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Gifted education and STEM: A Thematic Review

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ABSTRACT

In recent years, researchers have been interested in science, technology, engineering and mathematics (STEM), and educational studies of scientific giftedness have increased. In this study, we thematically reviewed studies both scientific giftedness and STEM education contexts. We aimed to shed light on the academic outcomes of STEM and scientific giftedness studies. In total 72 articles were examined. Articles available in the literature were analyzed using a matrix that consisted of content features (aims, research methods, samples or participants, results and suggestions) and general features (type of journal and year) in thematic review. The findings are presented under the themes shown in the matrix. In general, the researchers focused on the following content features: STEM schools and programs, STEM career choices, STEM talent development, and scientifically gifted student characteristics. Within this context, we discussed the results and implications for future research in the field of STEM education and impacts on gifted students.

Keywords: Gifted education, STEM education, thematic review, STEM talent.

INTRODUCTION

Gifted and talented students are special needs students who benefit from policies and practices that address their specific learning challenges. Strategies such as differentiated learning models that target talent development, advanced learning standards, teacher development programs and specialized educational programs may promote educational achievement in gifted student populations (National Association for Gifted Children [NAGC], 2010; Australian Association for the Education of the Gifted and Talented [AAEGT], 2006; Cooper, Baum, & Neu, 2005). From their research, Reis and Renzulli (2010) also determined that the need for gifted education programs remains critical. We agree with the statement of Watters and Diezman (2003) that gifted and talented youth are seen as crucial contributors to

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the incoming generation's information and technology society. The Australian Association for the Education of the Gifted and Talented (AAEGT) (1996) emphasized the influence of gifted education on Australia's prosperity, which depends on its ability to recognize and nurture the gifted and talented population. In general, to achieve that, the immediate goal for the talent development of gifted and talented students is to provide educational programs that are a better match to students' learning paces and levels of achievement (Olzsevski-Kubilius, 2010). Furthermore, the career success is an outcome for gifted students after promoting talent development and providing a proper learning environment (Bellanca & Brandt, 2010; Collins & Halverson, 2009; Tomlinson, 1996; Trilling & Fadel, 2009). The long-term goal of gifted education is to enable more gifted individuals to become creative producers in adulthood and achieve at the highest levels within their fields (Subotnik et al., 2011). Scientifically gifted students could be an important part of society for this purpose (Watters & Diezman, 2003).

In educational practices and research studies, STEM programs that promote integration of the STEM disciplines are currently under the spotlight. But STEM is not for specifically gifted students by itself. The report prepared by the US President's Council of Advisors on Science and Technology (PCAST, 2010), which makes policy recommendations and gives advice in areas such as understanding science and technology, emphasized that the STEM performances of middle school students in the USA are low. The PCAST report found a worrisome deficiency of skilled individuals and experts in STEM fields. As a result of such concerns, STEM education is seen as a key factor to increase the number of qualified individuals in the science, mathematics, technology and engineering fields. Subsequently, the Next Generation Science Standards (NGSS) report was published, which is about the extent of instruction of STEM education at all levels K-12, an important and detailed report. The one-size-fits-all approach is not likely to work with each STEM initiative's strengths (Breiner et al., 2012), especially for gifted children. The STEM education paired with gifted and talented education with regard to practical learning could create opportunities in talent development (Aydeniz et al., 2015). The existing STEM initiatives provide helpful information about the curriculum and activities needed in gifted and talented education and create opportunities for rigorous and high-order education (NAGC, 2015).

So, who are the scientifically gifted? To answer that question, first we need to look at the concept and understanding of giftedness. Kaufman and Sternberg (2008) indicated that giftedness is a label that varies over time and across places, and that it is a very broad concept. They also pointed out that giftedness is defined as something that is more domain-specific in that broad concept. Moreover, giftedness is seen as a synthesis of specific skills that conceptualize the gifted, like motivation, creativity, intelligence, and task-commitment (Sternberg, 2003, 2005; Renzulli, 1999). Researchers like Feldman (2000), Feldhusen (1998) and Gagne (2004) emphasized the talent development process and proposed models according to this developmental view. But as Kaufman and Sternberg (2008) said: "researchers will have to decide for him- or herself which conception or conceptions he or she finds to be compelling" (p.72). We understand that the modern gifted researchers share the same goal: identification and the nurturance of the specific talents (Kaufman and Sternberg, 2008). With this view in mind, we believe that scientific giftedness is a domain specific talent that could be developed using the talent development models. Nurturing skills like critical thinking and creativity is the first step of the developmental process of scientific giftedness. After identifying students as gifted, the discipline in which they have the most interest and display the most talent can be determined. They can be identified as scientifically talented when they show more success and talent in physics, chemistry and biology. On the other hand, they could be mathematically talented when they show more success and talent in mathematical areas. George (1997) described scientifically gifted students as those with a unique set of characteristics in science and those who show outstanding performance in science class, which sets them apart from their peers. Karnes and Riley (2005) stated that scientifically gifted individuals observe objects and events in the environment; are problem finders and solve problems; have a natural curiosity; desire to explore; and demonstrate continuity and motivation that results from their passion for science. Park, Park and Choe (2005) based their study upon the scientifically gifted students' characteristics, which include scientific ability, leadership, creativity, morality, motivation, and cognitive experimentalism. We agree with these definitions that come from the same idea that students can be defined through their characteristics and profiles, which they demonstrate in science practices. When scientifically gifted students' characteristics are considered, they will be interested in STEM fields due to the potential to persist and achieve in STEM domains (Stake & Nickens, 2005).

STEM and Skills

We have used the integrated "STEM education" concept in prior work. For this article, there is a need to explain what STEM education means. The most important modern understanding of STEM education might be relevant when paired with the concept of integration, which means STEM education is the integration of the disciplines to solve real-world problems (Labov, Reid, & Yamamoto, 2010; Sanders, 2009). This STEM education perspective involves the separate disciplines of science, technology, engineering, and mathematics as one unit, thus teaching the integrated disciplines as one cohesive entity (Brown, 2012). Merrill & Daugherty (2009) defined STEM education as a standards-based, meta-discipline residing at the school-level where science, technology, engineering, and mathematics (STEM) teachers apply an integrated approach to teaching and learning. In this approach, the discipline-specific content is not divided, but addressed and treated as one dynamic, fluid study. The common concept in both definitions is integration, which addresses the collaboration in STEM disciplines. Brown (2012) draws attention to the collaboration between Science, Technology, Engineering, and Math as the specific commonality between various STEM definitions. Literature directed us to the understanding that enhancing the STEM literacy of individuals or students is the main goal of STEM education (Brown, 2012; Zollman, 2012). From the definitions and gifted education literature, we believe that the integrated STEM concept is effective for gifted education. At present, critical thinking, creativity, problem-solving, communication, informatics, twenty-first century literacy, and analytical thinking are believed to be high-order skills, which are important to develop in the STEM education field (Carnevale, Smith & Melton, 2011; Olszewski-Kubilius & Thomson, 2015; Hong & Ditzler, 2013; Uttal & Cohen, 2012).

STEM education should be provided to all kinds of students. The NRC issued the Next Generation Science Standards (NGSS) (2012), and it establishes academic rigor for all students. Teachers can employ strategies to ensure that gifted and talented students receive instruction that meets their unique needs as science learners (NRC, 2013). The NRC argued that NGSS is a good option for science classrooms of gifted students (NRC, 2013).

We believed it is a starting point for gifted learners as well. However, it is not enough by itself. The objectives could align, but gifted education literature directs us to more challenging and advanced programming that addresses the concept of differentiation. Dailey (2016) also suggested that NGSS can be used as a differentiation point for gifted learners and the learning progress of advances learners increases in complexity as student advance in grade levels. Coxon (2016) mentioned NGSS as an advanced content that can help gifted learners' educational development. Adams, Cotabish and Ricci (2014) explained that there is a common ground and overlap among the standards between NGSS and NAGC. Lastly, Cotabish (2016) suggested that the similarities and the standards could be used as a guide to develop a curriculum that addresses multiple standards and it requires navigating these standards as gifted educators plan differentiated curricula and instruction practices. The differentiated activities, which are developed by using not only NGSS standards but also gifted education standards, could be effective in the development of scientifically gifted student skills using this relationship.

We noted from the literature that the scientifically gifted dimension of the STEM literature has not been examined yet. However, scientifically gifted and STEM literature requires research and should provide practice-oriented suggestions. In this study, which aimed to fill this gap, the academic outcomes of published studies are reviewed. In this context, if teachers and researchers want to develop materials or design research projects based on STEM education for scientifically gifted students, this literature review may provide suggestions for those projects and may be used as a framework resource. Furthermore, the benefits from scientific studies previously conducted in this area could reveal the need for developing STEM-oriented materials or designing research in the gifted science education frame.

For this study, we considered it a necessity to define the trends in research on STEM and scientific giftedness. In this way, we can give proper suggestions to the researchers and practitioners using STEM and scientific giftedness literature. This study aims to answer the following question: what are the most common and uncommon research areas in work on STEM and scientific giftedness? With this question in mind, the aim of this study is to examine research published in recent years about the current state and future of scientific giftedness based on STEM education, and to shed light on the academic outcomes of STEM and scientific giftedness studies. The research questions are given in this context:

1. What are the general features of published studies on STEM and gifted education?

2. What are the aims and rationales of the published studies when they concern both STEM and gifted education?

3. Which research design was used and what are the features of the research participants?

4. What are the results and suggestions of the published studies on STEM and gifted education?

5. Which theoretical findings should be considered for planning STEM-based research and materials aimed at gifted students?

METHOD

The present study is designed to examine the relationship between STEM and the scientifically gifted concept, and to provide some suggestions for future research using both scientifically gifted and STEM literature. In this frame, the thematic analysis design is used to examine studies published in recent years, in accordance with the research objectives. The similarities and differences were noted, as were the unmatched features of each study, which were clearly evident (Çalik, 2005; Kurnaz & Çalik, 2009). Using a thematic review design, studies were described and general trends were noted. The matrix of this study is given in Table 2. The matrix included both general features and content features. General features include types of journals and years of studies. Content features include rationales, aims, research methods, samples, data collection, results and suggestions (Calik, 2005; Goktas et al., 2012; Gulbahar & Alper, 2009; Kurnaz & Calik, 2009; Lee, 2009; Onder et al., 2013; Tsai & Wen, 2005; Unal, 2006). The explanations for each of these features are presented in Table 1.

Table 1. *The Matrix for the Thematic Review of STEM and Scientifically Gifted Literature*

Themes	Sub-themes	Explanations
General Features	Type of Studies	The study's index group (National, International, SSCI etc)
	Years	The study's publishing year
Content Features	Aim	The study's aim
	Rational	The study's rationale
	Research Method	The study's research method (qualitative, quantitative, theoretical, case study etc.)
	Sample	The study's sample type (gifted student, teacher, worker etc.) and sample size (N/A, 0-10, 10-50, 500-200 etc.)
	Results	The study's main results
	Suggestions	The study's main suggestions

Articles reviewed in this study were obtained from searching databases such as Education Full Text (Wilson), Education Research Complete, ERIC (EBSCO), Scopus, Web of Science, Science Direct, Elsevier, and Google Academy. Publications falling under the scope of gifted and talented education were researched. These were: Exceptionality, Theory into Practice, High Ability Studies, Gifted Child Quarterly, Gifted Child Today, Journal of Advanced Academics, Journal for the Education of Gifted and the Roeper Review. To identify articles specific to STEM education in the scientifically gifted domain, the researchers entered the keywords "STEM, STEM education, science gifted, scientifically gifted, engineering design, STEM and gifted" in an effort to find all articles regarding the aim of the study. We included the articles that contributed to the gifted education in STEM learning in given journals. The articles about gifted curricula regarding STEM domains, STEM/science schools, gifted practices in STEM, and different countries' implementation studies of STEM into gifted learning were the main subjects behind the inclusion of articles during the search. We excluded the articles that were irrelevant to both STEM and gifted education because we thought that the studies focused on both concepts presented the latest developments and knowledge in the common field. We considered that it is unlikely to find data about both STEM and gifted education in the studies only focused on STEM education or gifted education. Gifted Child Today is not a research journal, but it is important for researchers because it provides new insights and outcomes, which are explained in the problem statement. The articles about only STEM or gifted education were excluded. We did not consider the publication year of articles specifically, but paid attention to those published in recent years because of our purpose is uncovering the latest trends in this field. During the first search, we found 97 articles. In the end, we attempted to retrieve all studies and in total we obtained 72 articles that we actually used for the review.

These articles were analyzed using the matrix mentioned previously. The content analysis method was used, which required the researchers to first code the data and then collect the data under the appropriate theme. Inductive analysis strategy was used for the analysis of the collected data. This gradually led the researchers to generalize `plausible relationships proposed among concepts and sets of concepts' and to ascertain the categories, themes, and patterns of the data (Strauss and Corbin, 1994). Next, percentages and frequencies were calculated for descriptive statistics, which was used to show codes and themes using frequency and percentage tables. The coding-related section of articles (aim, method, results, etc.) using the matrix is designed to answer the research questions. Each research question concerning the relevant section of articles analyzed and coded. These codes were created the themes after the similar codes were merged. In addition, the percentage and frequency tables were developed to align with the aim of the research.

To ensure validity and reliability a second rater coded the articles chosen randomly and by this way interrater validity was ensured. Also, codes and themes were reviewed by a researcher and fixed by his\her reviews.

FINDINGS

The findings are given below under each of the research questions and the general features and content features explained in the matrix are shown. The general features are study type and year shown in the matrix. The content features are aim, method, sample, rationale, result and suggestions.

1. What are the general features of published studies on STEM and gifted education in science?

Table 2. *Distribution of Studies by Types and Journal*

J. Type	Journal Name	f	%	f	%
International Journal /SSCI	Roeper Review	12	16.67	48	66.71
	Gifted Child Quarterly	7	9.72		
	J. for the Education of the Gifted	7	9.72		
	J. of Advanced Academics	6	8.32		
	Theory into Practice	4	5.53		
	J. of Educational Psychology	2	2.76		
	High Ability Studies	2	2.76		
	Science Education	1	1.39		
	Research in Science Education	1	1.39		
	Thinking Skills and Creativity	1	1.39		
	Educational Sciences Theory and Practice	1	1.39		
	Learning and Individual Differences	1	1.39		
	Asia Pacific Education Review	1	1.39		
	Current Science	1	1.39		
	Annals of The New York Academy of Sciences	1	1.39		
International Journal	Gifted Child Today	5	6.94	21	29.16
	IAGC Journal	2	2.76		
	Science Education International	1	1.39		
	J. for the Education of Gifted Young Scientists	1	1.39		
	J. of the Korean Association for Science Education	1	1.39		
	J. of STEM Arts, Crafts, and Constructions	1	1.39		
	Thinking Skills and Creativity	1	1.39		
	Journal of Qualitative Research in Education	1	1.39		
	International Journal of STEM Education	1	1.39		
	Journal of Education in Science, Environment and Health	1	1.39		
	Trakya University Journal of Education Faculty	1	1.39		
	Journal of Research Initiative	1	1.39		
	Journal of Gifted Education and Creativity	1	1.39		
	Journal of Science Education and Technology	1	1.39		
	Journal of Gifted Education Research	1	1.39		
	Necatibey Faculty of Education Electronic Journal of Science & Mathematics Education	1	1.39		
Thesis	Master of Education Thesis	1	1.39	3	4.15
	Doctor of Philosophy Thesis	2	2.76		
	Total	72	100	72	100

The frequencies and percentages of the study types and journals are provided in Table 2. As evidenced in Table 2, 66.67% of the studies were published in SSCI journals such as Reoper Review, Journal of Educational Psychology, and Gifted Child Quarterly. Of the remaining studies, 29.16% were published in international indexed journals such as Gifted Child Today and Science Education International, and 4.16% were published as theses. Roeper Review, Gifted Child Quarterly, J. for the Education of the Gifted, J. of Advanced Academics and Gifted Child Today were the most frequent journals.

Table 3. *Distribution of Studies by Year*

Year of Study	International /SSCI		International		Thesis		Total	
	f	%	f	%	f	%	f	%
2019	6	8.33	6	8.33	-	-	12	16.66
2018	8	11.11	2	2.78	1	1.39	11	15.27
2017	5	6.94	2	2.78	-	-	7	9.72
2016	2	2.78	2	2.78	-	-	4	5.55
2015	4	5.55	3	4,17	-	-	7	9.72
2014	6	8.33	3	4,17	-	-	9	12.50
2013	3	4.17	2	2.78	1	1,39	6	8.33
2012	-	-	3	4.17	-	-	3	4.17
2011	-	-	4	5.55	1	1,39	5	6.94
2010	1	1.39	4	5.55	-	-	5	6.94
2009	1	1.39	1	1.39	-	-	2	2.78
2008	-	-	1	1.39	-	-	1	1.39
2008-2019	36	50.0	33	45.83	3	4.17	72	100

The frequencies and percentages of the study years are presented in Table 3. According to Table 3, 41.65% of studies were conducted in the last three years. Other studies were conducted between 2016 and 2008, mainly between2013-2015. After 2016, the studies regarding STEM education in the scientifically gifted education domain gradually increased.

2. What are the aims and rationales of the published studies when they concern both STEM and gifted education?

Table 4. *Distribution of Studies by Aim*

Theme	Category	Aim codes of Studies	f	%	f	%
STEM Schools and programs	Qualitative Based	Examination of STEM schools and programs	13	17.56	22	29.72
		Examination of teacher characteristics	4	5.40		
		Identification of giftedness	1	1.35		
		Disadvantaged Communities	1	1.35		
		Examination of parental perception	1	1.35		
		Integration art into STEM	1	1.35		
		STEM talent	1	1.35		
	Quantitative Based	Determination of problems and challenges	2	2.70	6	8.10
		Examine the relation between models and enrichment programs	2	2.70		
		Determination of advantages and disadvantages	1	1.35		
		Development of STEM education	1	1.35		

		in gifted				
Talent Development	Quantitative Based	Explore the spatial ability	6	8.11	21	28.37
		Development of science talent	3	4.05		
		Results of acceleration	2	2.70		
		Development of creativity	2	2.70		
		Determine relation between gender and skills	2	2.70		
		Interests of STEM students	2	2.70		
		Identification on design and technology	1	1.35		
		Relation between enrichment and achievement	1	1.35		
		Explore the effect on diverse students	1	1.35		
		Examination of participation in specialized instruction models	1	1.35		
	Qualitative Based	Correlation between STEM and gifted characteristics	4	5.40	13	17.56
		Integration of engineering design into gifted	2	2.70		
		Theoretical framework of STEM gifted education	2	2.70		
		Factors for academic success	2	2.70		
		Development of gifted identity	1	1.35		
		Development of scientific creativity	1	1.35		
		Measurement of scientific giftedness	1	1.35		
Career Choice	Qualitative Based	Diversity in STEM gifted education	5	6.75	8	10.81
		Investigating interests and choosing career in STEM fields	2	2.70		
		Stability on STEM related career	1	1.35		
	Quantitative Based	Career choice factors	3	4.05	4	5.4
		STEM careers of gifted girls	1	1.35		
Total			74	100	74	100

Table 4 includes the purposes of the articles and analyzes the results regarding STEM in the gifted domain. The aims of the articles were coded and then grouped under the themes. The themes have two categories: qualitative and quantitative based. Some of the articles' purposes are general, but some of them have specific expressions. Accordingly, the aims were coded and grouped under talent development, STEM schools and programs and career choice themes. The codes under the talent development theme included skills, characteristics, models, activities, practices, and identification and all of them are about scientific talent and related skills and how could it be developed. The codes under the STEM school theme are all about how a STEM school should be, the teachers at STEM schools, programs centered the STEM and gifted education and problems with STEM schools. As evidenced in Table 4, 37.82% of the articles included STEM schools and programs. Seventeen percent (17.56%) of the articles mentioned the examination of STEM schools and programs. Examination of teacher characteristics, determination of problems and challenges other codes highlighted. Forty-six percent (45.93%) of the articles are grouped under the talent development theme. In general, codes have the same frequency, but there is a vast variety across the articles according to their purposes. Under this theme, the following codes are the most emphasized:

Explore the spatial ability, development of science talent, correlation between STEM and gifted characteristics.

Table 5. *Distribution of Studies by Rationale*

Theme	Code	f	%	f	%
Deficiency in the field	Lack of representation in STEM fields	5	6.85	17	23.28
	Neglecting spatial ability	4	5.48		
	Need challenging and differentiated science education	3	4.11		
	The data necessary to support STEM field suggestions	1	1.37		
	Lack of awareness for talent search and programs	1	1.37		
	Lack of systematic inquiry into acceleration	1	1.37		
	Identifying the STEM lesson plan to evaluate the practices	1	1.37		
	Standardized measurement for scientific giftedness	1	1.37		
Talent development issues	Developmental needs of gifted (skills, characteristics, factors)	6	8.22	20	27.02
	Educational needs of the gifted students on STEM centered learning environment	5	6.85		
	Theoretical discussions on talent development concept	2	2.74		
	Representation of minority students and economically disadvantaged	2	2.74		
	Common interests and attributes of gifted and engineering-design	2	2.74		
	Positive impact of problem based/inquiry curriculum	1	1.37		
	Need to explore the effect of integrated STEM on gifted students	1	1.37		
	Importance of STEM gifted for the future of global economy	1	1.37		
STEM school and program issues	School overview and efficiency	6	8.22	19	26.02
	Effect of teachers on student development	4	5.48		
	Challenges in quality teaching	4	5.48		
	Provide opportunities to explore for STEM students in schools	3	4.11		
	Evaluation of specialized STEM schools	2	2.74		
Career choice issues	Need to increase career interest and performance in STEM fields	10	13.70	17	23.28
	Factors that pursuing or not pursuing STEM fields	3	4.11		
	Effect of interest studying and choosing career in STEM fields	2	2.74		
Total		73	100	73	100

Table 5 includes the findings of the reasons why the articles about STEM in gifted education were written. First, the rationales of the articles were coded and then grouped under the themes of deficiency in particular fields, talent development issues, STEM school and program issues and career choice issues. Deficiency in the field theme was emphasized in 23.28% of the articles' rationale sections. The proportion of articles that indicated talent development as the basis of rationale was 27.02%. There is a variation in the talent development aspect regarding the rationales but the most noticeable results of this theme were developmental needs of gifted and educational needs of the gifted students on STEM centered learning environment. Twenty-six percent (26.02%) of articles considered as STEM school and program issues. There is consistency on rationales of STEM schools nad programs theme which emphasized the efficiency of these schools and programs, teacher effect and challenges in teaching. The rationales of 23.28% of articles considered as the career choice issues of gifted students interested in the STEM field. Under this theme, articles focused on the needs to increase career interest and performance in STEM fields of gifted students.

3. Which research design was used and what are the characteristics of the research participants?

Table 6 includes frequency and percentage values related to the methods used in studies regarding STEM in gifted education.

Table 6. *Distribution of Studies by Methods*

Method		**International /SSCI**		**International**		**Thesis**		**Total**	
		f	**%**	**f**	**%**	**f**	**%**	**f**	**%**
Qualitative based	Literature Review	2	2.78	8	11.11	-	-	10	13.89
	Phenomenological	3	4.17	-	-	-		3	4.17
	Ethnographic	-	-	-	-	1	1.39	1	1.39
	Case Study	4	5.55	7	9.72	-	-	11	15.27
Quantitative based	Survey	7	9.72	5	6.94	-	-	12	16.67
Theoretical		4	5.55	2	2.78	-	-	6	8.33
Experimental		6	8.33	3	4.17	1	1.39	10	13.89
Non specified		5	6.94	6	8.33	-	-	11	15.27
Mix Method		5	6.94	2	2.78	1	1.39	8	11.11
Total		36	50.0	33	45.83	3	4.17	72	100

According to international/SSCI journals, the methods chosen in the articles were diversified. Quantitative based (survey), qualitative based (case study, literature review, phenomenological), experimental and theoretical researches were counted. Qualitative studies accounted for 34.72% of articles and 13.89% of the articles were experimental. Quantitative, experimental and mixed method studies are the most frequent methods used in SSCI journal articles. The vast majority of qualitative-based studies were literature reviews (13.89%) and case studies (15.27) particularly STEM school-oriented researches. In some articles, the study method was not indicated and these are included in the table as non-specified. However, the study methods of articles coded as non-specified thought mostly either case studies or literature reviews by researchers. International studies employed qualitative methods most often, in 20.83% of cases.

Table 7. *Distribution of Studies by Number of Samples or Participants*

Number of Samples	International /SSCI		International		Thesis		Total	
	f	%	f	%	f	%	f	%
N/A	12	16.67	15	20.83	-	-	27	37.50
0-10	1	1.39	-	-	1	1.39	2	2.78
11-35	6	8.33	8	11.11	-	-	14	19.44
36-200	7	9.72	5	6.94	1	1.39	14	19.44
200+	10	13.89	5	6.94	1	1.39	16	22.22
Total	36	50.0	33	45.83	3	4.17	72	100

An explanation is needed here in this Table 7. In reviewed articles, there are both qualitative and quantitative types of studies. Therefore, this made it difficult for us to categorize our review. In the end, we preferred to use the phrase "samples or participants" to give a general idea. Table 7 includes the data regarding the size of samples or participants, and Table 8 includes data regarding the types of samples or participants.

Of the studies, 16.67% did not have any sample or participants within the scope of SSCI, and 20.83% of the studies also did not have any sample or participants within the scope of international studies. Theoretical methods and literature reviews occupied this category in general as well as some of the case studies. Regarding SSCI articles, there is one study in the range of 0 to 10; 8.33% of studies have samples or participants ranging from 11 to 35, 9.72% have samples or participants ranging from 36 to 200, and 13.89% of studies have samples or participants ranging above 200. In the international category, 11.11% of articles have samples or participants ranging from 11 to 35 which the majority of qualitative studies in this category were the reason.

Table 8 includes the frequency and percentage with respect to the type of samples or participants. Gifted students were covered in 20.73% of the articles within the scope of SSCI journals, and 13.41% of the articles preferred gifted students in the sample or participants within the scope of international journals. On the other hand, 3.66% of articles were in the scope of SSCI and 4.88% of articles fell within the scope of international journals that focused on normal students as samples or participants. The sample or participants of teachers in reviewed articles was only 8.53%. With the ratio of 10.98%, articles have sample or participant types of graduate students within the scope of all journals. In total, 36.58% of studies preferred gifted students (K-12) within the scope of all studies. When we eliminate the samples or participants that were not applicable (NA), this rate went up to 65%, so we could say that the majority of samples or participants were gifted students (K-12) in the reviewed articles.

Table 8. *Distribution of Studies by Types of Sample or Participants*

Sample	International /SSCI		International		Thesis		Total	
	f	%	f	%	f	%	f	%
N/A	12	14.63	15	18.29	-	-	27	32.92
Teachers	4	4.88	3	3.66	-	-	7	8.53
Normal student (K-12)	3	3.66	4	4.88	-	-	7	8.53
Gifted students (K-12)	17	20.73	11	13.41	2	2.44	30	36.58
Students in graduate level	6	7.32	3	3.66	-	-	9	10.97
Working in STEM field	-	-	-	-	1	1.22	1	1.22
Gifted students' parents	1	1.22	-	-	-		1	1.22
Total*	43	52.44	36	43.90	3	3.66	82	100

*The reason behind the difference of the total number is that some of the articles has more than one type of participants

4. What are the results and suggestions of the published studies on STEM and gifted education?

Table 9 presents the results of the studies regarding STEM in gifted education. The results are categorized according to the following themes: career choice, STEM schools and programs, effect on development, and effects on characteristics.

Table 9. *Distribution of Studies by Results*

Theme	Result codes	f	%	f	%
Career choice	Factors address the STEM	7	9.33	13	17.33
	Importance of interest	2	2.67		
	Model development	2	2.67		
	Diverse students persist on STEM fields	1	1.33		
	Effectiveness of group mentoring	1	1.33		
STEM Schools and programs	Instruction proper to gifted characteristics and level	7	9.33	28	37.33
	Necessity/shift of new pedagogic approach, models and content	5	6.66		
	Problems in STEM schools	4	5.33		
	Increasing success and skills	4	5.33		
	Increasing interest in STEM	2	2.67		
	Young children's need for STEM education	2	2.67		
	Underrepresentation of diverse groups	2	2.67		
	Learning environment	1	1.33		
	Creativity activities	1	1.33		
Effect on characteristics	Males have more self-efficacy	1	1.33	2	2.67
	Identifying via scientific reasoning	1	1.33		
Effects on Development	Development of thinking skills	9	12.0	32	42.66
	Development of spatial thinking and learning	6	8.0		
	Development of challenge level	3	4.0		
	Importance of science teachers	2	2.67		
	Development on understanding science and enhance the learning	2	2.67		
	Increased interest in science or math	2	2.67		
	Necessity of using models in STEM talent identification	1	1.33		
	Receiving gifted instruction outperform their peers in diverse groups	1	1.33		
	Necessity of differentiation	1	1.33		
	Factors effect on academic success	1	1.33		
	Necessity of experimental studies	1	1.33		
	Self-efficacy of teachers	1	1.33		
	Promote STEM activities through inquiry	1	1.33		
	Spatial training narrows gender differences in spatial skills	1	1.33		
Total		75	100	75	100

As evidenced from Table 9, 42.66% of studies directed us to the students' developmental issues. Spatial thinking was 8%, thinking skills 12% and challenge level 4%;

these are the most frequent codes directing us to gifted students' developmental issues in the results. With the ratio of 37.33%, studies indicate that STEM schools and programs had problems and in the need of proper instruction; they also needed pedagogic approach and instruction and materials. The codes generally indicated the problems, needs and outcomes of STEM schools and programs. However, STEM schools were found to be successful for increasing success and interest. 17.33% of the studies researched gifted students' career choices in STEM fields and 2.67% of the studies examined the changes of gifted students' characteristics. The majority of the career choice studies (9.33%) addressed the factors affecting the STEM field choices.

Table 10. *Distribution of Studies by Suggestions*

Suggestion Codes	f	%
Enable with rich mix of STEM educational opportunities/activities	11	15.06
Provide experiences with nature of scientific investigation and inquiry	9	12.32
Gifted schools and programs need to re-organize	8	10.96
Conduct further research on STEM talent experiences	8	10.96
Providing supportive/challenging educational environment	6	8.22
Teachers must engage in quality teacher education experiences in STEM fields	5	6.85
Develop students' talent through challenging problems/activities	4	5.48
Model suggestion for diverse gifted students on STEM career	4	5.48
Implementation of specific skills for the identification of STEM talent	4	5.48
Improving STEM and gifted education theoretical framework	3	4.11
Reflection and evaluation of classroom practices needed	2	2.74
Need in-depth research on exploring the STEM interest of students	2	2.74
Need an educative intervention to support the STEM learning of gifted diverse students	2	2.74
Spatial activities and spatial skill development of STEM students	2	2.74
Applying grade–based acceleration in STEM fields	1	1.36
Acceptance the importance of scientific giftedness and measurement	1	1.36
Measurements of teachers	1	1.36
Total	73	100

Table 10 indicates the frequency and percentage values related to the suggestions found in the studies related to STEM in gifted education. Suggestions in articles were coded and grouped. According to Table 10, 10.96% of studies suggest gifted schools and programs need to re-organize, 12.32% of studies recommend providing experiences focused on the nature of scientific investigation and inquiry, and 15.06% of studies suggest enabling a rich mix of STEM educational opportunities/activities, which are the most frequent suggestions. Other frequent suggestions include conducting further research on STEM talent experiences, providing supportive/challenging educational environment and teachers must engage in quality teacher education experiences in STEM fields. They comprised 26.03% of the studies. In addition, challenging problems/activities, diverse groups and specific identification were the other important suggestion codes which highlighted by researchers with different sorts of suggestions and outcomes. The suggestions that researchers made were based on the talent development framework in general. They suggested more developmental practices.

DISCUSSION and CONCLUSION

The articles reviewed in this study focused on STEM education and scientific giftedness. Articles in this study were published in journals like Theory into Practice, Journal of Educational Psychology, Gifted Child Quarterly, and the Roeper Review. After reviewing these articles, this study found that themes like career choices and development, STEM schools and programs, characteristics of scientifically gifted students in the STEM domain and the effect on STEM talent development were the study topics in recent years.

According to the study findings and the results of the analysis, interest in STEM education in recent years revealed itself in the gifted education domain, especially in science. The number of published articles has increased in parallel. According to the analyses conducted for this study, a total of three studies were published in 2008-2009, in 2010-2011 ten such studies were published, and between 2012 and 2014 eighteen such studies were published. After 2015, 41 studies were published. In this context, it could be said that the importance given to STEM education in gifted education has increased since 2012, it is highly plausible that if STEM education manages to lead to positive outcomes (such as STEM literacy development or advanced thinking skills), the STEM education protects its importance in the gifted education field because of focusing on the same developmental purposes. In particular, United States education policy stresses the importance of this area (Kuenzi, 2008). NRC (2014) emphasized developing STEM literacy and 21st century skills of students through designing integrated STEM initiatives. STEM increased its effects gradually, especially after the No Child Left Behind (2004) policy started to be seen as a national educational objective. For that reason, science educators showed intense interest in the STEM field (Cannady, Greenwald & Harris, 2014; Maltese & Tai, 2011; Nugent et al., 2015; Christensen, Knezek & Tyler-Wood, 2015; Wilson, Iyengar, Pang, Warner & Luces, 2012; Bayer Corporation, 2014; 2012). Following the same logic, gifted/talented educators and researchers showed interest and studied this field. Other countries then became aware of these developments and started to study STEM and the gifted/talented domain; Korea, the UK, and China are examples. Why the researchers have an interest in these domains is clear. Students do not prefer to choose science and mathematics programs, and in the future, there will be a need for a qualitative workforce in innovative science, national security and leading technology. United States education policy aimed to increase those focused-on STEM domains in colleges and to create a talent pool for the future (NAGC, 2015).

The importance of studies concerning the career choices of gifted students emphasized those who have a personal interest in STEM domains (Heilbronner, 2013; Wai, Lubinski, Benbow & Steiger, 2010; Van der Vlies, 2013; Dai, Steenbergen-Hu & Yehan Zhou, 2015). The findings regarding these studies indicated that gifted students who graduated from STEM domains did not lose personal interest in their field. Efficiency in the work place and interest remained persistent. Accordingly, directing scientifically gifted students who have interest and talent in STEM fields to STEM oriented careers aligns with the reviewed research results. For STEM talented gifted students, choosing different career options rather than STEM domains due to external factors like family issues could have undesirable outcomes, and in the end, it could affect the work efficiency and the students' own interests. On the other hand, studies concerning diverse groups and gifted girls in career choice still remain its importance. Studies related to increasing interest and aspiring STEM career for these groups largely conducted and suggest more data about the issue.

According to the analysis of studies related to STEM in gifted education, some of the studies focus more on gifted education, but in general the aims of studies are varied with different aims such as spatial ability development, effect on talent development, participation in specialized instruction models in gifted, relation between STEM and gifted characteristics. But researchers examined specific themes such as talent development, STEM schools and programs or career choices. The studies related to the examination of STEM schools and programs (Olszewski-Kubulius, 2009; Jolly, 2009; Sikma & Osbourne, 2014; Talaue, 2014; Roberts, 2013; Jones, 2011; Heilbronner, 2011; Teo & Ke, 2014; Thomas & Williams, 2009; Choi, 2014; Subotnik, Tai, Rickoff & Almarode, 2010) are generally about improvement of schools and programs, determining the special STEM programs and curricula and teacher characteristics. The studies regarding talent development within STEM education were aimed at different aspects, including the development of science talent; Correlation between STEM and gifted characteristics; exploration of spatial ability; development of science/mathematics talent; relationship between enrichment and achievement; effects on skill development; integration of engineering design in gifted education; determining the need for spatial skills; and results of acceleration.

When the methods and samples of studies were analyzed, the data showed that literature tended more towards qualitative studies. The fact that the studies reviewed were qualitative-based shows there was need for deeper analysis about the research problems. The literature review studies showed that some research topics were examined or suggested the need for examination of other topics, especially with the theritical framework of STEM gifted education studies (Subotnik, Tai, Rickoff & Almarode, 2010; Thomas & Williams, 2009; Choi, 2014; Talaue, 2014; Ayar, Adıgüzel & Şahin, 2014; Teo & Ke, 2014; Sikma & Osbourne, 2014; Dai, Hu & Zhou, 2015; Olszewski-Kubilius, 2009; Hausamann, 2012; Mann, Mann, Strutz, Duncan & Yoon, 2011; Andersen, 2014; Kell & Lubinski, 2013; Root-Bernstein, 2015; Taber, 2010; Jones, 2011; Sternberg, 2018). Scientifically gifted students are a special group, thus there is a need to obtain deeper and richer information in order to understand their nature. Also, scientifically gifted students are usually studied in lower numbers of participants or samples. This may be due to the lack of effective identification practices and programs for scientifically gifted students, which creates a non-supportive environment for them to develop their gifts and talents (Ercan, 2013). Therefore, researchers used qualitative methods while designing their research. Interviews and observations are usually used in these research studies. In addition to the reasons stated about choosing qualitative designs, there are no participants in the theoretical studies that used a literature review or the case study as method. In large sample studies, which are generally quantitative and designed as experimental studies and surveys, gifted students largely constituted the samples. In this sense, we could say that there is a particular need for studies using teachers and other sample or participant types. Especially studies correlating normal and gifted students were greatly diminished. Experimental studies published in SSCI journals must be considered, and descriptive studies, like literature reviews and case studies, which are not preferred in SSCI journals, should also be assessed. Accordingly, a different variety of case study topics and developmental-based studies were used to examine the characteristics of gifted students.

The results from the studies regarding STEM in gifted education generally indicate that STEM schools have problems regarding curriculum and programs, but they are necessary for the development of STEM talent (Subotnik et al., 2010; Thomas & Williams, 2009; Choi, 2014; Talaue, 2014; Teo & Ke, 2014; Sikma & Osbourne, 2014; Jolly, 2009; Jones, 2011; Olszewski-Kubilius, 2009; Roberts, 2013). STEM school problems include the need for instruction and properly challenging material, a curriculum for identified gifted students, and activities that nurture them. Research studies that aimed to eliminate these kinds of problems are going to be useful for STEM schools and programs. In order with this result, Subotnik et al., (2009) suggested if these schools consider the integrated approaches along with the clear goals and assessment, it could develop STEM talent. There is also a need to examine gifted students' characteristics in STEM domains (Andersen & Ward, 2014; Heilbronner, 2011; Rinn, McQueen, Clark & Rumsey, 2008). Which characteristics are compatible with the STEM domain is still a question. However, studies emphasize that skill development is important for the development of STEM and gifted education domains (Park, 2011; Taber, 2010; Mann, Mann, Strutz, Duncan & Yoon, 2011; Newman & Hubner, 2012; Root-Bernstein, 2015; Kell & Lubinski, 2013; Hausamann, 2012; Andersen & Ward, 2014; Ayar, Adıgüzel & Şahin, 2014; Olszewski-Kubilius & Thomson, 2015; Assouline, Colangelo, Heo & Dockery, 2013; Robinson, Dailey, Hughes & Cotabish, 2014; Wai, Lubinski & Benbow, 2009; Twissell, 2011). Results regarding scientifically gifted students have come to prominence. These studies have also brought experimental data, so it is thought that they will contribute applicable information and offer new research topics. The level of challenge of lesson practices, and skills development like spatial thinking, self-confidence, and interest in science domains are some of the codes that highlight the importance given to talent and skills development in the studies analyzed. Research about spatial thinking skills shows some variety, as there are different points of view: skill development and its effects on STEM learning, gender differences, career choices, and identifying the gifted using spatial skills. It seems it is the most popular and developed subject in STEM and gifted education.

With respect to the suggestions made in the studies analyzed, it was determined that providing and enabling rich STEM educational opportunities and challenging experiences were the most common subject. In particular, the following code suggestions were made: gifted schools and programs need to re-organize (Olszewski-Kubilius, 2009; Almarode, Subotnik, Crowe, Tai, Lee & Nowlin, 2014; Andersen, 2014; Andersen & Ward, 2014); provide experiences focused on scientific investigation and inquiry (Olszewski-Kubilius, 2009; Subotnik, Tai, Rickoff & Almarode, 2010; Robinson, Dailey, Hughes & Cotabish, 2014; Heilbronner, 2013; Andersen & Ward, 2014; Thomas & Williams, 2009); enable a rich mix of STEM educational opportunities/activities (Thomas & Williams, 2009; Ayar, Adıgüzel & Şahin, 2014; Wai, Lubinski, Benbow & Steiger 2010; Mann, Mann, Strutz, Duncan & Yoon, 2011; Hausamann, 2012; Root-Bernstein, 2015); develop students' talents through struggling/challenging problems/activities (Roberts, 2013; Olszewski-Kubilius & Thomson, 2015; Heilbronner, 2011; Taber, 2010); conduct further research on STEM talent experiences (Van der Vlies, 2013; Heilbronner, 2011; Rinn, McQueen, Clark & Rumsey, 2008); and favor integrating STEM domain characteristics into the identification of STEM-gifted students, lesson and extracurricular activities and scientifically gifted characteristics. For example, as a STEM skill, spatial thinking is seen as a factor that should be considered in both identification and science activities. In general, the suggestions showed us that the talent development using gifted educational models or activities should be focus on the experimental researches. This is because the suggestions based on future research topics require experimental methods. That conclusion is also consistent with the methodology findings in this paper.

The most notable research results regarding STEM in gifted education include the experimental studies focused on skill and talent development and providing a rich, challenging STEM educational environment. Case studies and literature reviews frequently, more than other studies, could lead researchers to experimental studies. Identification, skill development, and modelling studies in STEM domains are needed for gifted education. Brown (2012) remarked that "STEM education centered research needs to further investigate to determine how different methods impact the classroom" (p.1).

Suggestions

When the studies regarding STEM in gifted education were examined, we noted that review and survey methodological research methods were preferred rather than experimental research, which focused on skill development and material usage in activities. In parallel with this situation, the fact that new studies should be conducted as experimental research is consistent with the suggestion of Subotnik et al. (2009) and Brown (2012), which is based on skills development like spatial thinking or creativity. We also concluded that to employ research to examine STEM-based activities in gifted education and to study the development and scope of scientific giftedness is necessary. After a growing interest in STEM and its reflection on gifted education, this research topic has established its importance.

Studies about the STEM schools were mostly reviews, and problems in programs were evaluated by the authors. Accordingly, first, the aims of these schools and programs should be clearly indicated. At that time, programs, curricula, models, lesson practices, and activities consistent with the aims should be determined, developed and implemented. Subotnik et al. (2009) also evaluated this issue and found that the effectiveness of different talent development models and initiatives must be built on clear and measurable program objectives, strive to standardize a range of desired outcomes and develop well-designed longitudinal studies of impact track program quality. Finally, the research topics, such as twenty-first century skills, the implementation of inquiry, challenge activities, and differentiation in STEM in gifted education require further exploration. The positive and negative effects of STEM education and the scientifically gifted concept will be revealed when these research topics are conducted with experimental methodology.

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