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Implementation of STEM in Secondary Mathematics Classrooms: Identification of Teachers' Beliefs

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ABSTRACT

The purpose of this study was to investigate teachers' beliefs about the implementation of STEM (Science Technology Engineering and Mathematics) approach in secondary (6-12 grades) mathematics classes and identify intervening belief aspects. A questionnaire was developed regarding practicing secondary level mathematics teachers' beliefs about the implementation of STEM in mathematics classes. An online form of the questionnaire was created and sent to all secondary math teachers in two counties in the state of Florida. Eighty-two were received back from teachers. The results of factor analysis confirmed that items were distributed under five major aspects. Finally, the results of the data analysis disclosed that although most teachers believe that the implementation of STEM education is necessary, some have concerns about the effectiveness of the implementation because of shortages of materials, resources, and equipment needed for implementation of STEM. Another important finding is that teachers don't have appropriate and sufficient knowledge for the implementation of STEM activities.

Keywords: STEM; Secondary mathematics classroom; Teachers' beliefs

1. INTRODUCTION

Individuals make many decisions during everyday life. One of the distinguished social learning theorists Bandura (1986) stated that beliefs are the best indicators of these decisions that individuals make. More than three decades ago Bandura (1986) said that teaching, as a behavior, is facilitated by beliefs of individuals. Thus, defining and understanding belief systems have long been an interest of educational researchers who are mostly in agreement on that teachers' beliefs about teaching and learning impact both their opinions and decisions, and these opinions and decisions may affect teachers performance, practices, and engagements while designing instruction, assessing student understanding, and engaging in professional development (Maass, Swan, Aldorf, 2017; Taylor, 2017; Wang, Knobloch, 2018; Wang, Moore, Roehrig, Park, 2011).

Moreover, Pajares (1992) claimed that the notion of belief needs to be described first and lucidly theorized and then systematic research must be carried on to distinguish relations between beliefs and actions in any context. As paralleling to this viewpoint, numerous research studies (e.g. Martínez-Sierra, García, Valle, Dolores-Flores, 2020; Beswick, 2018; Smith, Kim, McIntyre, 2016; Levitt, 2002; Haney, Czerniak, Lumpe, 1996; Tobin, Tippins, Gallard, 1994; Kagan,1992; Pajares, 1992; Ajzen, 1985) have been conducted in the area of education to define and explore beliefs of both preservice and practicing teachers about teaching, learning, and assessment. Some of these studies have also been conducted to investigate the relationship between teachers' beliefs and their actions and decisions considering classroom practices.

In connection with their beliefs and exercises, most teachers consider the integration of STEM as including all four areas in instruction with a lack of well-defined conceptualization of the idea of integration (Breiner, Harkness, Johnson, & Koehler, 2012). According to McMullin and Reeve (2014), teachers' beliefs on the effectiveness of STEM activities on learning seem to have an impact on their tendency to involve in and implement STEM-based classroom activities. They also claimed that teachers' knowledge and understanding of STEM have an important impact on student learning.

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Although teachers mostly do not fully understand the STEM integration, research studies revealed that teachers can perceive the interconnectedness of STEM areas (Wang & Knobloch, 2018; Wang et al, 2011) believing that integration of these areas nurtures a meaningful understanding of the concepts by making connections with everyday life experiences (Hargreaves & Moore, 2000; Mason, 1996; Schlechty, 1990). Research has also shown that teachers believe that STEM integration can improve the level of student involvement and problem-solving abilities (Kendall & Wendell, 2012).

On the other hand, some studies (Graves, Hughes & Balgopal, 2016; Kurup, Li, Powell & Brown, 2019; Bagiati & Evangelou, 2015; Bybee 2013) reported challenges that teachers face in integrating STEM subjects other than their disciplines since they have limited subject matter and pedagogical knowledge for efficient application of STEM activities. McNeill and Knight (2013) claimed that teachers generally concentrate on area-specific content rather than interdisciplinary designs. Supporting this claim, Bybee (2013) stated that this tendency originated from teachers' difficulties in facilitating interdisciplinary learning by enhancing the role of real-life problems and situations. The researcher also stated that teachers face difficulties in integrating technology and engineering since they have very limited knowledge and proficiencies in these fields.

Therefore, they often pay much more attention to integrating science and math concepts with almost no inclusion of technology or engineering (Bybee, 2013; Guzey, Tank, Wang, Roehrig & Moore, 2014; Moore, Stohlmann, Wang, Tank, Glancy & Roehrig, 2014; Smith, Rayfield & McKim, 2015).

Most research activities, irrespective of the main discipline of interest, in interdisciplinary integrated STEM, is focused on primary and middle school level (e.g., Cantrell, Pekcan, Itani & Velasquez-Bryant, 2006; Capobianco, DeLisi & Radloff, 2018; Donegan-Ritter & Zan, 2017; Guzey, Ring-Whalen, Harwell & Peralta, 2019; Hammack & Ivey, 2017; Mehalik, Doppelt & Schuun, 2008; Tuttle, Kaderavek, Molitor, Czerniak, Johnson-Whitt, Bloomquist & Wilson, 2016). Numerous difficulties have been identified and reported regarding the application of STEM activities in previous research studies (e.g., Graves et al., 2016; Lesseig, Elliott, Kazemi, Kelley-Petersen, Campbell, Mumme & Carroll, 2017). Weinberg and McMeeking (2017), for example, have conducted a study related to the integration of science and mathematics and identified hindrances such as standards, assessment fit, teacher knowledge, skills, and abilities that negatively affect the integration of science and mathematics concepts. Their results confirmed Buehl and Beck's (2015) findings of the effects of teachers' experience and knowledge, on their beliefs and practices.

As a result, since teachers' beliefs about teaching and learning would affect their instructional practices more research studies are needed to investigate the teachers' beliefs about STEM integration as a teaching approach in middle and high school mathematics classrooms. Therefore, the purpose of this study was to investigate teachers' beliefs about the integration of STEM (Science Technology Engineering and Mathematics) curriculum and approaches in secondary level (6-12 grades) mathematics classes and identify intervening belief aspects. Based on the purpose of the study, the specific research questions were:

1. What are the main aspects of mathematics teachers' beliefs about the integration of STEM in mathematics classrooms?
2. What are mathematics teachers' beliefs about the integration of STEM in mathematics classes in different aspects?

2. METHOD

2.1. Research Design

Based on the purpose, the present study is two-phased. The first part of the study consisted of developing a scale regarding practicing secondary level mathematics teachers' beliefs about integration and implementation of STEM in mathematics classes. The second part of the study consists of the application of the survey and analyzing the obtained data.

In the first part of the research, an extensive review of existing literature about teachers' beliefs and classroom practices was conducted to develop a scale regarding practicing secondary level mathematics teachers' beliefs about integration and implementation of STEM in mathematics classes. The researchers, in this phase, analyzed all the information provided by previous research and generated statements that could be used in the instrument. A Likert type survey form composed of 50 items was created. Then content validity and face validity was assessed by 8 content experts.

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In the second part of the study, the online form of the survey was applied to all secondary math teachers in two counties in the state of Florida during February 2020. Eighty-two surveys were completed and received back from teachers. Then, confirmatory factor analysis was conducted to confirm hypothesized factors in the scale. Finally results obtained from the developed survey revealed mathematics teachers' beliefs about integration and implementation of STEM in mathematics classes under these 5 belief factors.

2.2. Subjects

The target population of this study was in-service secondary level mathematics teachers teaching in middle and high schools in the state of Florida. To validate the developed instrument, an effort was made to include mathematics teachers working in different schools located in 2 counties in Florida. This study was conducted with a total of 82 in-service mathematics teachers (42 females and 40 male). Table-1 presents the distribution of participants in terms of "age". Table-2 represents the distribution of participants in terms of "years of teaching experience".

Table-1. Distribution of participants in terms of "Age".

Age	Number of Teachers
21-25	7
26-30	15
31-35	13
36-40	20
41-45	12
46+	15

Table-2. Distribution of participants in terms of "Years of Experience".

Years of	Number of Teachers
0-5 years	16
6-10 years	18
11-15 years	21
15-20 years	10
20+ years	17

2.3. Construction and Application of the Instrument

The instrument "TBISTEM" (Teachers' Beliefs about Integration of STEM) is used to evaluate practicing mathematics teachers' beliefs about the integration of STEM in secondary (6-12) mathematics classrooms. The initial item pool was constructed based on literature review, theory, using existing tests or inventories, observation, and conversations with teachers. Throughout draft item preparation, the researchers followed three ways:

I. First, an extensive review of existing literature about teachers' beliefs and classroom practices regarding the integration of STEM in mathematics classrooms was conducted.

ii. Second, the researchers analyzed all the information provided by previous research and generated statements that could be used in the instrument.

iii. Third, a Likert type scale structure was preferred to ask respondents to indicate their level of agreement with a declarative statement. Scale items were rated as "strongly agree", "agree", "undecided", "disagree" and "strongly disagree". Specifically, there were five underlying components (factors): (1) Beliefs about

Implementation and Adaption, (2) Beliefs about Instructional Practices, (3) Beliefs about Motivation, (4) Beliefs about Cognitive Development, (5) Beliefs about Teaching

Competency. Table-3 shows the operational definitions of each component and sample items on belief scales. The belief scale was comprised of 41 items. In the belief scale, practicing math teachers were asked to read each statement and then indicate their level of agreement with each statement.

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Table 3. Operational definitions of components and sample items on belief scale.

Components (Factors)	Operational Definitions	Sample Items
Beliefs about Implementation and Adaption	Giving emphasis to value of implementation and adaption of STEM in mathematics classes.	I believe that the stance of adopting and implementing appropriately leveled STEM education in 6-12 grade levels is achievable and hence should be supported.
Beliefs about Instructional Practices	Giving emphasis to value of implementation of STEM in terms of instructional benefits.	I believe that the inquiry, problem-based slant of STEM education suits my classroom teaching style.
Beliefs about Motivation	Giving emphasis to value of implementation of STEM in terms of students' motivation in learning mathematics.	I believe that implementation of STEM education makes students develop positive attitudes towards mathematics.
Beliefs about Cognitive Development	Giving emphasis to value of implementation of STEM in terms of cognitive development of students.	I believe that students understand mathematics concepts better by the implementation of STEM education in mathematics classrooms.
Beliefs about Teaching Competency	Giving emphasis to value of teacher competency and readiness for the implementation of STEM in mathematics classes.	I don't believe that I have appropriate and sufficient content knowledge in one or more of the content areas emphasized by STEM curricula.

2.4. Validity of the Instrument

Content validity was assessed by eight faculty members as content experts. They reviewed each item and then used a 3-point scale as "good", "fair" or "poor" to judge the content relevancy of items. After gathering each juror's ratings, the content validity ratio (CVR) was calculated for each item based on the formula developed by Lawsche (1975). In the (CVR) formula, "nh" refers to the number of jurors indicating "good" and "N" refers to the total number of jurors. A minimum CVR value of 0.75 was necessary for statistical significance at $p < 0.05$ based on eight content reviewers (Lawsche, 1975). Items were retained if their CVR values were equal or greater than a determined minimum CVR (0.75). Since 9 items did not meet this criterion, they were removed from the instrument. In the end, the 41 items were kept in the revised version.

$$CVR = \frac{n_h - \left[\frac{N}{2}\right]}{\left[\frac{N}{2}\right]}$$

2.5. Reliability of the Instrument

For the reliability of the instrument, "Cronbach's Alpha" was found to be 0.822. After determining the level of reliability of the scale, "Cronbach's Alpha if Item Deleted" values were calculated to find out whether there was any item negatively affecting the reliability of the scale. It is seen in table-4 below that "Corrected Item Total Correlation" points of 4 items (#1, #12, #18, and #20) were less than 0.3. This means that these items had negative effects on the reliability of the scale. Thus, deletion of these 4 items from the scale was found to be necessary. After deletion of 4 items, remaining items in the scale were renumbered (from 1 to 37) and "Cronbach's Alpha" was recalculated to determine level of reliability of the scale. "Cronbach's Alpha" was found as 0.861.

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Table-4. Item-Total Statistics

Item #	Corrected Item-Total	Cronbach's Alpha if Item
1	-0.052	0.852
12	0.205	0.835
18	0.117	0.841
20	-0.012	0.848

3. RESULTS

3.1. Results for Research Question-1

This section reveals the results to answer the first research question (What is the factorial structure of mathematics teachers' beliefs about STEM in mathematics classrooms?)

Considering the first research question, the belief construct of the TBISTEM was tested to establish structural aspect of reliability evidence. Reliability of the scale was found to be high regarding the value of Cronbach's Alpha coefficient which is 0.861. The underlying assumption in this study was that teachers' beliefs included multiple dimensions; Confirmatory Factor Analyses (CFA) were performed until defensible model for this measure was reached. Results of the CFA presented that teachers' beliefs about implementation of STEM in mathematics classes were multifaceted construct shaped by the factors of: (1) Beliefs about Implementation and Adaption, (2) Beliefs about Instructional Practices, (3) Beliefs about Motivation, (4) Beliefs about Cognitive Development, (5) Beliefs about Teaching Competency.

3.1.1. Confirmatory Factor Analysis

CFA techniques were performed to confirm the hypothesized- five factor structure of the scale. Therefore, a total of 37 continuous factor indicators (individual items in the scale) referred to the observed factor indicators in the model.

Initially, KMO (Kaiser-Meyer-Olkin) and BTS (Bartlett's Test of Sphericity) tests were applied for the examination of factorability of the instrument. KMO value (0.8413) for measure of sampling adequacy showed acceptable sample size and BTS was found to be significant (x"(82) = 4,491.215, $p < .05$) for multivariate normal distribution. Factor analysis showed that items were distributed under 5 factors which had eigenvalues greater than 1.00. Principle Component Analysis (PCA) was used as an extraction method.

Table-5. Rotated Component Matrix.

Item #	Components				
	1	2	3	4	5
1	0.793				
2	0.657				
3	0.712				
4	0.541				
5	0.654				
6	0.542				
7					0.780
8	0.911				
9	0.631				
10		0.633			
11		0.604			
12		0.626			
13				0.692	
14				0.780	
15		0.649			
16				0.667	

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17		0.827			
18					0.565
19				0.843	
20				0.522	
21				0.922	
22				0.575	
23				0.830	
24		0.563			
25		0.773			
26		0.700			
27		0.541			
28			0.829		
29			0.866		
30			0.876		
31			0.702		
32			0.887		
33			0.602		
34				0.832	
35			0.604		
36					0.893
37					0.713

3.1.2. Reliability of Factors (Subscales)

In the second phase of the Confirmatory Factor Analysis (CFA), reliability of each subscale or each factor was computed. Table-6 below represents the reliability of the five factors (subscales).

Table-6. Reliability of factors.

Factors	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Beliefs about Implementation and	0.692	0.697	8
Instructional Beliefs	0.774	0.778	9
Motivational Beliefs	0.807	0.808	7
Cognitive Beliefs	0.832	0.835	9
Beliefs about Teaching Competency	0.669	0.673	4

3.2. Results for Research Question-2

This section reveals the results to answer the first research question (What are mathematics teachers' beliefs about the integration of STEM in mathematics classes?)

3.2.1. Beliefs about Implementation and Adaption (Subscale-1)

Mathematics teachers' beliefs about implementation and adaption of STEM in secondary (grades 6-12) mathematics classes were identified by 8 items in the scale. Here are the results of teachers' responses for this subscale:

1. Of all participated math teachers, 83.87% stated that they actively and openly support the adoption and implementation of appropriately leveled STEM education into 6-12 grade levels.
2. For confirmation purposes, a negative item was placed on the scale. 90.32% of the participants opposed to resisting the adoption and implementation of appropriately leveled STEM education into 6-12 grade levels.
3. In addition, 80.46% of the math teachers stated that they believe that adopting and implementing appropriately leveled STEM education is achievable and hence should be supported.
4. Furthermore, 88.37% of the math teachers stated that they believe that the stance of STEM education can be adapted to the needs and abilities of students in 6-12 grade levels.

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5. Finally, as an important result, 35.48% of the teachers believe that the implementation of STEM education is not efficiently manageable because of the shortages of materials, resources, and equipment needed for teaching STEM.

Overall, results for the subscale-1 indicated that although most teachers (around 85%) believe that the implementation of STEM education is necessary, some (around 35%) have concerns about the effectiveness of the implementation because of shortages of materials, resources, and equipment needed for teaching STEM.

3.2.2. Instructional Beliefs (Subscale-2)

Mathematics teachers' beliefs about how instructional activities can be affected by the integration of STEM in secondary (grades 6-12) mathematics classes were identified by 9 items on the scale. Here are the results of teachers' responses for this subscale:

1. Of all participated math teachers, 74.19% stated that inquiry, the problem-based slant of STEM education suits their classroom teaching style.
2. The results of the study clearly revealed that 93.54% of the participants believe that STEM education provides a variety of classroom learning experiences (e.g. cooperative, individual, student-centered, and teacher-directed learning).
3. In addition, 81.48% of the math teachers stated that they believe that the integration of STEM education makes more mathematics content teachable through the use of student explorations.
4. Furthermore, 64.51% of the math teachers stated that STEM education is sufficiently flexible to manage day-to-day use in the classroom.
5. On the other hand, as an important result, 70.37% of the teachers believe that STEM-related instructional strategies are time-consuming and require additional instructional time.

Overall, results for the subscale-2 indicated that although most teachers (around 75 to 90%) believe that the integration of STEM education provides effective instructional strategies, the main concern from the instructional perspective is time. Most teachers (around 70%) have concerns about additional instructional time.

3.2.3. Motivational Beliefs (Subscale-3)

Mathematics teachers' beliefs about the role of integration of STEM in secondary (grades 6-12) mathematics classes on students' motivation were identified by 7 items on the scale. Here are the results of teachers' responses for this subscale:

1. Of all participated math teachers,

    i. 92.59% stated that STEM education makes mathematics fun,
    ii. 88.89% stated that STEM education increases student enthusiasm,
    iii. 81.48% stated that STEM education increases student involvement in mathematics classrooms.
    iv. 77.78% stated that STEM education makes students develop positive attitudes towards mathematics.
    v. 84.07% stated that STEM education increases student motivation.

2. On the other hand, as an important result, only 25.92% of the teachers believe that the implementation of STEM education makes students study harder.

Overall, results for the subscale-3 indicated that although most teachers (around 77 to 93%) believe that the integration of STEM education increases the students' motivation, they mostly (around 75%) don't believe that implementation of STEM education makes students study harder.

3.2.4. Cognitive Beliefs (Subscale-4)

Mathematics teachers' beliefs about the role of integration of STEM in secondary (grades 6-12) mathematics classes on students' cognitive developments were identified by 9 items in the scale. Here are the results of teachers' responses for this subscale:

1. Of all participated math teachers,

    i. 96.42% stated that students understand math concepts better by the implementation of STEM education,
    ii. 89.28% stated that STEM education aligns with the educational needs of grades 6-12 students,

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iii. 89.28% stated that students develop problem-solving skills better by the implementation of STEM education,
iv. 82.14% stated that students learn abstract concepts better by the implementation of STEM education,
v. 64.28% stated that students learn more mathematics concepts through self- exploration by the implementation of STEM education.

2. For confirming purposes, two negative items were also included in this subscale. According to given responses to those negative items,

i. Only 7.14% believe that implementation of STEM education will result in lower student achievement,
ii. 25% believe that students lose basic computational skills by the implementation of STEM education.

3.2.5. Beliefs about Teaching Competency (Subscale-5)

Mathematics teachers' beliefs about appropriate and sufficient knowledge for implementation of STEM in secondary (grades 6-12) mathematics classes were identified by 4 items in the scale. Here are the results of teachers' responses for this subscale:

1. *Of all participated math teachers,*

i. Only 48.38% stated that professional training is informative and beneficial for teachers on how to best implement a STEM curriculum,

ii. Only 46.42% believe that they have appropriate and sufficient content knowledge in one or more of the content areas emphasized by STEM curricula,

iii. 48.14% stated that they have some fears and problems about applying STEM-related instructional strategies,

iv. Only 51.85% believe that they are confident about applying STEM-related instructional strategies in my classroom,

Overall, results for this subscale indicated that nearly half of the mathematics teachers believe that they don't have appropriate and sufficient knowledge for implementation of STEM in secondary (grades 6-12) mathematics classes

4. DISCUSSION

It seems very promising that the results of this research study were supported by multiple studies' findings concerning teachers' beliefs and challenges they face in the integration of STEM. First of all, the findings of this research study indicated that most of the mathematics teachers (around 85%) believe that the implementation of STEM education is necessary and they actively and openly support the implementation of STEM. This result highly resembles the results of other research studies (Hsu, Purzer, Cardella, 2011; McMullin and Reeve 2014; Smith et al. 2015) found in the literature emphasizing teachers' strong feelings that STEM should be integrated into students' K-12 education. In other words, they felt STEM is important. However, some (around 35%) of the participated teachers have concerns about the effectiveness of the implementation because of shortages of materials, resources, and equipment needed for teaching STEM. This finding also perfectly aligns with some of the previous studies. For example, in their research study Park, Dimitrov, Patterson, and Park. (2017) claimed that teachers perceived a lack of instructional resources which was a hurdle in their path to provide STEM opportunities for their students. Also, it was noted in several studies (Asghar, Ellington, Rice, Johnson, Prime, 2012; Wang et al. 2011) that teachers expressed their need for specific, ready-made STEM problems and resources they could use in their classrooms immediately. These problems must be grounded in the STEM disciplines and driven by the standards.

Although most of the mathematics teachers (around 90%) believe that the integration of STEM education provides effective instructional strategies, the main concern from the instructional perspective is time. Even though they believe that integration of STEM education makes more mathematics content teachable through the use of student explorations, they (around 70% of them) have concerns about the need for additional instructional time. Other research studies have revealed similar concerns about time.

Bagiati and Evangelou (2015), for example, emphasized in their study that teachers have to find more time to plan with other subject areas and to prepare the materials for students. According to Hsu et al. (2011), presenting the material and allowing for varying ability levels among students also required more time. This makes a lack of time one of the teachers' primary concerns when implementing STEM (Goodpaster, Adedokun, Weaver, 2012; Park, Byun, Sim,

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Han, Baek 2016). In these studies, it is also emphasized that teachers were concerned with the increased workload associated with STEM programming.

Most of the participating mathematics teachers in the present study expressed that integration of STEM education makes mathematics fun, increases student enthusiasm, increases student involvement in mathematics classrooms, makes students develop positive attitudes towards mathematics, and increases student motivation. In summary, teachers believe STEM education is inherently motivating to students. Teachers feel the interest gained by students are very valuable as they work on STEM challenges and that students eventually begin to feel motivated and empowered by their ability to solve complex problems. Moreover, other research studies reported that teachers felt an increase in student enjoyment and engagement after integrating STEM into their curriculum (Dare, Ellis, Roehrig, 2014; Herro and Quigley 2017; Lesseig, Slavit, Nelson, Seidel 2016; McMullin and Reeve 2014; Srikoom, Hanuscin, Faikhamta 2017; Van Haneghan, Pruet, Neal-Waltman, Harlan, 2015).

Regarding students' cognitive developments, mathematics teachers mostly believe that students understand and learn abstract mathematical concepts better through self- exploration activities and develop their problem-solving skills by STEM applications education. Some research studies (Bruce-Davis, Gubbins, Gilson, Villanueva, Foreman, Rubenstein, 2014; Dare et al. 2014; Goodpaster et al. 2012; Van Haneghan et al. 2015) reported similar results indicating that teachers highly valued the STEM activities that are a fundamental, necessary and beneficial for student' conceptual understanding and meaningful learning. Similarly, it was noted in the mathematics education research literature (Asghar et al. 2012) that secondary teachers felt the STEM activities would be particularly useful as students are mastering abstract math concepts.

However, teachers' only concern about cognitive development seems to be students' achievement in high stake tests. A small number of teachers believe that STEM education may lower students' achievements in these tests because of weakened procedural skills. They believe that students may lose basic computational skills and procedural skills to do well in most of the multiple-choice items in tests. A similar result has been reported by Park et al. (2016) stating that secondary teachers have a more negative view on the impact of STEM education on student achievement when compared to elementary teachers.

Although there is not much information on the relationship between STEM education and students' achievement in the high-stake testing, a recent study (Koklu, 2019) found no significant student achievement differences in high-stake tests such as SAT (Scholastic Aptitude Test) and ACT (American College Testing) between STEM integrated and non- STEM integrated high schools. More studies that document the relationship between students' achievement in tests and integration of STEM programs would be beneficial to teachers, teacher educators, and policy-making authorities.

Finally, the results of the study indicated that nearly half of the mathematics teachers believe that they don't have appropriate and sufficient knowledge for the implementation of STEM in secondary mathematics classes. More specifically, more than half the participating teachers thought that professional in-service training and teacher training programs are not fully informative and beneficial for teachers on how to best implement a STEM curriculum. They also stated that they have some fears and problems with applying STEM-related instructional strategies. Only half of the participating teachers believe that they are confident about applying STEM-related instructional strategies in their classrooms. Paralleling to the result of the current study, other research studies (Lesseig et al. 2016; Nadelson, Seifert, Moll, Coats 2012; Nadelson, Callahan, Pyke, Hay, Dance, Pfiester 2013; Nadelson and Seifert 2013; Van Haneghan et al. 2015) reported that teachers believe that well-organized and frequently available professional learning opportunities would facilitate successful STEM initiatives. The most often mentioned support that would increase the effectiveness of STEM education was learning opportunities for teachers to increase their ability to effectively integrate STEM content into their curriculum. Previous research studies (Nadelson et al. 2013; Van Haneghan et al. 2015) also indicates that effective professional development or continuing education directly influences teacher practice and student learning.

5. CONCLUSION

The findings of this research uncovered some important aspects of teachers' beliefs and concerns when it comes to implementing STEM. These beliefs and concerns of teachers should be taken into consideration by educational authorities in district, state, and national levels as well as by teacher education institutions. Generally speaking, secondary mathematics teachers mostly have positive beliefs about the integration and implementation of STEM. They

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believe that this integration can increase students' understanding of most mathematics concepts conceptually and meaningfully. However, teachers face a variety of challenges when it comes to understanding and applications of STEM curriculum and STEM activities in their classrooms. The findings of this study, therefore, has great importance to recognize sot all but some of these difficulties.

The most important challenge they have expressed was shortages of materials, resources, and equipment needed for teaching STEM. Teachers expressed their need for specific, ready-made STEM problems and resources they could use in their classrooms immediately. Curriculum designers, school administrators, district, and state authorities should take initiatives to resolve these problems to meet teachers' needs. Without sufficient materials, resources, and equipment, the integration of STEM education will not go further beyond teachers' good intentions and positive beliefs for implementation.

Another important finding of this study is that teachers don't have appropriate and sufficient knowledge for the implementation of STEM in secondary mathematics classes. Most of the participating teachers thought that professional in-service training and teacher training programs are not fully informative and beneficial for them on how to best implement a STEM curriculum. They also stated that they have some fears and problems with applying STEM-related instructional strategies. This finding is very important for teacher preparation programs in higher education institutions. Teacher training programs have to reconsider their curriculum to enhance teacher candidates' knowledge and practice on how to best implement STEM in classrooms. Also, these programs should consider more frequent in-service workshops and symposiums for practicing teachers to keep them up to date on new approaches and resolve immediate problems they faced in the application of STEM activities.

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List of Tables

List of abbreviations

ACT	: American College Testing
BTS	: Bartlett's Test of Sphericity
KMO	: Kaiser-Meyer-Olkin
CFA	: Confirmatory Factor Analysis
CVR	: Content Validity Ratio
FVR	: Face Validity Ratio
SAT	: Scholastic Aptitude Test
STEM	: Science Technology Engineering and Mathematics
TBISTEM	: Teachers' Beliefs about Integration of STEM