benefits or gets in the way of student learning.

Research Objective 2.2

The research found a high level of agreement towards the statements regarding the 21st century learning attitudes. These learning attitudes involve discipline as well as students taking responsibility for themselves and others, but these are not the only ways in which students can develop in STEM classroom. According to Bybee (2013), "In STEM education, students may develop cognitive skills while engaged in the study of specific STEM-related social or global situation" including "adaptability, complex communication, nonroutine problem solving, self-management, and systems thinking" (p.38). STEM teachers need to be intentional about ensuring their students are given the opportunity to develop these skills in their classrooms.

Research Objective 2.3

The research found a high level of agreement towards the statements regarding the teacher leadership attitudes. The participating teachers believe it is important that they take responsibility for all students learning and empower students. As Lauermann (2013) states, Teachers' personal sense of responsibility potentially influences their instructional practices, psychological well-being and ultimately their students' learning and performance.

Research Objective 3

The research found no significant difference between male and female teachers' self-efficacy in the following three variables: STEM teaching self-efficacy and beliefs, STEM teaching outcome expectancy and STEM instruction. Similar study by Martin, Yin, and Mayall (2006) showed that female teachers have a lower level of self-efficacy in regards to classroom management than male teachers. Butucha (2013) also found a significant gender difference in self-efficacy in regards to classroom management where male teacher scored higher than female teachers. According to Lesha (2017), a study exploring the differences between male and female teachers found that male teachers are more competent in classroom management self-efficacy and student engagement than female teachers, as male teachers are usually stricter.

As cited in Truscott (2006), female students prefer female teachers to male teachers in STEM classes. The author states that female students would benefit from female teacher-student STEM mentorship programs.

Research Objective 4

The research found no significant difference in teachers' attitudes in the following three variables: student technology use in STEM classes, 21st century learning attitudes and teacher leadership attitudes. In a study, Srikoom, Hanuscin & Faikhamta (2018) found that male teachers have a more positive attitude towards student use of technology in the classroom than female teachers. In addition, Alrasheedi (2009) found that ICT training has a greater impact on male teachers than on female teachers.

There is lower rate of female faculty hired in STEM fields but the retention rate remains the same for both males and females (Kaminski & Geisler, 2012). Moreover, female teachers are taking a lead in early childhood (Kelleher, 2011). Truscott (2006) mentions that female teachers are more reliable than male teachers in terms of social persuasion as a source of self-efficacy.

Recommendations

In this study, teachers' self-efficacy for teaching STEM subjects and attitudes toward STEM education consist of teachers' knowledge and skills that can be used to help students develop critical thinking skills and find solutions to everyday problems such as climate change and sustainable living. The following recommendations are offered based on the findings of this study.

Recommendations for Administrators

One of the biggest factors that contributes to students' academic achievement is teachers. Teachers' ability to increase student knowledge depends on the management of the school and their professional communities. The following recommendations are offered in order to help administrators manage the school effectively.

Especially because STEM is a relatively new field, the administration should invest in their STEM teachers by providing many engaging, relevant professional development opportunities. Administrators must create policies and practices that encourage teachers to engage in professional learning. Administrators must identify the needs of their STEM teachers and then evaluate specialized professional learning programs to find the best fit for their teachers. Schools should purchase the relevant resources to facilitate their teachers continued development in STEM knowledge.

Administrators must take the time to find a well-written and engaging STEM curriculum for each grade level. The learning objectives must be properly thought out for each grade level so that the skills learned at one grade level prepare the students for the next grade level. Assessments should not be multiple choice or fill in the blank but should require that the student demonstrate the use of practical skills.

Administrators should create a network of local businesses and community partners to facilitate outside-the-classroom STEM experiences for the students. This could include internships, workshops geared to the students' age level and level of STEM knowledge and mentorships. Before students are permitted to visit STEM companies, administrators must ensure that the students will be safe. Administrators should ensure that the students are exposed to balanced number of male and female STEM field employees.

Recommendations for Future Researchers

The following recommendations are offered for those who are interested in studying teachers' STEM teaching self-efficacy and attitudes. The scope of this study was limited to Wattana Wittaya Academy; therefore, the future researcher can broaden the sample size of teachers who are teaching STEM subjects in other schools and universities in order to obtain more data. As well as a well-balanced of genders in sample size.

Future researchers could consider using a mixed quantitative and qualitative research design in order to obtain a deeper understanding of all relevant factors including those that can affect teacher self-efficacy and attitudes: experience, level of qualification, race, family background, age, and grade level. Other relevant factors include students' interests, students' living conditions, parent influence and school culture.

More studies must be conducted that are able to demonstrate the success of STEM classrooms in a variety of schools and locations. Studies that demonstrate STEM success by students from low-achieving and or from diverse backgrounds would be encouraging to administrators seeking to introduce STEM classes to their schools.

The future researcher can design and implement research that examines a variety of approaches taken in STEM classes, including what program models and instructional strategies work for particular age groups and under what conditions.

Future research is also needed regarding the success of STEM in early childhood education.

Recommendations for Teachers

Teachers must prepare students to meet our planet's challenges by embracing best practices in STEM education such as hands-on learning, STEM competitions and the integration of informal learning with technology and project-based learning. Teachers should make use of evidence-based learning and use a multi-strategy approach in order to engage their students and create a sense of excitement in the classroom. Teachers should allow students to work in small groups and engage in discussions. Teachers must encourage students to reflect on their work and keep records of their learning.

STEM teachers should form a collaborative teaching culture with their STEM colleagues. Teachers should plan with and discuss curriculum, teaching materials and teaching strategies. STEM should share science laboratories and equipment. These teachers need to develop a common language to describe their common work.

STEM teachers should understand the impact of gender stereotyping in STEM and how female teachers especially can have an impact on girls' participation in STEM, both in school and in a career. Teachers can work against gender stereotyping in STEM by talking about female scientists with their students and encouraging their students to pursue a STEM career when interest and aptitude are demonstrated.

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APPENDICES

APPENDIX A

TEACHERS' SELF-EFFICACY FOR TEACHING STEM SUBJECTS AND ATTITUDES TOWARDS STEM EDUCATION (T-STEM) QUESTIONNAIRE

ENGLISH VERSION

Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education (T-STEM) Questionnaire

Part 1: General Information:

Place a check mark ✔ in the answer that corresponds to you.

Gender: _____ Male _____ Female

Part 2: For items 1 to 37 place a check mark ✔ in the box that corresponds to your feeling about your own teaching.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I am continually improving my STEM teaching practice.					
2. I know the steps necessary to teach STEM classes effectively.					
3. I am confident that I can explain to students why STEM experiments work.					
4. I am confident that I can teach STEM classes effectively.					
5. I wonder if I have the necessary skills to teach STEM classes.					
6. I understand STEM concepts well enough to be effective in teaching STEM classes.					
7. Given a choice, I would invite colleagues to be evaluate my STEM teaching.					
8. I am confident that I can answer students' STEM questions.					
9. When a student has difficulty understanding a STEM concept, I am confident that I know how to help the student to understand it better.					
10. When teaching STEM, I am confident enough to welcome student questions.					

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
11. I know what to do to increase student interest in STEM.					
12. When a student does better than usual in STEM, it is often because the teacher exerted a little extra effort.					
13. The inadequacy of students' STEM background can be overcome by good teaching.					
14. When a students' learning in STEM is greater than expected, it is most often due to their teacher having found a more effective teaching approach.					
15. The teacher is generally responsible for students' learning in STEM.					
16. If students' learning in STEM is less than expected, it is most likely due to ineffective STEM teaching.					
17. Students' learning in my STEM classes is directly related to my effectiveness in teaching.					
18. I think when a low achieving student progresses more than expected in STEM classes, it is usually due to extra attention given by the teacher.					
19. I think if parents comments that their child is showing more interest in STEM at school, it is probably due to the performance of the child's teacher.					
20. I think if student learning in STEM can generally be attributed to their teachers.					
21. I think it is important that students have learning opportunities to lead others to accomplish a goal.					
22. I think it is important that students have learning opportunities to encourage others to do their best.					
23. I think it is important that students have learning opportunities to produce high quality work.					
24. I think it is important that students have learning opportunities to respect the differences of their peers.					
25. I think it is important that students have learning opportunities to help their peers.					

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
26. I think it is important that students have learning opportunities to include others' perspectives when making decisions.					
27. I think it is important that students have learning opportunities to make changes when things do not go as planned.					
28. I think it is important that students have learning opportunities to set their own learning goals.					
29. I think it is important that students have opportunities to manage their time wisely when working on their own.					
30. I think it is important that students have learning opportunities to choose which assignment out of many needs to be done first.					
31. I think it is important that students have learning opportunities to work well with students from different backgrounds.					
32. I think it is important that teachers take responsibility for all students' learning.					
33. I think it is important that teachers communicate vision to the students.					
34. I think it is important that teachers use a variety of assessment data throughout the year to evaluate progress.					
35. I think it is important that teachers use a variety of data to organize, plan and set goals.					
36. I think it is important that teachers establish a safe and orderly environment.					
37. I think it is important that teachers empower students.					

Directions: For items 38 to 59 respond to the following items about how often students engage in the specified tasks during your instructional time by placing a check mark ✓ in the box that corresponds to your response.

	Never	Occasionally	About half the time	Usually	Every time
38. During your STEM instructional classes, how often do your students develop problem-solving skills through investigations (for example, scientific, design or theoretical investigations)?					
39. During your STEM instructional classes, how often do your students work in small groups?					
40. During your STEM instructional classes, how often do your students make predictions that can be tested?					
41. During your STEM instructional classes, how often do your students make careful observations or measurements?					
42. During your STEM instructional classes, how often do your students use tools to gather data (for example, calculators, computer programs, scales, rulers, compasses, etc.)?					
43. During your STEM instructional classes, how often do your students recognize patterns in data?					
44. During your STEM instructional classes, how often do your students create reasonable explanations of results of an experiment or investigation?					
45. During your STEM instructional classes, how often do your students choose the most appropriate methods to express results (for example, drawings, models, charts, graphs, technical language, etc.)?					
46. During your STEM instructional classes, how often do your students complete activities with a real-world context?					
47. During your STEM instructional classes, how often do your students engage in content-driven dialogue?					
48. During your STEM instructional classes, how often do your students reason abstractly?					
49. During your STEM instructional classes, how often do your students reason quantitatively?					

	Never	Occasionally	About half the time	Usually	Every time
50. During your STEM instructional classes, how often do your students critique reasoning of others?					
51. During your STEM instructional classes, how often do your students learn about careers related to the instructional content?					
52. During your STEM instructional classes, how often do your students use a variety of technologies (for example, productivity, data visualization, research and communication tools)?					
53. During your STEM instructional classes, how often do your students use technology to communicate and collaborate with others beyond the classroom?					
54. During your STEM instructional classes, how often do your students use technology to access online resources and information as a part of activities?					
55. During your STEM instructional classes, how often do your students use the same kinds of tools that professional researchers use (for example, simulations, databases, satellite imagery)?					
56. During your STEM instructional classes, how often do your students work on technology-enhanced projects that approach real-world applications of technology?					
57. During your STEM instructional classes, how often do your students use technology to help solve problems?					
58. During your STEM instructional classes, how often do your students use technology to support higher-order thinking (for example, analysis, synthesis and evaluation of ideas and information)?					
59. During your STEM instructional classes, how often do your students use technology to create new ideas and representations of information?					

-Thank you for taking the time to participate in

Teachers' Self-Efficacy for Teaching STEM Subjects and Attitudes Toward STEM Education

(T-STEM) Questionnaire-

APPENDIX B

TEACHERS' SELF-EFFICACY FOR TEACHING STEM SUBJECTS AND ATTITUDES TOWARDS STEM EDUCATION (T-STEM) QUESTIONNAIRE

THAI VERSION

ความสามารถและทัศนคติของครูผู้สอนที่มีต่อหลักสูตรการศึกษา STEM

แบบสอบถาม T-STEM

ส่วนที่ 1: ข้อมูลทั่วไป :

กรุณาใส่เครื่องหมาย ✓ หน้าข้อมูลที่ถูกต้อง

เพศ : _____ ชาย _____หญิง

ส่วนที่ 2: กรุณาใส่เครื่องหมาย ✓ ข้อ 1-37 โดยเลือกข้อที่ตรงกับประสบการณ์การสอนของท่านมากที่สุด

	ไม่เห็นด้วยอย่างยิ่ง	**ไม่เห็นด้วย**	**ไม่แน่ใจ**	**เห็นด้วย**	**เห็นด้วยอย่างยิ่ง**
1. ข้าพเจ้ามีการพัฒนาในการสอนแบบ STEM					
2. ข้าพเจ้ารู้ถึงขั้นตอนสำคัญของการสอนแบบ STEM					
3. ข้าพเจ้าสามารถอธิบายถึงวิธีการใช้แนวทางSTEM ให้แก่					

นักเรียนได้					
4. ข้าพเจ้าสามารถสอนแนวการศึกษาแบบ STEM ได้อย่างดี					
5. ข้าพเจ้าไม่แน่ใจว่าข้าพเจ้ามีทักษะที่จำเป็นในการสอนแนวทางการศึกษาแบบ STEM					
6. ข้าพเจ้าเข้าใจแนวคิดของการศึกษาแบบ STEM เป็นอย่างดี ซึ่งทำให้ข้าพเจ้านำไปใช้ในการเรียนการสอนได้					
7. ข้าพเจ้าต้องการเชิญให้เพื่อนร่วมงานของข้าพเจ้าประเมินการสอนแบบ STEM ของข้าพเจ้า					
8. ข้าพเจ้าสามารถตอบคำถามของนักเรียนที่เกี่ยวข้องกับการศึกษาแบบ STEM					
9. ข้าพเจ้าสามารถช่วยเหลือนักเรียนที่ไม่เข้าใจแนวทางการศึกษาแบบ STEM ให้มีความเข้าใจที่ดียิ่งขึ้นได้					
10. ข้าพเจ้าเปิดโอกาสให้นักเรียนตั้งคำถามเมื่อมีการเรียนการสอนแบบ STEM					
	ไม่เห็นด้วยอย่างยิ่ง	ไม่เห็นด้วย	ไม่แน่ใจ	เห็นด้วย	เห็นด้วยอย่างยิ่ง
11. ข้าพเจ้ารู้วิธีที่จะเพิ่มความสนใจของนักเรียนต่อแนวทางการศึกษาแบบ STEM					
12. นักเรียนมีประสิทธิภาพในการเรียนแบบ STEM มากยิ่งขึ้น เมื่อข้าพเจ้าทุ่มเทให้แก่การสอนมาก					

ขึ้น					
13. ข้าพเจ้าเชื่อว่าการสอนที่มีประสิทธิภาพ จะช่วยแก้ไขปัญหาความบกพร่องต่อการศึกษาแบบ STEM ของนักเรียนได้					
14. เมื่อนักเรียนมีความรู้และความเข้าใจต่อการศึกษาแบบ STEM สูงกว่าความคาดหวัง ทั้งนี้เป็นเพราะวิธีการสอนที่มีประสิทธิภาพ					
15. ครูเป็นผู้รับผิดชอบต่อความรู้และความเข้าใจของนักเรียนที่มีต่อการศึกษาแบบSTEM					
16. หากนักเรียนมีความรู้และความเข้าใจต่อการศึกษาแบบ STEM ต่ำกว่าความคาดหวัง ทั้งนี้เป็นเพราะความไม่มีประสิทธิภาพของวิธีการสอน					
17. ประสิทธิภาพในการสอนวิธีการศึกษาแบบ STEM ของข้าพเจ้า มีผลต่อความรู้ด้าน STEM ของนักเรียน					
18. เมื่อนักเรียนที่มีผลการเรียนต่ำมีการพัฒนาเพิ่มขึ้นในการเรียนการสอนแบบ STEM นั้นเป็นเพราะความเอาใจใส่ที่เพิ่มขึ้นจากครู					
19. เมื่อได้รับความคิดเห็นจากผู้ปกครองว่าบุตรหลานมีความสนใจในการศึกษาแบบ STEM มากขึ้น ทั้งนี้เป็นเพราะสมรรถนะในการสอนของข้าพเจ้า					
20. การเรียนรู้ขั้นต่ำที่นักเรียนได้รับในการเรียนการสอน STEM มักเป็นเพราะการนำมาประกอบ					

ของข้าพเจ้า					
21. ข้าพเจ้าคิดว่าการที่นักเรียนควรได้รับโอกาสในการเป็นผู้นำผู้อื่นเพื่อบรรลุเป้าหมายนั้นเป็นสิ่งสำคัญ					
22. ข้าพเจ้าคิดว่าการที่นักเรียนควรได้รับโอกาสในการผลักดันผู้อื่นให้ทำงานได้อย่างเต็มที่นั้นเป็นสิ่งสำคัญ					
23. ข้าพเจ้าคิดว่าการที่นักเรียนควรได้รับโอกาสในการผลิตผลงานที่มีคุณภาพนั้นเป็นสิ่งสำคัญ					
	ไม่เห็นด้วยอย่างยิ่ง	**ไม่เห็นด้วย**	**ไม่แน่ใจ**	**เห็นด้วย**	**เห็นด้วยอย่างยิ่ง**
24. ข้าพเจ้าคิดว่าการที่นักเรียนได้เรียนรู้การเคารพในความแตกต่างของผู้อื่นนั้นเป็นสิ่งสำคัญ					
25. ข้าพเจ้าคิดว่าการที่นักเรียนได้เรียนรู้การช่วยเหลือผู้อื่นนั้นเป็นสิ่งสำคัญ					
26. ข้าพเจ้าคิดว่าการที่นักเรียนได้เรียนรู้การให้ความสำคัญต่อมุมมองของผู้อื่นในการตัดสินใจนั้นเป็นสิ่งสำคัญ					
27. ข้าพเจ้าคิดว่าการที่นักเรียนได้เรียนรู้ที่จะเปลี่ยนแปลงเมื่อมีสิ่งที่ไม่เป็นไปตามที่ตั้งใจเกิดขึ้นนั้นเป็นสิ่งสำคัญ					
28. ข้าพเจ้าช่วยนักเรียนในการตั้งเป้าหมายของการเรียนรู้ของพวกเขา					
29. ข้าพเจ้าช่วยนักเรียนของข้าพเจ้าในการจัดการกับเวลาของ					

พวกเขาอย่างมีประสิทธิภาพเมื่อต้องทำงานด้วยตนเอง					
30. ข้าพเจ้าคิดว่านักเรียนควรมีโอกาสที่จะได้เลือกว่างานที่ได้รับมอบหมายงานใดควรจะต้องลงมือทำก่อนนั้นเป็นสิ่งสำคัญ					
31. ข้าพเจ้าคิดว่านักเรียนควรมีโอกาสในการร่วมงานกับนักเรียนคนอื่นที่มีพื้นฐานที่แตกต่างกันนั้นเป็นสิ่งสำคัญ					
32. ข้าพเจ้าคิดว่าครูเป็นผู้รับผิดชอบต่อการเรียนรู้ของนักเรียนทุกคน					
33. ข้าพเจ้าคิดว่าการที่ครูสื่อสารเพื่อสร้างความเข้าใจแก่นักเรียนเป็นสิ่งสำคัญ					
34. ข้าพเจ้าคิดว่าการที่ครูใช้ข้อมูลในการประเมินที่หลากหลายภายในปีการ ศึกษานั้นเป็นสิ่งสำคัญ					
35. ข้าพเจ้าคิดว่าการที่ครูใช้ข้อมูลที่หลากหลายในการจัดการวางแผนและกำหนดจุดประสงค์นั้นเป็นสิ่งสำคัญ					
36. ข้าพเจ้าคิดว่าครูสร้างสภาพแวดล้อมที่ปลอดภัยและเป็นระเบียบนั้นเป็นสิ่งสำคัญ					
37. ข้าพเจ้าคิดว่าครูต้องให้การไว้วางใจในตัวนักเรียนนั้นเป็นสิ่งสำคัญ					

คำสั่ง : กรุณาใส่เครื่องหมาย ✔ ข้อ 38-59 โดยเลือกจากจำนวนความถี่ของการมี

ส่วนร่วมของนักเรียนในช่วงเวลาการเรียนการสอนตามประสบการณ์ของท่าน

	ไม่เคย	เป็นบางครั้ง	ปานกลาง	เป็นส่วนมาก	ทุกครั้ง
38. นักเรียน มีการพัฒนาทักษะการแก้ปัญหาผ่านการค้นคว้าในระหว่างการเรียนการสอนแบบ STEM (เช่น การออกแบบทางวิทยาศาสตร์หรือการทดสอบทางทฤษฎี)					
39. นักเรียนทำงานเป็นกลุ่มเล็ก ๆ ในระหว่างการเรียนการสอนแบบ STEM					
40.นักเรียนสามารถคาดการณ์ที่สามารถทดสอบได้ ระหว่างการเรียนการสอนแบบ STEM					
41. นักเรียนมีความตั้งใจในการสังเกตการณ์ระหว่างการสอนแบบ STEM					
42. นักเรียนใช้เครื่องมือในการค้นคว้าข้อมูลในระหว่างการเรียนแบบ STEM (เช่น เครื่องคิดเลข โปรแกรมคอมพิวเตอร์ ตาชั่ง ไม้บรรทัด เข็มทิศ)					
43. นักเรียนจัดเรียงรูปแบบของข้อมูลได้จากการเรียนรู้แบบ STEM					
44. นักเรียนสามารถอธิบายความเป็นเหตุเป็นผลของการทดลองในระหว่างการเรียนการสอนแบบ STEM					
45. นักเรียนเลือกใช้วิธีการนำเสนอผลลัพธ์ที่เหมาะสมในระหว่างการเรียนการสอนแบบ					

STEM (เช่น การวาดภาพ แบบจำลอง กราฟ แผนภูมิ ภาษาทางเทคนิค)					
46. นักเรียนสามารถทำงานได้สมบูรณ์โดยใช้บริบทโลกแห่งความจริงจากการเรียนการสอนแบบ STEM					
47. นักเรียนได้แลกเปลี่ยนความคิดเห็นเกี่ยวกับเนื้อหาสาระที่เรียนระหว่างการเรียนการสอนแบบ STEM					
48. นักเรียนสามารถให้เหตุผลที่เป็นนามธรรมได้ในระหว่างการเรียนการสอนแบบ STEM					
49. นักเรียนสามารถให้เหตุผลเชิงปริมาณได้ในระหว่างการเรียนการสอนแบบ STEM					
	ไม่เคย	**เป็นบางครั้ง**	**ปานกลาง**	**เป็นส่วนมาก**	**ทุกครั้ง**
50. นักเรียนสามารถแสดงความคิดเห็นและให้เหตุผลกับนักเรียนคนอื่นได้ในระหว่างการเรียนการสอนแบบ STEM					
51. นักเรียนเรียนรู้เกี่ยวกับอาชีพที่มีความเกี่ยวข้องกับเนื้อหาของการเรียนการสอน ในระหว่างการเรียนการสอนแบบ STEM					
52. นักเรียนใช้เทคโนโลยีหลายประเภทในระหว่างคาบเรียนแบบ STEM (เช่น เครื่องมือที่ใช้ค้นคว้าและรวบรวมข้อมูล และเครื่องมือที่ใช้ในการสื่อสาร)					

53. นักเรียนใช้เทคโนโลยีเพื่อสื่อสาร และทำงานร่วมกันในคาบเรียนแบบ STEM และนอกเหนือคาบเรียน					
54. นักเรียนใช้เทคโนโลยีในการเข้าถึงข้อมูลออนไลน์ในการทำงานที่ได้รับมอบหมายในระหว่างคาบเรียนแบบ STEM					
55. นักเรียนใช้เครื่องมือในการค้นหาข้อมูลเช่นเดียวกับนักวิจัยอาชีพใช้ในระหว่างคาบเรียนแบบ STEM (เช่น การทดลอง ฐานข้อมูล ดาวเทียม มโนภาพ)					
56. นักเรียนได้ลงมือปฏิบัติงานที่นำเทคโนโลยีมาผนวกใช้ เพื่อให้มีความเข้าใจและเข้าถึงเทคโนโลยีในชีวิตประจำวัน					
57. นักเรียนใช้เทคโนโลยีในการแก้ไขปัญหาในระหว่างคาบเรียนแบบ STEM					
58. นักเรียนใช้เทคโนโลยีเพื่อสนับสนุนการคิดขั้นสูงในระหว่างคาบเรียนแบบ STEM (เช่น การวิเคราะห์ การสังเคราะห์ การประเมินผลจากข้อมูลและแนวคิด)					
59. นักเรียนใช้เทคโนโลยีเพื่อสร้างแนวคิดใหม่ ๆ และนำเสนอข้อมูลนั้นในระหว่างคาบเรียนแบบ STEM					

ขอบคุณที่สละเวลาตอบคำถามแบบสอบถาม-

ความสามารถและทัศนคติของครูผู้สอนที่มีต่อหลักสูตรการศึกษา STEM *แบบสอบถาม*

T-STEM

BIOGRAPHY

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Career Objective:	Passionate teacher to establish safe-learning environments, to meets the physical, emotional, intellectual, social and creative, needs of children. Proven ability to developed and adjusted lesson plans to meet unforeseen classroom situations.

Work Experiences

May 2018 to Present	Homeroom Kindergarten Teacher, Wattana Wittaya Academy, Bangkok
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