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ANALYSIS OF POSTGRADUATE THESES RELATED TO STEM EDUCATION IN TURKEY: A META-SYNTHESIS STUDY

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Abstract: Importance and prevalence of STEM, which is a holistic educational approach that includes science, technology, engineering and mathematics, has been increasing in recent years. It is stated that STEM is very important for countries to compete and stand out in the new world order and economy. In this study, postgraduate theses on STEM education in Turkey were investigated by meta-synthesis method. In this context, 58 theses, 9 of which were doctoral and 49 of them were master's thesis were examined. Topics covered in the theses, research methods used, preferred sample groups, data collection tools and results presented in theses, similar and different aspects were examined in detail. It is understood that various skills, opinions, academic achievement, learning approaches, career, attitudes, and interest/perception are studied in the theses. In the studies, it was determined that mostly mixed, quantitative and qualitative methods were preferred respectively, middle school students and teacher candidates were frequently studied groups, and questionnaire/scale and interview (form) tools were frequently used as data collection tools. The results, similarities and differences of the theses were expressed with key statements and some suggestions were presented.

Key words: STEM Approach, STEM Education, Meta-Synthesis Method

1. Introduction

STEM is an educational approach that is used as an abbreviation for Science, Technology, Engineering, and Mathematics. It is stated that STEM, which is based on teaching science, mathematics, technology, and engineering fields together, is particularly common in the USA and the USA adopts this approach for world leadership. It is emphasized that it is fundamentally related to the fact that the USA considers the innovative and technological achievements of China and India as a threatening factor and related to growing trade wars, competition and the expectation from industrial-business world and education for training individuals equipped with the necessary skills in the fields of science, engineering and technology by abstaining from the general discourse. It is specified that in the USA, STEM education schools are opened, and STEM is becoming widespread in other countries besides the USA (Akgündüz et al., 2015). Many countries that want their citizens to have multi-dimensional capabilities in modern life encourage STEM education. Moreover, it is expected that STEM education will solve the problem of low career interest in science/technology areas and inadequate performance problems observed in international examinations such as TIMMS, PISA (Pimthong and Williams, 2018).

Bybee (2010b), who explains that the origins of STEM were based on the USA National Science Foundation-NSF in 1990s and that STEM is used as a general label for any event, policy, program or practice involving one or more of its disciplines, indicates that the educational community has adopted this motto without spending enough time to clarify what the term means when applied beyond a general label. It is emphasized that there is no clear definition or framework on STEM, which is both educational and professional focus of interest (Hwang and Taylor, 2016). Çorlu, Capraro and Capraro (2014) define STEM education as "*knowledge, skills and beliefs built in cooperation in more than one field out of science, technology, engineering and mathematics*''. The essence of STEM education is explained as establishing a connection between the workforce in 21st century and STEM-focused activities and enabling students to apply what they have learned in school to their future professions (Ejiwale, 2013). In the case of group studies, laboratory research and project activities within the

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STEM approach are applied properly, it is stated that individuals can obtain the necessary skills for the 21st century and it contributes to making the right decisions on important issues such as personal health, energy efficiency, environmental quality, resource utilization and national security (Bybee, 2010a). In fact, according to Bybee (2010a), the needs of citizens to understand and solve such issues from personal to global perspectives are clearly linked to the knowledge of STEM disciplines such as economics, politics and cultural values.

Fan and Yu (2016) point out that STEM is not an approach that is considered important only in the USA, but rather STEM is the focus of many countries' curriculum reforms (as cited in Lai, 2018). Lai (2018), who attributed the reason of it to the fact that developed countries such as the USA are fully understood the linear relationship between performance in STEM disciplines and the economic development and competitiveness of a country, defines STEM education as *"an integrated education combining scientific inquiry-research, technology, engineering design and mathematical analysis with a coherent learning paradigm including curriculum content, teaching activities and educational policy"*. Fan and Yu (2016) emphasize that in STEM education it is essential for students to apply their knowledge interdisciplinary, to reveal their desire to learn STEM subjects, to develop their skills for STEM professions and to gain STEM literacy which a person should know in our age. In addition, the authors state that STEM programs often contain the following important components (as cited in Lai, 2018):

1. Using real world problem situations,
2. Curriculum design related to project-based, problem-based or inquiry/research-based learning,
3. Having clear course objectives, content areas and learning indicators,
4. Providing student-centered learning experiences,
5. Emphasizing the connection and integration of STEM information,
6. Consideration of the development of higher order thinking, such as logical thinking, problem solving and critical thinking,
7. Emphasizing the link between curriculum and business markets.

Stating that STEM is not a concrete teaching method but a comprehensive educational concept, Kanematsu et al (2014) specify that STEM is necessary for future generations to live with high level of welfare. According to them, STEM, which can be defined as science and engineering education at an early stage, can be extended until after secondary education and the factors such as joy, entertainment etc. are particularly important in the success of STEM education at pre-secondary education levels. Similarly, Koç-Akran and Aşiroğlu (2018), who noted that STEM is not a specific model, teaching technique or strategy, define STEM as a continuation of the constructivist approach and continue as follows: STEM and constructivist approaches have similar and different aspects. In STEM education, the teacher increases the self-confidence of the students with the environment s/he creates and the students are not afraid of making mistakes. With the theoretical and practical knowledge he provides, the teacher provides students with knowledge in STEM disciplines, gains high-level thinking skills and helps students in using the acquired knowledge in an innovative way. However, in the constructivist education approach, the teacher generally serves as a role model in providing students with appropriate and high-level skills.

STEM education and research play a key role in finding answers to the advanced technology, medicine, sustainability, agriculture, national security, economy, society, and life. Therefore, STEM academic programs determine their vision as meeting the needs of local and regional industries, providing national security, focusing on labor development and research to compete in the global market. It is asserted that these needs change constantly, new challenges emerge and thus, the STEM academy has to change and adapt itself to these changes to meet its primary vision and missions (Egarievwe, 2015). In a world where STEM education is rapidly changing and evolving, we have to follow the innovations in the field of education as a country and to increase our efforts towards STEM education in particular. In Turkey, in line with the other countries, STEM education is given more

importance in recent years, various studies are carried out in this field and STEM draws attention as a subject mentioned in educational circles.

There are various studies conducted on STEM in Turkey. Examples of such studies are the evaluation report for STEM education in Turkey by Akgündüz et al. (2015), the views of prospective science teachers on STEM by Bakırcı and Kutlu (2018), research on the implementation of STEM approach in teacher education by Bozkurt-Altan et al. (2016), STEM awareness scale development for teachers by Çevik (2017). The researches conducted in this field can be listed as STEM awareness of prospective chemistry and mathematics teachers by Aslan-Tutak et al. (2017), STEM awareness scale development by Buyruk and Korkmaz (2016), STEM studies in education faculties in Turkey by Çolakoğlu and Günay-Gökben (2017), views of prospective science teachers on STEM education practices by Erdoğan and Çiftçi (2017), validity and reliability study of the integrated STEM teaching orientation scale Turkish form by Hacıömeroğlu and Bulut (2016), views of prospective science teachers on STEM by Kızılay (2016), evaluation of STEM activities prepared by prospective pre-school teachers by Koyunlu-Ünlü and Dere (2018), views of prospective chemistry teachers on STEM practices by Tarkın-Çelikkıran, Aydın-Günbatar (2017), views of science and mathematics teachers on STEM by Yıldırım and Türk (2018c) and examination of secondary school mathematics textbooks in the context of STEM by Sarıca (2019).

1. 1. The Purpose and Importance of the Research

In studies on Turkish education system, it is observed that STEM education in curriculum development activities, in particular, has started to be focused recently. Çepni (2018) explains this situation as studies on STEM have increased in our country but there is no clarity about how STEM will be implemented in educational environments. In the academic field, studies on STEM education have been initiated but not at the desired level yet. When the national literature is scanned, it is a phenomenon that we frequently encounter. It is observed that the majority of the studies are related to specific disciplines and are concentrated on a particular education level. In addition, it is understood that the studies focus on views rather than revealing a product or outcome related to STEM education. At this point, these situations are considered as a necessity and it is thought that a comprehensive examination of STEM studies conducted in our country will be useful. The aim of this study is to investigate the postgraduate theses written on STEM education in Turkey. In this context, with regard to postgraduate theses on STEM education in Turkey has sought answers to the following questions:

1. What is the distribution of theses by years?
2. What are the issues addressed in the theses?
3. What are the research methods used in theses?
4. What are the preferred study groups in the theses?
5. What are the data collection tools used in theses?
6. What are the results of the theses?

In this research, postgraduate theses on STEM education in Turkey were examined and the issues addressed in these studies, the research methods used, the preferred study groups and data collection tools, the results of the studies, similar and different aspects of these studies were established. Therefore, it is obvious that such a detailed evaluation will contribute to the relevant literature and present the situation/tendencies of the current studies. At the same time, it is envisaged that this study will provide a holistic perspective on STEM literature, provide convenience to researchers, and provide the opportunity to develop new perspectives by seeing the shortcomings of the literature. Thus, in the relevant literature, there will be an opportunity to focus on different aspects of the subject, which have not been studied rather than the studies that have already been conducted as a repetition of each other. In terms of including the reflections on our current situation regarding STEM education, the Ministry of National Education will be able to guide the studies and practices on this subject.

2. Method

In this study, the meta-synthesis approach which is one of the qualitative research designs is adopted. Meta-synthesis is defined as the assertion and comparison of similarities and differences by examining the studies conducted on a specific subject with a qualitative approach (Çalık and Sözbilir, 2014). Meta-synthesis is not an ordinary review of the studies in the relevant literature, but a methodological approach to develop new knowledge based on the interpretive analysis of the current research results. In addition, the main idea in this process is to combine the findings of primary studies and use them as data in a third-level interpretation (Aspfors and Fransson, 2015). In recent years, in the meta-synthesis studies, which draw attention as an approach frequently used in national and international education literature, the qualitative findings of researches related to a particular subject/case studies are interpreted, examined and new results are deduced (Polat and Ay, 2016). Meta-synthesis seeks to integrate the results of a number of different but interrelated qualitative studies to produce new views and this process involves induction and interpretation (Hughes-Morley et al., 2015).

2. 1. Data Collection and Inclusion Criteria

The aim of this study is to examine postgraduate theses on STEM education conducted in Turkey. Thus, master and doctorate theses on STEM education carried out in Turkey are covered by the studies included in this research. In order to realize this aim, a comprehensive literature screening was performed in the Thesis Center of Higher Education Council. Inclusion criteria of this study are as follows: it should be carried out in Turkey, it should be a master or doctorate thesis, information such as method, sample group, data collection tools of the relevant study should be clearly stated and the relevant studies should be accessible. The subject field was selected as education and training and the theses that include the STEM or FeTeMM (Turkish abbreviation for STEM) words in their titles or abstracts were reached. All of the theses that provide access permission at the date of data collection of the study were included in the data of the study. Since the theses conducted on 2019 were not open access at the time of data collection, those theses were not included in this study. Within the scope of these criteria, 58 studies, 49 of which were master and 9 of which were doctorate theses, were examined. As STEM is a new and wide spreading issue in Turkey, the limitations such as time, year or date range were not applied to the studies to be included in this research.

2.2. Coding Process

In this process of the study, the related parts of the studies included in the research were read in detail and some preliminary notes were taken. Afterwards, these data were transferred to the electronic environment by revising the notes related to the studies and removing the nonsense parts. The research problems, qualitative and quantitative findings of the theses within the scope of the research were examined in order and the codes and themes were formed. These codes and themes are shown in Table 1. The studies included in the research were coded as "T_1, T_2, T_3… T_{58}" in order to facilitate the analysis process and because all of the studies were thesis, and this coding was used in the study.

Table 1. *Meta-Synthesis code table*

Themes	Sub-Themes	Codes
Awareness	Awareness towards STEM	SA
Opinions	Opinions towards STEM	SV
Interest/Perception	Interest towards STEM	SI
	Perception towards STEM	SS
	Perception of Competence towards STEM	SCS
	Effect of STEM on Perception of Inquiry Learning Skills	SSILS
	Effect of STEM on Perception of Engineering	SSE
	Effect of STEM on Perception of Technology	SST
Motivation	Effect of STEM on Course Motivation	SCM
	Motivation towards STEM Disciplines	SDM

Attitude	Effect of STEM on Attitudes towards Course Attitude towards STEM	SAtC AtS
Academic Achievement	Effect of STEM on Academic Achievement Effect of STEM on Conceptual Understanding Effect of STEM on Learning Outputs Effect of STEM on Retention	SAA SCU SLO SR
Various Skills	Effect of STEM on (Scientific) Creativity Skills Effect of STEM on Problem Solving Skills Effect of STEM on Critical Thinking Skills Effect of STEM on Scientific Process Skills Effect of STEM on Reflective Thinking Skills Effect of STEM on Psychomotor Skills Effect of STEM on Engineering (Design) Skills Effect of STEM on Self-Regulation Skills	S(S)CS SPSS SCTS SSPS SRTS SPS SE(D)S SS-RS
STEM and Other Learning Approaches	STEM Integrated Argumentation Based Science Learning Problem Based STEM Education Early STEM and Authentic Learning Webquest Supported STEM Education Mobile Technology Based STEM Practices STEM Education in Simulation Based Inquiry Learning Environment Scenario Based Learning Approcah Based on STEM Activities STEM and 5E Integration Montessori Based STEM	SIABSL PBSE ES WSSE MTBSP SESBILE SBLABSA S5EI MBS
Practicability / Effectiveness	The practicability of STEM Effectiveness of STEM Interdisciplinarity in STEM	SP SE IiS
Competence	Competence towards STEM STEM Teaching Self-Efficacy Beliefs of Teachers	SC STSEBT
Examination of Studies on STEM	Content Analysis of STEM Articles Meta-synthesis of STEM Based Lesson Plans	CASA M-SSBLP
Career	Career Interst towards STEM Disciplines Perception of Career towards STEM Disciplines Career Preferences towards STEM Disciplines Recognizing STEM Professions The Effect of STEM on Understanding STEM Disciplines STEM Career Development The Effect of STEM on Professional Development	SDCI SDCS SDCP SPR SDU SCD SPD
STEM Scale Development	STEM Scale Development	SSD
Teacher Education	STEM's Effect on Pedagogical Content Knowledge The effect of STEM on Self-Efficacy Beliefs in Science Teaching The effect of STEM on Teacher Self-Efficacy Beliefs The effect of STEM on STEM Teaching Orientation	SPCK SS-EBST STS-EB STO

2.3. Theses Examined within the scope of Meta-Synthesis

The theses examined in line with the aim of this study are shown in Table 2. For each study, information such as number, type, author and year of publication, research method, study group, data collection tool(s), theme codes are provided. Furthermore, as shown in Table 2, theses are listed in chronological and alphabetical order. Accordingly, 84.5% of the examined theses were master theses and 15.5% were doctorate theses.

Table 2. *Studies examined within the scope of meta-synthesis*

No	Type	Author and Year	Method, Study Group, Data Collection Tools	Theme Code
T_1	Master Thesis	Ceylan, S. (2014)	Quantitative, 56 students (8th grade), Achievement Test, Scientific Creativity Test, Problem Solving Inventory, Student Opinion Survey on STEM Education	SAA SSCS SPSS SV
T_2	PhD	Gülen, S. (2016)	Mixed, 40 students (6th grade), Achievement Test, Reflective Thinking Scale, Interview Form, Psycho-Motor Skills Observation Form, STEM Integrated Argumentation-Based Science Learning Approach Activities	SIABSL SAA SRTS SPS
T_3	PhD	Gülhan, F. (2016)	Mixed, 55 students (5th Grade), STEM Perception Test, STEM Attitude Test, Draw an Engineer Test, Questions about Students' Professional Preferences, Conceptual Understanding Questions, Scientific Creativity Questions, Student Journals, Design Papers, Photos and Presentation Videos	AtS SS SCU SSCS
T_4	Master Thesis	Irkıçatal, Z. (2016)	Quantitative, 20 students (7th Grade), STEM Career Interest Scale, Engineering and Science Attitude Scale, What Does the Engineer Do? Scale, What is Engineering? Scale, and What is Technology? Scale	SAA SS
T_5	PhD	Yıldırım, B. (2016)	Mixed, 78 students (7th Grade), Achievement test, Perception Scale of Inquiry Learning Skills for Science, Science Motivation Scale, STEM Attitude Scale, Interview Form, STEM Disciplines Questionnaire Form	SAA SSILS SCM AtS SR SV
T_6	Master Thesis	Alan, B. (2017)	Mixed, 62 prospective science teachers, Scientific Process Skills Test, Problem-Solving Inventory, Integrated STEM Teaching Orientation Scale, Interview, Journals and Observation Form	SPSS SSPS STO SV
T_7	Master Thesis	Ensari, Ö. (2017)	Qualitative, 8 prospective physics teachers, Interview Form	SV
T_8	Master Thesis	Konca-Şentürk, F. (2017)	Mixed, 52 students (7th grade), Conceptual Understanding Test, Scientific Creativity Scale, Interview Form	SCU SSCS SV
T_9	Master Thesis	Ocak, M. H. (2017)	Quantitative, 1161 secondary school students, STEM Attitude Scale, STEM Career Interest Scale	AtS SDCI
T_{10}	Master Thesis	Öztürk, M. (2017)	Quantitative, 175 classroom teachers, 3433 students (4th Grade), Primary School Teachers STEM Competence and Attitude Scale, Elementary School Students STEM Attitude Scale	AtS SC
T_{11}	PhD	Pekbay, C. (2017)	Mixed, 71 students (7th grade), Daily Living Problem Solving Skills Test, STEM Interest Scale, Field Notes, Activity Work Sheets, Thoughts on Process Form, Interviews	SPSS SI SV

T_{12}	Master Thesis	Sarıcan, G. (2017)	Quantitative, 44 students (6th Grade), Achievement test, Reflective Thinking Skills Scale for Problem Solving	SAA SR SRTS
T_{13}	Master Thesis	Şatgeldi, A. N. (2017)	Quantitative, 306 science teachers, STEM Readiness Scale	SSD
T_{14}	Master Thesis	Tantu, Ö. (2017)	Qualitative, 10 teachers (1 physics teacher, 5 science, 4 IT teachers), Interview, Demographic Information Form, Assessment Form	MTBSP
T_{15}	Master Thesis	Tezsezen, S. (2017)	Mixed, 204 prospective teachers (Elementary Mathematics, Computer, Physics, Chemistry, Secondary Mathematics, Science), STEM Awareness Open Ended Survey, Interview	SA
T_{16}	Master Thesis	Yasak, M. T. (2017)	Mixed, 46 students (8th Grade), Achievement test, Science Attitude Scale, Interview Form	SAA SAtC SV
T_{17}	PhD	Acar, D. (2018)	Mixed, 68 students (4th Grade), Achievement test, Critical Thinking Skills Scale, Problem Solving Skills Scale, Interview Form	SAA SCTS SPSS SV
T_{18}	Master Thesis	Açıkgöz, S. (2018)	Qualitative, 14 pre-school teachers, Interview Form, Personal Information Form	SV SP
T_{19}	Master Thesis	Akay, M. (2018)	Qualitative, 10 BİLSEM (Science and Arts Education Center) students (6th,7th, 8th Grade), Lesson plans, Rubric, Activities	SP
T_{20}	Master Thesis	Alıcı, M. (2018)	Mixed, 22 secondary school students (5th Grade), STEM Attitude Scale, STEM Career Perception Scale, STEM Career Interest Scale, Interview Form	PBSE AtS SV SDCI SDCS
T_{21}	Master Thesis	Altaş, S. (2018)	Mixed, 27 prospective classroom teachers, Technology Perception Scale, Engineering Perception Scale, Observation, Document, Voice Recording	SEDS SSE SST
T_{22}	Master Thesis	Arslan, Ö. (2018)	Mixed, 20 prospective science teachers, Self-Efficacy Scale in Science Teaching, Interview Form	SS-EBST SPCK
T_{23}	Master Thesis	Aygen, M. B. (2018)	Mixed, 65 prospective science teachers, Achievement Test, Integrated STEM Teaching Orientation Scale, Journals, Interviews	SAA STO SV
T_{24}	PhD	Ayverdi, L. (2018)	Mixed, 41 BİLSEM (Science and Arts Education Center) students (5th, 6th,7th, 8th Grade), Context-Based Scientific Creativity Test, STEM Attitude Scale, Observation Form, Interview Form, Documents	S5EI SSCS SSPS SES
T_{25}	Master Thesis	Badur, S. (2018)	Mixed, 834 secondary school students (5th, 6th,7th, 8th Grade), STEM Career Interest Scale, Interview Form	SDCI
T_{26}	Master Thesis	Belek, F. (2018)	Mixed, 52 prospective science teachers, Teacher Self-efficacy Belief Scale, Thought Scale for Science Teaching, STEM Education Orientation Scale, Interview	SV STO STS-EB

T_{27}	Master Thesis	Biçer, B. G. (2018)	Quantitative, 115 Science Teachers, Science Teachers Opinion on STEM Scale	SV
T_{28}	Master Thesis	Bilekyiğit, Y. (2018)	Mixed, 51 students (10th Grade), Achievement Test, STEM Career Interest Scale, Interview Form	SAA SDCI SV
T_{29}	Master Thesis	Bozan, M. A. (2018)	Qualitative, 28 students (4th Grade), Journal, Interview, Video Records, Student Products	SPD SV
T_{30}	Master Thesis	Büyükdede, M. (2018)	Mixed, 85 prospective mathematics teachers, Achievement Test, Conceptual Understanding Test, STEM Education Student Opinion Survey	SAA SCU SV
T_{31}	Master Thesis	Çakır, Z. (2018)	Mixed, 50 prospective pre-school teachers, Problem Solving Scale, Critical Thinking Disposition Scale, How Creative Are You Scale, Interview Form	MBS SPSS SCTS SCS SV
T_{32}	Master Thesis	Çiftçi, M. (2018)	Mixed, 56 students (7th Grade), STEM Career Interest Scale, Professional Freehand Drawing Test, Interdisciplinary Relationship Sentence Completion Test, Scientific Creativity Test and Field Notes	SSCS SDU SPR
T_{33}	Master Thesis	Dedetürk, A. (2018)	Mixed, 158 students (6th Grade), Achievement Test, Interview	SAA
T_{34}	Master Thesis	Doğanay, K. (2018)	Mixed, 40 students (7th Grade), Achievement Test, Work Sheets, Science Attitude Scale, Interview, Focus Group Interview, Observation Form	PBSE SAA SAtC
T_{35}	PhD	Dönmez, I. (2018)	Mixed, 63 students (7th Grade), Interview, Witkin's Group Embedded Figures Test, Life Story, Observation, Journal, STEM Activities, Colleague Opinions, Word Association Test, Drawing, Cognitive Styles Test, Holland Profession Selection Inventory, Kahoot Application	SCD
T_{36}	Master Thesis	Dumanoğlu, F. (2018)	Mixed, 88 students (7th Grade) Achievement Test, STEM Attitude Test, Interview, Student's notebooks	SAA AtS
T_{37}	Master Thesis	Duygu, E. (2018)	Mixed, 39 Prospective science teachers, Scientific Process Skill Test, STEM Awareness Scale, Interview Form	SESBILE SSPS SA SV
T_{38}	Master Thesis	Ersoy, Z. (2018)	Quantitative, 56 classroom and pre-school teachers, STEM Teaching Self-Efficacy Scale, Teacher Recognition Form	STSEBT
T_{39}	Master Thesis	Gazibeyoğlu, T. (2018)	Mixed, 52 students (7th Grade), Achievement Test, Science Attitude Scale, Interview Form	SAA SAtC SV
T_{40}	Master Thesis	Girgin, Ş.(2018)	Qualitative, 1st graders' teacher, 13 students (4th Grade), Observation, Field Notes, Interview	ES
T_{41}	Master Thesis	Helvacı Özacar,B. (2018)	Quantitative, 32 teachers (Science and Mathematics), Lesson Plans	IiS

T_{42}	Master Thesis	Karcı, M. (2018)	Quantitative, 50 students (5th Grade), Achievement Test, STEM Career Interest Scale, Science Course Motivation Scale	SBLABSA SAA SCM SDCI
T_{43}	Master Thesis	Kaya, M.E.(2018)	Mixed, 32 Prospective science teachers, How Creative Are You Scale, Self-Regulation Scale, Interview Form	SS-RS SCS SV
T_{44}	Master Thesis	Kayalar, A. (2018)	Quantitative, 76 Prospective science teachers, Engineering STEM Career Interest Scale, STEM Motivation Scale, Design Skills Scale, System Intelligence Inventory, Teacher Self-Efficacy Scale	MTBSP SEDS SV
T_{45}	PhD	Kızılay, E. (2018)	Quantitative, 1667 students (secondary school), STEM Career Interest Scale, STEM Motivation Scale	SDM SDCI
T_{46}	Master Thesis	Koca, E. (2018)	Mixed, 33 students (7th Grade), Achievement Scale, Science Attitude Scale, Interview, Document Analysis	SP SAA SAtC SV
T_{47}	Master Thesis	Murat, A. (2018)	Quantitative, 193 Prospective science teachers, STEM Attitude Scale, 21st Century Skills Competence Test for Prospective Teachers	AtS
T_{48}	Master Thesis	Nağaç, M. (2018)	Mixed, 44 students (6th Grade) Achievement Test, Problem Solving Inventory, Interview Form	SAA SPSS SV
T_{49}	Master Thesis	Onsekizoğlu, A. S. (2018)	Mixed, 21 students (11th Grade), Learning Styles Scale, Multiple Intelligence Scale, Academic Success Questions, WebQuest, Design Book, Rubrics, Observation, Interview Questions	WSSE SAA SCU SV
T_{50}	Master Thesis	Öcal, S. (2018)	Quantitative, 26 students (preschool), Preschool Scientific Process Skills Scale for 60-72 months of children	SSPS
T_{51}	PhD	Özçakır-Sümen, Ö. (2018)	Mixed, 46 prospective classroom teachers, Achievement Test, STEM Awareness Scale, Belief Scale Regarding Mathematical Problem Solving, Problem Based Study Papers, Interview	SLO SAA SA SPSS SV
T_{52}	Master Thesis	Özmen, N.(2018)	Qualitative, 82 lesson plans, National Thesis Center, Bahçeşehir University Online Database, Google Search, Google database	M-SSBLP
T_{53}	Master Thesis	Öztürk, S.C. (2018)	Mixed, 30 prospective science teachers, Critical Thinking Disposition Scale, Problem-Solving Inventory, Interview Form	SCTS SPSS SV
T_{54}	Master Thesis	Tabar, V.(2018)	Qualitative, 67 articles, Google Academics, Eric, Web of Science Databases	CASA
T_{55}	Master Thesis	Tekin-Poyraz, G. (2018)	Qualitative, 17 persons (administrator, teacher, student, parents) 12 persons (academician, expert), Interview, Journal	SP
T_{56}	Master Thesis	Topsakal, İ. (2018)	Mixed, 81 students (7th Grade), Learning Climate Scale, Critical Thinking Disposition Scale, Perception Scale for Problem Solving Skills,	PBSE

			Interview Form, Report (Experience Journal Form)	
T_{57}	Master Thesis	Türker, B. (2018)	Quantitative, 314 University Preparatory Class Students, Survey	SDCP
T_{58}	Master Thesis	Üçüncüoğlu, İ. (2018)	Mixed, 35 prospective science teachers, STEM Awareness Scale, Integrated STEM Teaching Orientation Scale, STEM Concept Map Form, Lesson Plans, STEM Activity Module Disciplinary Content Form, STEM Education Opinion Form and Field Notes	SE SA SV SCS

2.4. Validity and Reliability

In this study, the validity types of Sandelowski and Barroso (2007) determined in their meta-synthesis studies are considered and these are as follows:

1. Descriptive Validity: In this type of validity, the validity of the data is based on the facts. In this context, in this study, they are significant and accurate definitions derived from each study.
2. Interpretive Validity: It means expressing perspectives of the researchers completely and accurately.
3. Theoretical Validity: This type of validity is based on the reliability of the researcher in explaining and interpreting the findings. It also covers loyalty to the method used (as cited in: Aküzüm and Özmen, 2013).

2.5. Data Analysis

Noblit and Hare (1988) identified seven steps for the analysis of data related to the meta-synthesis study (as cited in: Aküzüm and Özmen, 2013). These steps followed in this study are as follows:

Step 1. *Deciding and starting a factual study:* In this step, STEM education in Turkey is defined as the study field of this research.

Step 2. *Deciding which studies will be used for the selected subject area:* In this step, a literature review was conducted on the subject. In addition, the master and doctorate theses to be included in this study were determined according to the inclusion criteria.

Step 3. *Reading the qualitative data:* In this step, the themes and sub-themes of the studies included in the research were examined comprehensively. Key statements and expressions regarding the themes were identified (Table 8). In this way, data related to each other can be determined and conversions can be made.

Step 4. *Determining how the data are related:* In this step, similar and different aspects of the examined studies are given. In this context Table 2 was formed. In Table 2, similar and different aspects of the studies in terms of publication year, type, method, sample group, data collection tools and theme codes were shown. In addition, descriptive statistics such as method, sample group, frequency and percentage for data collection tools are presented in the findings section of this study.

Step 5. *Translating the data into one another:* The process of translating the data into one another is based on the assumptions made based on the studies in the previous step.

Step 6. *Synthesising translations:* This step is conducted when many studies are included in the research and it requires a second-level synthesis process.

Step 7. *Expressing the synthesis:* This step is the last step in which the synthesis is effectively expressed.

3. Findings

The distribution of theses by years, which is the first sub-problem of this study, examined within the scope of this research is given in Table 3.

Table 3. *Distribution of theses by years*

Year	Type	Theses	f	%
2014	Master Thesis	T_1	1	1.7
2016	Master Thesis	T_4	1	1.7
	PhD	T_2, T_3, T_5	3	5.2
2017	Master Thesis	$T_6 - T_{10}, T_{12} - T_{16}$	10	17.3
	Doktora	T_{11}	1	1.7
2018	Master Thesis	$T_{18} - T_{23}, T_{25} - T_{34}, T_{36} - T_{44}, T_{46} - T_{50}, T_{52} - T_{58}$	37	63.8
	PhD	$T_{17}, T_{24}, T_{35}, T_{45}, T_{51}$	5	8.6
Total	Master Thesis & PhD	$T_1 - T_{58}$	58	100

As seen in Table 3, 1.7% of the theses examined within the scope of this study are the studies conducted in 2014, 6.9% of them conducted in 2016, 19% of them conducted in 2017 and 72.4% of them conducted in 2018. According to these findings, it can be said that the number of studies carried out on the subject has increased in recent years.

The findings on the subjects related to the STEM covered by the theses that are examined within the scope of this study, which is the second sub-problem of this study, are given in Table 4.

Table 4. *Topics examined in theses*

Topics Examined in STEM Theses	f	%
Various Skills	29	19.6
Opinions	27	18.2
Academic Achievement	26	17.6
STEM and Other Learning Approaches	12	8.1
Career	12	8.1
Attitude	11	7.4
Interest/Perception	7	4.7
Teacher Education	6	4.1
Practicability/Effectiveness	6	4.1
Awareness	4	2.7
Motivation	3	2.0
Examination of Studies on STEM	2	1.35
Competency	2	1.35
STEM Scale Development	1	0.66
Total	148	100

When Table 4 was examined, it was seen in the theses on STEM examined within the scope of this study that various skills, views and academic achievement were among the frequently discussed topics. STEM and other learning approaches, career, attitudes, teacher training, interest/perception, practicability/effectiveness, awareness, motivation were studied in theses. It is understood that there are limited number of theses conducted on examination of studies related to STEM, competency, and scale development.

The results of the research methods of the theses examined within the scope of this study, which is the third sub-problem of the study, are shown in Table 5.

Table 5. *Preferred research methods*

Research Methods	Theses	f	%
Mixed	T 2, 3, 5, 6, 8, 11, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 28, 30, 31, 32, 33, 34, 36, 37, 39, 43, 46, 48, 49, 51, 53, 56, 58	33	57
Quantitative	T 1, 4, 9, 10, 12, 13, 27, 38, 41, 42, 44, 45, 47, 50, 57	15	26
Qualitative	T 7, 14, 18, 19, 29, 35, 40, 52, 54, 55	10	17
Total	T 1 – T 58	58	100

When Table 5 is examined, it is understood that mixed methods are frequently used in the postgraduate theses examined within the scope of this study. This is followed by a quantitative and qualitative method respectively.

The findings of the study groups preferred in the theses examined within the scope of this study, which is the fourth sub-problem of this research, are given in Table-6.

Table 6. *Preferred study groups*

Study Groups	f	%
Secondary School Students (5, 6, 7 and 8th grade)	24	38.7
Prospective Teachers	16	25.8
Teachers	9	14.5
High School Students (9, 10, 11 and 12th grade)	4	6.5
Primary School Students (1, 2, 3 and 4th grade)	3	4.8
Undergraduate Students	1	1.6
Preschool Students	1	1.6
Administrators & Parents	1	1.6
Academician & Experts	1	1.6
Academic Study (Article, Thesis, Book Chapter etc.)	1	1.6
Lesson Plan	1	1.6
Total	62	100

In Table 6, it is seen that secondary school students (f=24, 38.7%) are frequently preferred as the study group in the theses examined within the scope of this study. It was observed that this was followed by prospective teachers (f=16, 25.8%), teachers (f=9, 14.5%), high school students (f=4, 6.5%) and primary school students (f=3, 4.8%). It was understood that other study groups such as undergraduate students, preschool students, administrators, parents, experts etc. were also preferred. At this point, the reason why the total number of study group (f=62) is more than the total number of theses (f=58) examined in this article is that more than one study group is preferred in some theses. For example, the administrator, parents, academicians, groups of experts were selected as study group in a single thesis, or in some theses, and the study group was consisted of both teachers and students.

The findings related to the data collection tools used in the theses examined within the scope of this study, which is the fifth sub-problem of this research, are given in Table 7.

Table 7. *Preferred data collection tools*

Data Collection Tools	f	%
Questionnaire / Scale	44	27.9
Interview / Meeting (form)	36	22.8
Academic Achievement Test	18	11.4
Other Tests	9	5.7
Activities (their products) / Practices	9	5.7
Observation (form)	8	5.0
Diaries	7	4.4

Audio-Visual Tools such as Audio Records, Videos, Photographs	4	2.5
Documents	4	2.5
Other Data Collection Forms	4	2.5
Questions (Forms)	3	1.9
Course Plans	3	1.9
Field Notes	3	1.9
Student Notebooks	2	1.3
Webquest & Module	2	1.3
Rubric	2	1.3
Total	158	100

When Table 7 is considered, it is being understood that data collection tools such as questionnaire / scale (f=44, 527.9), interview / meeting (form) (f=36, 22.8%), and academic achievement test (f=18, 11.4%) are frequently being used in the theses examined within the scope of this study. Moreover, it is being observed that data collection tools such as other tests, activities (their products) / practices, observation (form), diaries, and audio-visual tools such as audio records, videos, photographs, and documents, other data collection forms, questions, course plans, field notes are also being preferred. Tools such as student notebooks, webquests & module, rubric had also been used in the theses as data collection tools even if not so frequently.

One of the stages of meta-synthesis method is to reveal the similar and different aspects of examined studies. The findings revealed within the scope of this stage of meta-synthesis method constitute the sixth and final sub-problem of this research. Key statements regarding the themes enabling to manifest the similar and different aspects of the examined theses are being provided in Table 8.

Table 8. *Key statements regarding to themes*

Themes	Key Statements	f	%
Various Skills	STEM education improves the problem solving skills.	7	4,64
	STEM education affects scientific creativity skills positively.	7	4,64
	STEM education immproves the scientific process skills.	4	2,65
	STEM education improves the critical thinking skills.	3	1.99
	STEM education improves engineering (design) skills.	2	1.32
	STEM practices do not make a significant diffrerence in pupil's problem solving skills.	1	0.66
	STEM education improves reflective thinking skills.	1	0.66
	STEM education does not increase reflective thinking skills significantly.	1	0.66
	STEM education based on mobile technology could not be effective in developing engineering (design) skills.	1	0.66
	STEM education affects self-regulation skills positively.	1	0.66
	STEM education improves the psychomotor skills.	1	0.66
Opinions	Pre-service teachers & teachers have positive opinons about STEM.	11	7.30
	Students' remarks regarding STEM education is generally positive.	9	6
	Teachers do not have sufficient knowledge and are not well equipped with STEM education.	4	2.65
	With the STEM approach, positive changes occur in the students' views towards STEM.	3	1.99
	Pre-srevice teachers think STEM is not applicable in current conditions of schools.	1	0.66
	STEM practices make the course effective.	1	0.66
	STEM education increases / positively affects academic achievement.	17	11.26
	STEM practices / education do not increase academic achievement	3	1.99

Academic Achievement	significantly.		
	STEM education affects the conceptual understanding positively.	3	1.99
	STEM eucation does not make a significant difference in conceptual learning.	2	1.32
	STEM education has no significant effect on retention.	1	0.66
	STEM education has a significant effect on retention.	1	0.66
Career	STEM education increases the career interest towards STEM disciplines.	2	1.32
	The interest in STEM professions change in regard to demographic variables such as gender, grade, parents' education level, income.	2	1.32
	STEM education affects perception of career towards STEM disciplines positively.	1	0.66
	STEM activities do not make a significant difference on interest of STEM career.	1	0.66
	Engineering and Space Sciences are the most demanded ones among the STEM careers.	1	0.66
	Students who make STEM career choices at the university have higher STEM self-efficacy and families with more interest in STEM issues.	1	0.66
	STEM activities are effective in students' understanding STEM disciplines.	1	0.66
	STEM activities are effective in recognizing STEM professions.	1	0.66
	STEM education is beneficial for the professional development of teachers.	1	0.66
	In the STEM-based education process, teachers develop professionally and students develop their STEM career understanding.	1	0.66
STEM and Other Learning Approaches	Problem based STEM education	3	1.99
	STEM practices based on mobile technology	2	1.32
	STEM integrated Argumentation based science learning	1	0.66
	Early STEM and authentic learning	1	0.66
	Webquest-supported STEM education	1	0.66
	STEM education in simulation based inquiry learning environment	1	0.66
	Scenario based learning approach based on STEM activities	1	0.66
	Montessori based STEM	1	0.66
	STEM and 5E integration	1	0.66
Attitude	STEM practices enhance students' attitudes towards science lesson.	4	2.65
	Student's attitude towards STEM is positive.	2	1.32
	STEM activities affect students' attitudes towards STEM disciplines positively.	2	1.32
	STEM practices do not make a significant difference on students' attitudes towards STEM.	1	0.66
	STEM education makes a significant difference on students' attitudes towards STEM.	1	0.66
	Pre-service teachers' attitudes towards STEM are generally positive.	1	0.66
Interest / Perception	STEM activities affect students' perception of STEM positively.	2	1.32
	STEM activities enhance the students' interest in STEM positively.	1	0.66
	STEM based practices are effective in improving teacher candidates' perception of competence towards STEM.	1	0.66
	STEM practices do not make a significant difference on students' perception of inqury learning skills.	1	0.66
	STEM practices enhance students' perception of engineering positively.	1	0.66
	STEM practices enhance students' perception of technology positively.	1	0.66

Teacher Education	STEM education incresas STEM teaching orientations.	2	1.32
	STEM practices have no effect on STEM teaching orientations.	1	0.66
	STEM education affects preservice teachers' self-competence beliefs towards science teaching positively.	1	0.66
	STEM activities have no significant effect on preservice teacher's self-competence beliefs.	1	0.66
	STEM practices affect preservice teachers' pedagogics and field knowledge positively.	1	0.66
Practicability / Effectiveness	STEM education is applicable.	2	1.32
	There are a number of problems in the implementation of STEM training (formal or distance).	2	1.32
	STEM based practices are effective.	1	0.66
	In STEM, interdisciplinarity and integration of disciplines are important.	1	0.66
Awareness	STEM education affects students' STEM awareness positively.	1	0.66
	There is not a significant difference between first and last grade pre-service teachers in terms of STEM awareness.	1	0.66
	STEM education increases pre-service teachers' STEM awareness significantly.	1	0.66
	STEM based practices enhanced pre-service teachers' STEM awareness.	1	0.66
Motivation	Class level, gender, education level of parents, income variables are effective on motivation towards STEM disciplines.	1	0.66
	STEM activities make a significant difference in motivation towards science course.	1	0.66
	STEM activities do not make a significant difference in motivation towards science course.	1	0.66
Competence	Science and mathematics proficiency beliefs of the students are not at the desired level, and the class teachers' proficiency beliefs about STEM education are above the middle level.	1	0.66
	Teachers' STEM teaching self-efficacy beliefs are very low.	1	0.66
Examination of Studies on STEM	In the studies, it was mostly studied with prospective teachers and K-12 student groups and opinions, perception and attitudes towards STEM were investigated more.	1	0.66
	STEM does not have an agreed framework in the literature.	1	0.66
STEM Scale Development	STEM readiness scale was developed for science teachers.	1	0.66
Total		151	100

Key statements and expressions regarding the themes obtained from the theses examined related to the STEM education, and the relevant frequency and percentage values are also being provided in Table 8. According to this, under the theme of various skills, there are findings regarding that STEM education or practices have positive effects on the development of skills such as problem solving, scientific creativeness, scientific process, critical thinking, reflective thinking, engineering design, and self-regulation. Even if just a few, there are also results which provides the conclusion that STEM education is not effective in developing the skills, or that it doesn't create statistically significant difference. Under the theme of opinions regarding STEM, there are results related to the fact that the views of students, prospective teachers and teachers on STEM are positive, that positive changes are occurring in the views of students on STEM through the STEM approach, and that the STEM practices are making the course more effective. Other key statements showing up under this theme are the views regarding that the teachers do not have sufficient knowledge and experience on STEM

education, and that the prospective teachers find the STEM education inapplicable under the current school conditions.

Under the theme of academic achievement, there are statements regarding that STEM education is increasing and positively affecting academic success and the conceptual understanding. There are also results that STEM education is not statistically significantly increasing the academic success and conceptual understanding, and that it both has and does not have significant effect on permanence. Under the theme of career, there are results regarding that STEM education is positively affecting the career interests and perception relevant to fields of STEM, that it doesn't constitute a significant difference on career interest, that interest in STEM professions is differentiating as per some demographical variables, that STEM activities are being effective on students in understanding the STEM disciplines and in knowing their professions, that the most preferred ones among STEM careers are engineering and space sciences, that the teachers are developing in professional aspect and that the students are developing in terms of their STEM career comprehension in the educational process based on STEM practices, and that the students preferring STEM career at undergraduate degree level have higher STEM self-efficacy and that they have families having more interest on STEM issues.

Under the theme of STEM and other learning approaches, there are the key statements of Problem Based STEM Education, STEM Practices Based on Mobile Technology, STEM Integrated Argumentation Based Science Learning, Early STEM and Authentic Learning, Webquest Supported STEM Education, STEM Education in Simulation Based Inquiry Learning Environment, Scenario Based Learning Approach Based on STEM Activities, Montessori Based STEM, and STEM and 5E Integration. It is being understood that STEM education is being used along with these approaches, or that its integration is being examined. Under the theme of attitude, it is being observed that there are results regarding that STEM education is increasing the attitude of students relevant to science course, that the attitudes of students and prospective teachers regarding STEM are generally positive, that STEM activities are positively affecting the students' attitudes regarding the fields of STEM, and that the STEM activities and practices both create and don't create significant difference on the attitudes of students regarding STEM.

Under the theme of interest/perception, there are results regarding that the STEM activities are positively affecting the students' STEM perceptions and their interest regarding STEM. In addition, there are results that the STEM practices are improving the engineering and technology perceptions of the students, and the competence perceptions of prospective teachers regarding STEM. There are also results regarding that STEM practices does not create significant difference on the prospective teachers' inquiry learning skill perceptions. Under the theme of teacher education, there are results regarding that STEM education is increasing the prospective teachers' tendencies to teach STEM and that it is positively affecting their self-efficacy beliefs regarding teaching of science. There are also results regarding that STEM practices and activities do not have effect on STEM teaching tendency, that they do not have significant effect on the prospective teachers' self-efficacy beliefs, and that they are positively affecting the pedagogic and field knowledge of the prospective teachers.

Under the theme of practicability /effectiveness, there are results regarding that STEM education is applicable and effective, that interdisciplinarity and integration of disciplines are important in STEM, and that there are some problems at the point of implementation of STEM education. Under the theme of awareness, there are results regarding that STEM education is positively affecting the students' STEM awareness, that it is significantly increasing the prospective teachers' STEM awareness, that the STEM focused practices are improving the prospective teachers' STEM awareness, and that there is no significant difference among the first grade and final grade prospective teachers in terms of STEM awareness.

Under the theme of motivation, results regarding that variables such as grade level, gender, educational level of mother and father and income are being effective on motivation regarding fields of STEM, that STEM practices both create and don't create significant difference on motivation regarding science course are attracting attention. Under the theme of competence, there are results regarding that the students' science and math competence belief levels are not at required level, and that the teachers' competence belief regarding STEM education is over the medium level, and that the

teachers' STEM teaching self-efficacy belief is at extremely low level. Under the theme of examination of studies on STEM, there are results regarding that it is mostly being studied with prospective teachers and K-12 students in the studies, that the subjects such as opinions, perceptions and attitudes regarding STEM are being searched more, and that STEM does not have a frame on which it is reached a consensus in literature. Under the theme of STEM scale development, there is a result regarding that STEM readiness scale development study is conducted for the science teachers.

4. Discussion, Conclusion and Recommendations

In this study, postgraduate theses related to STEM education in Turkey was investigated by meta-synthesis methods. In this context, 58 theses were examined, 49 of which were master's thesis and 9 of which were PhD and they were analyzed in detail. It is thought that it is important to discuss and present the findings of the study in the context of the related literature.

The first sub-problem of this study is results of the distribution of the theses by years. It is seen that the majority of theses in STEM field were conducted in 2018. This is followed by 2017, 2016 and 2014 respectively. The theses, which are accessible at thesis center of Higher Education Council at the time of collecting the data, were included in the scope of this study. As the theses conducted on 2019 were not accessible at the time of data collection, these theses were not included in this study. The total number of theses reached in this study is 58 and it is understood that the majority of these studies have been carried out in recent years. In this context, it can be said that interest and studies related to STEM education have increased in recent years. In addition, Hacıömeroğlu and Bulut (2016) mention that the number of publications on STEM in the domestic literature has increased in recent years. Hwang and Taylor (2016) also reported that the interest in STEM has increased.

The second sub-problem of this study is the results regarding the issues addressed in the theses on STEM education. According to this, various skills, opinions, academic achievement, other learning approaches, career, attitude, interest/perception, techer education, practicability/effectiveness, awareness, motivation, examination of studies, competence and scale development subjects regarding STEM had been studied respectively in the theses. In a similar manner, Kaleci and Korkmaz (2018) are sharing in their researches –in which they had performed the content analysis of studies regarding STEM education- the finding that primarily the cognitive factors such as success, permanence, competence, effectiveness, and then affective factors such as attitude, interest, motivation are the frequently encountered learning outputs. Tezel and Yaman (2017) are specifying that the studies performed in national literature regarding STEM are close to each other, and that their results are similar, and that different studies are required in this field, and they are mentioning the importance of especially the integration of STEM disciplines, and of the performance of researches regarding development of education materials regarding the same.

The third sub-problem of this study is the results regarding research methods being preferred in the theses regarding STEM education. According to this, it is being observed that mostly the mixed method, then the quantitative method and then the qualitative method are being preferred in the theses that were examined within the scope of this study. It is being specified that mostly quantitative method, then qualitative method and then the mixed method are being used in the studies on articles regarding the STEM education (Gökpete-Yıldız and Özdemir, 2015). In another study, in which publications regarding STEM education had been examined, it is being specified that mostly quantitative method, then qualitative method and then mixed method are being used in these researches (Yıldırım, 2016). The difference in between the results of this study, and the results of other studies whose findings had been shared might have arose from the examination of theses regarding STEM education in this study, and from the examination of mostly the articles in other studies.

The fourth sub-problem of this study is the results regarding study groups being preferred in the theses regarding STEM education. In the theses examined within the scope of this research, it is being determined that secondary school students are mostly being preferred as study group. It is specified that prospective teachers, teachers, secondary school, and elementary school students are following the same respectively. It is being understood that other study groups such as undergraduates, pre-school students, administrators, parents, specialists etc. are also being preferred even if just a few. Jeong,

Hmelo-Silver and Jo (2019) stated that the effect is greatest with secondary school students in their article, which is a meta-analysis study about the impact of computer-supported collaborative learning in STEM education. They specified that although the effect of computer-supported collaborative learning in STEM education would enhance with knowledge and experience secondary level students benefit much more than undergraduate or other adult learners. In a similar manner, it is being noted that secondary school students are the student group being preferred the most in the studies regarding STEM education, and then prospective teachers are the group being preferred the next (Herdem and Ünal, 2018). Moreover, in another study, the order of frequency regarding groups worked with in the researches regarding STEM education is as follows: elementary school and secondary school students, prospective science teachers, science teachers (Kaleci and Korkmaz, 2018).

The fifth sub-problem of this study is the results regarding data collection tools being preferred in the theses regarding STEM education. It is being understood that data collection tools such as questionnaire / scale, interview / meeting (form) and academic achievement test are being used as per the order of frequency in the theses examined within the scope of this study. Moreover, it is being specified that data collection tools such as other tests, activities (their products) / implementations, observation (form), diaries, and audio-visual means such as audio records, videos, photographs, and documents, other data collection forms, questions, course plans, field notes are also being preferred. Tools such as student notebooks, webquests & module, rubric had also been used in the theses as data collection tools even if not so frequently. In the study performed by Herdem and Ünal (2018), it is being specified that tools respectively such as scale, questionnaire and tests are being used the most in the researches regarding STEM in which quantitative method was used, and that tools such as semi-structured interviews, field notes and drawings are being used the most in the researches in which qualitative method was preferred. In the study performed by Kaleci and Korkmaz (2018), the data collection tools being used in the researches made regarding STEM education are being listed as documents, interviews, tests (perception, attitude, aptitude etc.), achievement tests, observations, questionnaires, other data collection tools and alternative assessment and evaluation tools as per order of frequency.

The sixth and the final sub-problem of this research is the themes developed in order to reveal the similar and different aspects of the examined studies, and the results regarding expressions and statements relevant to the same. As many key statements and expressions are present under each theme within the scope of this sub-problem, it had been preferred to discuss the frequent key statements due to reasons such as article's page limit and not to bother the reader. As it will also be understood from the statements being present under theme of various skills, STEM education is developing the skills such as problem solving, creativeness, scientific process, critical thinking etc. It is emphasized that STEM approach is providing an interdisciplinary perspective to students for them to gain high level thinking skills such as problem solving, and creative and critical thinking (Kubat and Guray, 2018). Kuo et al (2019) remarked STEM interdisciplinary Problem Based Learning (PBL) is effective to enhance students' creativity. Moreover, it is emphasized that STEM education should cover veins of higher order thinking skills like creative thinking, problem solving, critical thinking and scientific thinking and so that STEM training improve students' those higher order thinking skills (Baharin, Kamarudin, & Manaf, 2018) In a similar manner, there are the findings that STEM education is developing the students' scientific creativeness skills in the researches of Gülhan and Şahin (2018), that it is developing their problem solving skills in the studies of Yıldırım and Türk (2018a), and that STEM approach is developing the students' scientific process skills in the publications of Yamak, Bulut and Dündar' (2017).

Under the theme of opinions, there are statements regarding that prospective teachers, teachers and students generally have positive views on STEM. There are similar results in the relevant literature. In one of them, there are the views of prospective chemistry teachers regarding that they have significant contribution in terms of gaining interdisciplinary perspective, improving the design skills, field knowledge, remembering and enhancing the things learned related to the STEM education practices (Tarkın-Çelikkıran and Aydın-Günbatar, 2017). In another study, there are the views of prospective teachers regarding that they want to apply the STEM approach when they embark on their career (Erdoğan and Çiftçi, 2017). Furthermore, in another study, thoughts of science teachers regarding that

STEM approach will increase the interest of the students in the course, and that it will provide students with the skills of decision-making, inquiry-questioning, creative thinking and multiple perspectives (Bakırcı and Kutlu, 2018).

Under the theme of academic achievement, there are statements regarding that STEM education is increasing academic success, and positively affecting the conceptual understanding. In the semi-experimental study of Sarıcan and Akgündüz (2018), they are informing that integrated STEM education has positive contributions and reflections on academic success. In a similar manner, Gülhan and Şahin (2018) are informing by their experimental study that the academic success of the experiment group students to whom the course is being taught through STEAM (STEM + Art) activities is significantly improving compared to control group students. Olivarez (2012) specified that involving in a STEM academic program affected eight grade students' academic success in math, science and reading positively. In the study in which the effect of STEM educational practices on the learning outputs of the students is being searched through meta-analysis method, it is being emphasized that the effect of STEM practices on academic success is at medium level (Saraç, 2018). As different from these studies, James (2014) is specifying that the science and math success of 7th grade students having education at traditional classes is higher compared to the group having education through STEM approach. This result is again having parallelism with the statement regarding the finding that STEM education is not significantly increasing the academic success even if it has low frequency under the theme of academic achievement. Under the theme of career, there are key statements regarding that STEM education is positively affecting the STEM career interest and perception, and that the interest in STEM professions is differentiating as per demographical variables such as gender, social class, educational level of mother and father, and income. Gaspard et al. (2019) expressed that pupils have higher expectations and values in STEM disciplines are more likely to select a STEM major. In addition to this, according to them students' academic success and demographic traits like gender, socio-economic status and school type are meaningfully related with their profile that can be associated with students' choice of STEM career. In a similar manner, it is being informed that STEM activities are positively affecting the students' perceptions and attitudes regarding these disciplines (Gülhan and Şahin, 2016). Moreover, it is being reported that students' STEM profession interests is significantly differentiating as per variables such as gender, academic success, and frequency of technology usage (Karakaya, Avgın and Yılmaz, 2018).

Under the theme of attitude, there are statements regarding that STEM education is positively affecting the students' attitude towards science course and STEM fields, and that the attitudes of the students regarding STEM are generally positive. It is being emphasized that the 4, 5, 6, 7 and 8th grade students' attitudes towards STEM are at good level (Aydın, Saka and Güzey, 2017). In their study, Toma and Greca (2018) revealed that students participated in integrative STEM training showed more positive attitude towards science and overperformed academically than students who took place in traditional classes. Under the theme of interest/perception, there are statements regarding that STEM practices are positively affecting the students' perceptions and interests relevant to STEM, and their perceptions of engineering and technology. Similar with this finding, it is being specified that STEM practices are positively affecting the students' perceptions and attitudes regarding STEM fields (Gülhan and Şahin, 2016). Under the theme of teacher education, there are statements regarding that STEM education is positively affecting the prospective teachers' STEM teaching tendency, their self-efficacy beliefs in that teaching of science, and their pedagogic and field knowledge, but that it does not have significant effect on their self-efficacy beliefs. For the STEM education and approach to be effectively and efficiently applied at the schools, at the first stage it is required to train teachers who have sufficient knowledge and experience regarding this approach (Tarkın-Çelikkıran and Aydın-Günbatar, 2017). It is being specified that the teachers' qualified preparation and perspective is important on the students' success in the field of STEM (Hacıömeroğlu and Bulut, 2016).

Under the theme of practicability/effectiveness, there are statements regarding that STEM education is applicable, but that there are some problems at the point of implementation, and that integration of disciplines is important in STEM. Ejiwale (2013) is informing that there are some obstacles before the successful implementation of STEM education. According to that these obstacles are as follows: few number of qualified STEM teachers, lack of sufficient investment in the teachers' professional

development, lack of students' sufficient preparation, and lack of their source of inspiration, lack of communication with the ones learning individually, lack of sufficient support from the school system, lack of research and cooperation in the fields of STEM, insufficiency in the preparation of content, presentation of weak contents and evaluation method, poor condition of laboratory facilities and educational tools, and lack of applied activities for the students (Ejiwale, 2013). It is being specified that there are some problems under headings such as teachers' competence, their professional development training, assessment and evaluation, physical and social background, curriculum development studies, problems in implementation, and lack of cooperation among administrators of schools and stakeholders in the process of integration of STEM education to curriculum in our country (Akgündüz et al., 2018).

Under the theme of awareness, there are statements regarding that STEM education is positively affecting the prospective teachers' and students' STEM awareness. In a study, it is revealed that there are significant changes in the awareness of the prospective teachers who are trained on STEM education (Aslan-Tutak, Akaygün and Tezsezen, 2017). Moreover, in another study, it is being specified that the STEM awareness levels of university students are high, and that this awareness is not significantly changing as per grades (Hebebci and Usta, 2017). Under the theme of motivation, there are statements regarding that some demographic variables are effective on motivation in the fields of STEM, that the STEM practices are both significantly increasing and not significantly increasing the motivation regarding science course. Chittum et al. (2017) pointed out in their study that an afterschool program had positive impacts on students' motivation in science, their perception about science as a discipline and their intentions to pursue a STEM career. In a study performed with the prospective teachers, it is specified that the prospective teachers think that the STEM education increases the motivation of the students (Yıldırım and Türk, 2018b). Under the theme of competence, there are statements regarding that the students' science and math –from among STEM fields- competence belief level is not at required level, and that the teachers' self-efficacy belief on STEM teaching is exceptionally low. In a similar manner, it is being emphasized that the teachers do not have sufficient knowledge and equipments, and it is being suggested to overcome this problem through in-service trainings (Bakırcı and Kutlu, 2018). In another study, it is being informed that the teachers – who will apply the STEM education- only have teaching knowledge in their field of expertise, and that it will not be sufficient (Çorlu, Capraro and Capraro, 2014). In a similar manner, Pimthong and Willliams (2018) are emphasizing that there are problems in training STEM teachers, and that the teachers are focusing on the results of integration of STEM fields, but that they don't have sufficient knowledge on how that integration will be. It can be said that the STEM approach is new in our country. It is being observed that the endeavors of Ministry of National Education and studies of academia on the subject are increasing. It is being asserted that there are some problems in the integration of STEM education to our country's education system (Akgündüz et al., 2018). It can be said that the STEM proficiency levels of teachers and students will increase in time through implementations and practices on the subject.

Under the theme of examination of studies on STEM, there are statements regarding that it is mostly being studied with prospective teachers and K-12 students, the subjects of opinions, perceptions and attitude regarding STEM is being studied more, and that STEM doesn't have a frame on which it is reached a consensus in literature. There are also results close to these statements in the studies by which the studies regarding STEM education are examined (Göktepe-Yıldız and Özdemir, 2015; Herdem and Ünal, 2018; Kaleci and Korkmaz, 2018). Under the theme of scale development regarding STEM, it is being determined that STEM readiness scale development study is being made for the science teachers. It is being understood that there are various scale development (Buyruk and Korkmaz, 2016; Hacıömeroğlu and Bulut, 2016), and adaptation (Koyunlu-Ünlü et al., 2016) studies regarding STEM in the relevant domestic literature.

In this study, the postgraduate theses made regarding STEM education in Turkey had been examined through meta-synthesis method. The following suggestions may be made in the direction of the study's findings:

Within the scope of integration studies of STEM approach to our education system, trainings on the subject should be provided for the teachers, school administrators or other stakeholders. It is required

to equip the schools with tools and physical facilities required for this approach. Within the scope of teachers' education, STEM education should be expanded not only in the education of prospective math and science teachers, but also in all the teaching departments, and applied trainings should be included especially at graduate degree level. It is being observed that academic studies are concentrating on specific fields. It will be beneficial to perform mostly experimental researches regarding STEM education, and to perform studies for designing and developing implementation based activities and materials that cover the integration of STEM fields. It is noteworthy that the practices in the theses are mostly carried out in science lessons with the teachers or prospective teachers of the science course. In this sense, it is being required to have the implementation samples of this approach at different levels and courses, with different branch teachers or prospective teachers. For instance, its implementation in the fields such as the education of gifted ones, pre-school education, adult education or non-formal education will contribute to the relevant literature. In the studies performed regarding this approach, it is being understood that fields of science and math are being driven forward, and that fields of technology and engineering are being left in the back seat. In this sense, importance should be attached to all the fields of STEM, and performance of studies covering some of these fields at the same time may be enlightening. Public service advertisement development efforts that expand awareness regarding this approach may be beneficial. It is being specified that prospective teachers have the requirement of education regarding STEM (Erdoğan and Çiftçi, 2017; Yıldırım and Türk, 2018c). It is reported that it is important to consider the expectations of the students in the learning-teaching process (Sarıca, 2020). Therefore, STEM applications can be carried out in line with the expectations of the students. Within this frame, if we want to be successful in STEM education, and if we want to compete with the world, we have to attach the required importance to STEM education, and we have to train our teachers –who are raising the new generations- on this subject. In this context, we have to review our education system by starting from pre-school education to higher education, and we have to make the STEM approach effective at all levels.

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