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A Review of Studies on STEM and STEAM Education in Early Childhood

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ABSTRACT

This paper aims to focus on national and international studies regarding STEM education and visual arts integrated STEM education in early childhood. After a detailed search by using six different databases, 22 scientific research published between the years of 2006 and 2016 were accessed. Accessed studies were handled in terms of their methods, year of publication, participants, and main findings. The literature review in the current study signifies that STEM education and especially the integration of arts into STEM acronym (STEAM) in early childhood classrooms are two new research fields for both national and international literature. On the other hand, the limited literature indicates that integration of these disciplines contributes preschoolers' learning in STEAM fields. In the discussion and implementations part, by considering reviewed literature, some implications are presented for early childhood education in Turkey.

Keywords: STEM, STEAM, early childhood education, content analysis.

Okul Öncesi Dönemde STEM ve STEAM Eğitimine Yönelik Çalışmaların İncelenmesi

ÖZ

Bu çalışma, ulusal ve uluslararası alan yazında yer alan, okul öncesi eğitimde STEM ve sanatın STEM disiplinleri ile bütünleştirilmesine dayanan STEAM eğitimi uygulamalarına odaklanmayı hedeflemektedir. Bu amaçla, altı farklı veri tabanı çeşitli anahtar kelimeler kullanılarak taranmış ve son 10 yılda yayınlanmış olan 22 akademik çalışmaya ulaşılmıştır. Çalışmalar yöntemleri, yayınlandıkları yıl, katılımcıları ve temel bulguları açısından ele alınmıştır. Bu çalışmada gerçekleştirilen detaylı alan yazın taraması, STEM ve özellikle de sanat ile bütünleştirilmiş STEM eğitiminin ulusal ve uluslararası alan yazında az sayıda çalışma tarafından ele alınan iki yeni araştırma alanı olduğuna işaret etmektedir. Diğer yandan, son on yıla ait bu sınırlı alan yazın bütünleştirilmiş fen, teknoloji, mühendislik, matematik ve sanat etkinliklerinin okul öncesi dönem çocuklarının bu disiplinlere yönelik öğrenmeleri üzerindeki katkısını desteklemektedir. Çalışmanın tartışma kısmında, alan yazında yer alan çalışma bulguları göz önünde bulundurularak, Türkiye'deki okul öncesi eğitime yönelik bazı öneriler sunulmuştur.

Anahtar kelimeler: STEM, STEAM, okul öncesi eğitimi, içerik analizi.

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INTRODUCTION

STEM which has aroused a global interest from educational and workforce perspectives in recent years (English, 2016) is the acronym of the interconnected science, technology, engineering, and mathematics disciplines. Once after the economic decline and growing competition among developing economies (Guyotte, Sochacka, Constantino, Walther & Kellam, 2014), STEM education has been introduced in U.S. during the 1990s by National Science Foundation [NRC] (English, 2016) as an educational reform. This educational reform has aimed to fit students for 21st century's global economy (Yakman & Hyonyong, 2012) and has become the focus of educators and researchers for recent ten years (Sousa & Pilecki, 2013; Soylu, 2015).

A large variety of social and personal matters from health to the environment and to social networking necessitate some comprehension of STEM. In this manner, children's learning about STEM disciplines throughout their schooling forms their intellectual development, career choices and their ability to make conscious decisions on not only political and civil matters but also their own lives (NRC, 2011). Besides of improving their academic achievement, STEM education meets children with the critical knowledge required for future's workforce (Quigley & Herro, 2016).

STEM education aims to give students required competence, knowledge and an interdisciplinary point of view towards problems (Şahin, Ayar & Adıgüzel, 2014) by eliminating the barriers of the conventional education system which presents children STEM disciplines separate from each other (Vasquez, Sneider, & Comer, 2013). Instead of introducing content and expecting from students to comprehend the connections to real-life practices (Kelley & Knowles, 2016), STEM education integrates related disciplines into one lesson or unit which depends on liaisons between the topics and real-life problems (Moore et al., 2014). In this way, it can be possible for children to put their theoretical knowledge into practice, product and innovative inventions (Çorlu, 2013).

STEM in Early Childhood Education

As the earliest espouser of the technological development and eager investigators, preschool children have a natural eagerness to explore STEM disciplines (STEM Smart Brief). Since some of them have not undergone the knowledge and ability related to school readiness yet, preschool children are mistakenly assumed as ineligible in terms of main intellectual dispositions like giving the meaning of experience, predicting, hypothesizing and analyzing (Katz, 2010). Contrary to what is believed, preschool children wonder, reason and generate ideas about how the physical, social and biological world around them work (National Research Council, 2012). They permanently explore, experiment and engage in all sorts of tools, solve problems, compare things (Sharapan, 2013) and interrogate facts and rules. Indeed, notwithstanding their ability, preschoolers are ready, eager and able to deal STEM activities.

Therefore, they should be introduced to STEM concepts at from their younger ages. In the early childhood classrooms where STEM activities are performed, preschoolers construct scientific and mathematical connections by experimenting and exploring with materials. In this way, STEM education provides them meaningful learning underlying future educational experiences (Moomav & Davis, 2010).

From STEM to STEAM

Some researchers claim that STEM is a puzzle which constitutes of complementary disciplines, however, there is a lacking part; "Arts" (Kim & Park, 2012; Sharapan, 2013; Sochacka, Guyotte, Walther, 2016). STEAM is defined as "the inclusion of liberal arts and humanities in STEM education" (Spector, 2015, p. 5). STEAM-based education aims to prepare children to sort the world's issues by means of innovation, creative and critical thinking, cooperation, effective communication in the light of new information (Quigley & Herro, 2016). Indeed, arts education is crucial to creativity underlying innovation. Similarly, innovation is essential to produce modern industries in future which provide a basis for eventual economic welfare (Sochacka et al., 2016). According to Sousa and Pilecki (2013), STEM and arts are considered as two independent fields in some aspects. Arts are subjective, intuitive, unique and related to feelings, while STEM disciplines are objective, repeatable, logical and analytical. On the other hand, arts and science are two incomparable and indispensable parts of education which complement each other, because some skills considered as scientific tools such as drawing on wonder, observing exactly, perceiving an item with several dimensions, thinking spatially and working efficaciously with others are at the core of fields of arts.

As it is very hard to think the world without arts (Sousa & Pilecki, 2013), it is very hard to imagine an early childhood education (ECE) without arts. Indeed, art activities are the natural component of early childhood classrooms (Sharapan, 2013). As Edwards (2006) stressed, the field of visual arts is one of the five main components of art (literature, drama, music, dance and visual arts). Visual arts activities including creation of primarily two-dimensional visual works like drawing, painting and printing and three-dimensional visual works like creating a model, sculptures, and buildings is an expression of thoughts and feelings of children (Edwards, 2006). Some researchers claim that integration of visual arts into STEM allows preschool children to be more successful in STEM disciplines (Schirrmacher, 2002; Wynn & Harris, 2012), enhances their motivation and engagement, and efficient learning in STEM disciplines (Henrkisen et al., 2015). Moreover, visual arts contribute children's manipulative and fine motor skills and their visual spatial thinking abilities required for achievement in scientific subjects (Newcombe, 2010).

On the other side, Sharapan (2013) defends that arts integration may be beneficial to not only learning of preschool children but also training of their teachers. According to Sharapan (2013), arts integration may enable preschool

teachers to find ways of practicing STEM concepts into the education program, and to lay the foundation of STEM knowledge, benefiting from the arts to hearten children to express themselves in diverse creative ways. However, as in STEM education, integration of arts into STEM disciplines are a newly-emerging research topic for early childhood education. Therefore, as Rabalais (2014) stressed, findings related to these two important topics will shed light on their implication in ECE. This paper aimed to review the research conducted over the past decade regarding the STEM education and arts integrated STEM education practices in ECE, and in the light of these studies, to present some implications for enhancing arts integrated STEM education practices in Turkey.

METHOD

In this study, the content analysis method was utilized in order to examine national and international studies conducted on STEM and STEAM education in early childhood period. Content analysis enables researchers to reach concepts and relationships explaining the collected data. Therefore, in content analysis, the main procedure is to gather similar data under the certain contents and themes and to organize and interpret these data in an understandable way by the readers (Yıldırım & Şimşek, 2011). In addition, using content analysis, it is possible to reveal research trends and examine what points researchers focus on in their studies (Fraenkel, Wallen, & Hyun, 2012). Similarly, in this review, studies concerning STEM and visual arts integrated STEM education practices in ECE between the years of 2006 and 2016 was examined and some research trends were tried to reveal.

Review and Selection Criteria

In the current study aiming to review of STEM and STEAM studies in ECE, data were collected by using Middle East Technical University Online Library. In order to determine the articles to be used in the study, some selection criteria were determined by the researchers before the study was conducted. These criteria were related to the databases, research topics, year of publication and whether the full-text of the study can be reached. In this regard, firstly, databases under the "Education" title were examined and six of them were selected by considering their connection with social sciences (American Research Complete, EBSCOhost, Education Source, ERIC, Teacher Reference Center and ULAKBIM Turkish National Database) in order to access studies. Then, these six databases were searched by using the keywords of "STEM education in early childhood", "STEM education in early years", "Preschool children and STEM education", "Visual arts integration STEM in early childhood education" and "STEAM education in early childhood". Finally, consideration was given to the fact that work was carried out between 2006 and 2016, and studies outside this range were excluded from the scope of the study. Consequently, abstracts of the 24 studies were initially screened. Two studies were removed from the pool since their full-texts were not accessed. Finally, 22 research studies were selected for the analysis, because they complied the criteria.

Data Analysis

After completion of the selection procedure, key features of accessed studies were examined under the determined themes. These themes can be listed as follows;

- Titles,
- Author(s),
- Publication years,
- Purposes,
- Participants,
- Countries,
- Main focuses,
- Main findings.

In this review, by considering these themes a database was created and key features of the studies were analyzed descriptively by using this database. Indeed, all accessed studies were analyzed and reported in terms of their year of publication and main foci points under related headings. Besides of year of publication and main foci, accessed empirical studies were examined in terms of their participants, country and main findings.

FINDINGS

STEM education is regarded as an interdisciplinary approach including educational activities from ECE to post-doctorate (Gonzalez & Kuenzi, 2012), however, its implication in ECE have been the subjects of a limited number of studies. Indeed, after a detailed literature review, totally 22 academic studies took place in academic journals and conducted between the dates specified were accessed (Aladé, Lauricella, Beaudoin-Ryan, & Wartella, 2016; Aldemir & Kermani, 2016; Aronin & Floyd, 2013; Atiles, Jones, & Anderson, 2013; Bagiati & Evangelou, 2015; Bagiati & Evangelou, 2016; Bers, Seddignin, & Sullivan, 2013; Dejonckheere, Wit, Keere, & Vervaet, 2016; Evangelou, Dobbs-Oates, Bagiati, Liang, & Choi, 2010; Hoisington & Winokur, 2015; Kazakoff, Sullivan, & Bers, 2013; Kermani & Aldemir, 2015; Linder, Emerson, Heffron, Shevlin, & Vest, 2016; Lyons & Tredwell, 2015; McDonald & Howell, 2012; Moomaw & Davis, 2010; Ong et al., 2016; Sharapan, 2013; Soylu, 2015; Tank, Pettis, Moore, & Fehr, 2013; Torres-Crespo, Kraatz, Pallansch, 2014; Verdine, Golinkoff, Hirsh-Pasek, & Newcombe, 2014). 16 of these studies were based on empirical evidence about STEM implementations in ECE classrooms, and remaining six articles offered some strategies about STEM practices in ECE (Aronin & Floyd, 2013; Hoisington & Winokur, 2015; Linder et al., 2016; Lyons & Tredwell, 2015; Sharapan, 2013; Soylu, 2015).

Findings with regard to the Years of Publication

All examined studies were carried out in or after 2010. In 2010, two studies were carried out (Evangelou et al., 2010; Moomaw & Davis, 2010). On the other side,

it was encountered with only one study which belonged to 2012 (McDonald & Howell, 2012), while any study published in 2011 was not accessed. Majority of the studies (86.3%) were published in and after 2013. Each in the years of 2013 (Aronin & Floyd, 2013; Atiles et al., 2013; Bers et al., 2013; Kazakoff et al., 2013; Sharapan, 2013) and 2016 (Aladé et al., 2016; Bagiati & Evangelou, 2016; Dejonckheere et al., 2016; Linder et al., 2016; Ong et al., 2016), six studies (27.7%) were conducted. Respectively, five studies published in 2015 (Bagiati & Evangelou, 2015; Hoisington & Winokur, 2015; Kermani & Aldemir, 2015; Lyons & Tredwell, 2015; Soylu, 2015), while two studies published in 2014 (Torres-crespo et al., 2014; Verdine et al., 2014). This information may support that STEM education in ECE has gained a popularity in recent years (see Figure 1). Although, it was not possible to mention about this popularity in national literature, because, among these studies, only Soylu (2015) touched on STEM education in Turkish early childhood education and offered some suggestions for improvement of STEM education in Turkey.

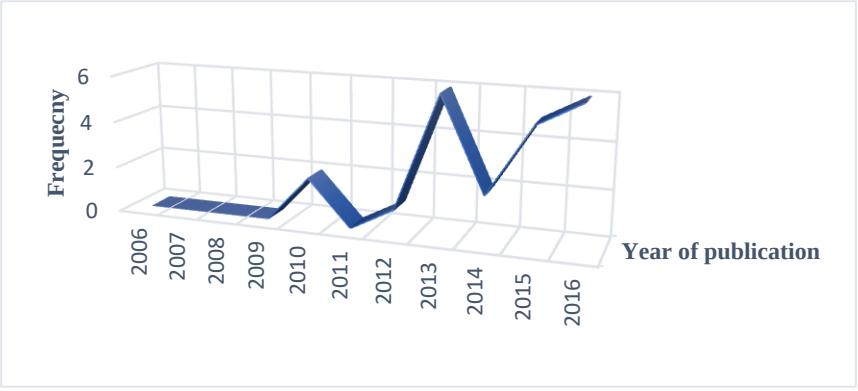

Figure 1. Distribution of the accessed studies in terms of year of publication

Findings with regard to the Main Focus Points

After the in-depth examination, it was revealed that the studies varied in terms of their focuses. Majority of the studies (27,2%) focused on engineering and its effect on learning in other STEM disciplines (Bagiatti & Evangelou, 2015; Bagiati & Evangelou, 2016; Evangelou et al., 2010; Hoisington & Winokur, 2015; Torre-Crespo et al., 2014; Verdine et al., 2014). In addition, the effect of planning and practicing an integrated STEM curriculum on preschool teachers' professional knowledge and skills on and attitudes toward STEM education (18,1%%) (Aldemir & Kermani, 2016; Linder et al., 2016; Ong et al., 2016) and on children's learning in STEM disciplines (Kermani & Aldemir, 2015) was the second major point of the studies. On the other hand, three studies examined in the scope of this study, focused on integration of technology into engineering, especially robotics and programming (13.6%) (Bers et al., 2013; McDonald & Howell, 2012; Kazakoff et al., 2013), while two studies (9.0%) touched on

STEM implementations in inclusive early childhood classrooms (Lyons & Tredwell, 2015; Moomav & Davis, 2010). Among remaining studies, each focused respectively on STEM education in Turkish early childhood education (Soylu, 2015), science and inquiry in ECE (Dejonckheere et al., 2016), integration of literature into science and engineering (Atiles et al., 2013; Tank et al., 2013), utilization of iPad in ECE classrooms as a mediator of learning in STEM fields (Aronin & Floyd, 2013), and arts integration into STEM education (Sharapan, 2013) (see Figure 2).

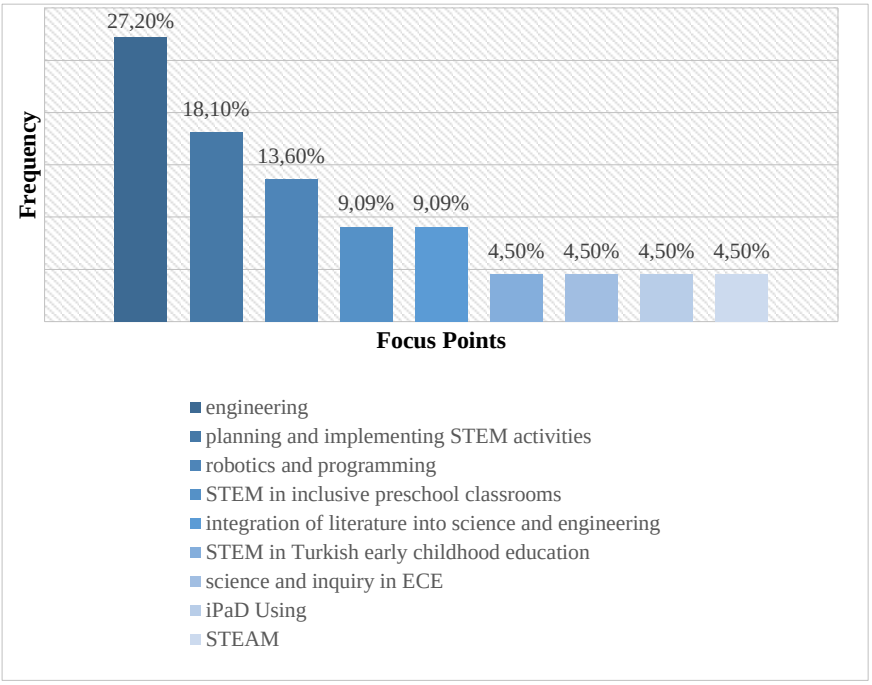

Figure 2. The percentages of the focus points of the studies

Findings with regard to the Participants

When empirical studies were considered in terms of their participants, it was revealed that a large body of them (68,75%) were conducted with preschool children aged from 36-72-months (Aladé et al., 2016; Bagiati & Evangelou, 2016; Dejonckheere et al., 2016; Evangelou et al., 2010; Kazakoff et al., 2013; Kermani & Aldemir, 2015; McDonald & Howell, 2012; Moomav & Davis, 2010; Tank et al., 2013; Torre-Crespo et al., 2014; Verdine et al., 2014). On the other hand, three studies were conducted with in-service preschool teachers (Atiles et al., 2013; Bers et al., 2013; Ong et al., 2016), while remaining two studies focused on both preschool children and preschool teachers and their STEM practices (Aldemir & Kermani, 2016; Bagiatti & Evangelou, 2015) (see Figure 3). Unexpectedly, any of these 16 studies conducted over the past decade

on STEM and STEAM education did not touch on pre-service early childhood teachers.

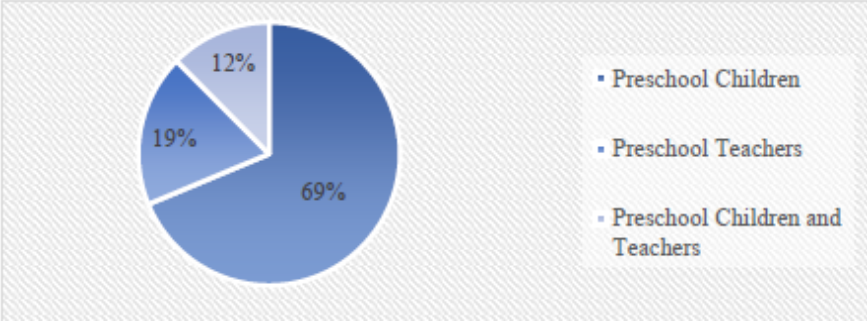

Figure 3. Distribution of Accessed Empirical Research in terms of Participants

Findings with regard to the Locations

Examination of literature with regard to the locations where they were conducted may enable to understand the popularity of STEM research among diverse countries. As demonstrated in Figure 4, a great majority of examined empirical studies were conducted in United States (n=9; 56.2%) (Aladé et al., 2016; Aldemir & Kermani, 2016; Bagiati & Evangelou, 2015; Bers et al., 2013; Evangeluo et al., 2010; Kazakoff et al., 2013; Kermani & Aldemir, 2015; Sullivan et al., 2013; Torres-Crespo et al., 2014). Other studies were conducted in Belgium (Dejonckheere et al., 2016), Australia (McDonald & Howell, 2012) and Malaysia (Ong et al., 2016), while any information was not given about the location where the studies carried out in four studies (25%) (Atiles et al., 2013; Bagiati & Evangelou, 2016; Moomav & Davis, 2010; Verdine et al., 2014; Tank et al., 2013). This finding signifies the need for more empirical studies which will be conducted in different countries.

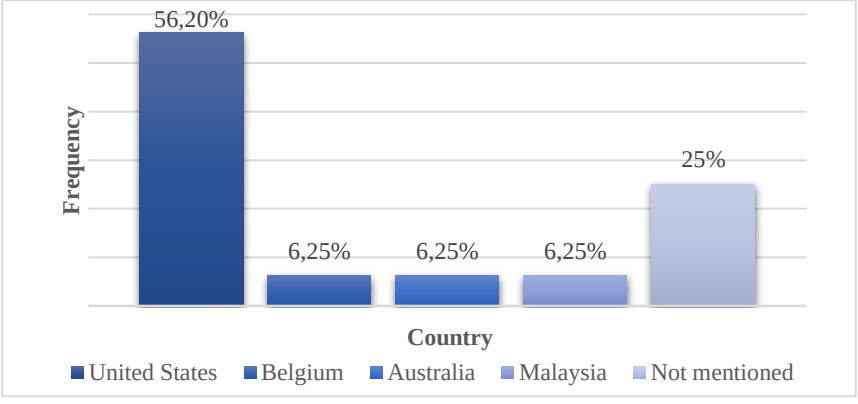

Figure 4. The percentage of the research related to STEM education with regard to the countries

Findings regarding to Main Findings of the Studies

When the main findings of the studies were examined, it was revealed that STEM education might be effective for preschool children's learning in STEM concepts and skills. For instance, Bagiati and Evangelou (2016) made naturalistic observations and videotaped children during their free play with diverse open-ended, structured and semi-structured materials (e.g. blocks, Legos, puzzles, snap circuits). Data collected throughout four months indicated that children were skilled in problem-solving, determining a need, setting a construction goal, progressing to address this specific goal by means of design and implementation and reaching solutions via continuous testing. Preschoolers also showed the ability to collaborate with their peers to reach the final construction and of repeating a pattern. In another study, Verdine et al. (2014) investigated the spatial assembly skills of three-year-old children by means of interlocking plastic block constructions by considering gender and socioeconomic level. In addition, they probed the association between spatial assembly and early mathematical skills. Results revealed that there was a significant relationship between emerging mathematical ability and spatial skills needed by structured block play. Besides, even if children did not differ in their spatial assembly performance in terms of gender, children from families with lower socioeconomic status (SES) indicated lower performance rather than their peers from higher SES.

In a similar way, Torre-Crespo et al. (2014) who used picture books in their study to facilitate children's STEM learning revealed that children gained a deep and meaningful learning by means of this method. On the other hand, Evangelou et al. (2010) found that besides of concrete objects, presentation of the artifacts in picture books and sketches were applicable to expose preschoolers to the engineering products, however, exploring actual artifacts themselves had an advantage with regard to the duration of time children spent for exploring artifacts and realizing their typical functionality. In addition, children engaged in tangible objects indicated more knowledge and opinion about probable functions of the artifacts. In another study, Dejonckheere et al. (2016) investigated the role of science and inquiry in ECE. Their study signified that children's reasoning skills might be improved by means of inquiry-based methods.

Different from above-mentioned studies, Kazakoff et al. (2013) and McDonald and Howell (2012) interested in the consequences of integration of technology into engineering, especially in robotics and programming. Their studies revealed that engaging in robotics and programming positively affected children's sequencing (Kazakoff et al., 2013), literacy and numeracy skills (McDonald & Howell, 2012). In a similar manner, Alade et al. (2016) tested the effectiveness of an educational app on children's non-standard measuring. They assigned children randomly to three different conditions. Children in interactive condition engaged in an interactive game. This interactive game "Measuring That Animal" teaches children approximate measuring which is considered as essential to math and science education. On the other hand, children in non-interactive video

condition watched a video including a recorded version of the same game. Lastly, children in control condition engaged in an analogous game "Murray Cleans Up" which was irrelevant to STEM and did not serve for featuring any sort of measuring lesson. Findings revealed that a child-targeted educational app supported preschoolers' learning in measuring by means of non-standard units, and children's achievement on transfer task was facilitated by the interactive and non-interactive educational technology.

Research conducted with preschool children is not limited to only typical preschool children. In their study, Moomav & Davis (2010) studied with children who have different disabilities and implemented some STEM-based activities in this inclusive classroom. Their study revealed that disabled children grasped essential mathematical and scientific associations by means of implemented STEM activities.

On the other hand, some of the studies (Kermani & Aldemir, 2015; Ong et al., 2016) revealed that integration of STEM disciplines might not only be effective on not only children's learning in these disciplines but also teachers' confidence and ability in practicing an integrated curriculum. In this manner, Bers et al. (2013) carried out their study with preschool teachers revealed that just three-days professional development related to robotics and programming improved significantly preschool teachers' content knowledge in technology, pedagogy, and robotics, self-efficacy in and attitude towards technology integration (Bers et al., 2013). Similarly, Bagiatti & Evangelou (2015) conducted their study with preschool teachers. Their study revealed that teachers and their positive attitudes toward engineering and STEM, in general, were one of the most significant factors of STEM education. In another study, Ong et al. (2016) compared early childhood teachers' self-reported pedagogical knowledge, skills, and attitudes concerning STEM integration before and after an in-service training. The three-day training was related to the integration of STEM by means of Project-Based-Inquiry Learning (PIL). According to the findings, a significant improvement was observed in teachers' knowledge and skills about and attitudes towards STEM integration by using PIL. In addition, preschool teachers reported that the training provided them stimulating experiences specifically in learning on STEM by means of hands-on experiences instead of boring didactic manners, conducting engaging projects and seeing their products, and the training gave them the opportunity of sharing their ideas with their colleagues and improved their pedagogical knowledge related to STEM education. The study conducted by Aldemir and Kermani (2016) supported Ong et al. (2016). Indeed, the focus of Aldemir and Kermani (2016) was to plan and apply a STEM curriculum to encourage children's STEM knowledge and skills and to improve preschool teachers' attitudes and professional abilities in planning and integrating STEM concepts into daily activities. To that end, in this quasi-experimental, pre-post intervention study, a STEM curriculum was implemented for 10 weeks in two of the four classrooms. According to the results, preschool children can get higher-levels of comprehension in STEM if they particularly promoted by means of

well-planned, developmentally appropriate and inspiring activities. In a similar way, intervention group preschool teachers' understanding of the important role of STEM to intellectual development, professional knowledge and skills in STEM areas and their confidence in implementing STEM integration in their classrooms was positively supported through the intervention.

Lastly, arts are regarded as the missing component of the bridge established between scientific understanding and innovation (Rabalais, 2014), however, none of the empirical studies examined in this paper was about arts integrated STEM education in ECE. Indeed, only Sharapan (2013) touched on STEAM education in ECE in her/his paper and presented some suggestions for implementation of STEAM in ECE classrooms. Even if this study did not approach arts by dividing it into its five main dimensions (music, dance, visual arts, drama, and literature, it provided important information about arts integrated STEM education. In her/his study, Sharapan (2013) presents some examples of arts integration and introduce preschool teachers with the STEAM education from the viewpoint of Fred Rogers. This study emphasizes that STEAM takes place in everywhere and everything. According to (Sharapan, 2013) a long-term and wonderful project can begin with an everyday and simple experience like digging a hole. This discovery grows out of a child's exploration of a small hole outside and continues with the participation of other children. They cooperate to test how deep and broad a hole they can dig. They experienced diverse kinds of tools to dig a deeper and broader hole. As the hole grows, children take its photos, and thus they take the advantage of technology in their experience. Moreover, they demand to know the depth of the hole they have dug, and make reference to math. If they add water to the hole or find out livings in the dirt, that will be science. If they want to establish dams to manage the flow of the water, that will be engineering. Finally, children may draw a draft which shows the path of the water, draw pictures of livings in the dirt or compose a song on the hole. Therefore, in a simple and everyday activity, all of the components of STEAM can come together.

DISCUSSION AND IMPLICATIONS

This paper aimed to review the literature (2006-2016) regarding STEM and visual arts integrated STEM education practices in ECE and suggest some implications. When the dramatic increase of research about STEM education practices in higher grades is taken into consideration, the number of scientific research accessed at the end of this detailed literature review indicates that STEM education in ECE is a new subject for researchers. In a similar way, STEM education practices and research increased in our country (Baran, Bilici, Mesutoğlu, & Ocak, 2016; Bozkurt-Altan & Kırıkkaya, 2016; Çorlu, Capraro, & Capraro, 2014) Turkish literature dealing STEM in early childhood years is very limited (Soylu, 2015). On the other hand, children are curious explorers of the world around them from the moment they were born. They wonder, observe, interrogate, investigate, explore, make trial and errors, measure, compare,

develop hypotheses, ask questions and try to find answers, create and invent intrinsically. Therefore, early childhood years are the time when the foundations of STEM disciplines are laid. This literature review indicated that there was a tendency to focus on engineering and technology components of STEM in research conducted during the last decade. On the other side, engineering and technology are two areas that give a limited place in the Turkish ECE curriculum (Ministry of National Education [MoNE], 2013). Starting from this point, in the education of young children, STEM disciplines should be considered as interdisciplinary and each discipline should be given evenly. In this manner, much more scientific research should be conducted STEM education in early childhood, and these studies should deal different STEM practices performed all around the world and the impact of these implementations on children's developmental fields, future achievement, and career choices by means of longitudinal studies. In addition, future research should focus on not only engineering and technology, but also other disciplines found in the STEM acronym. By considering new approaches to STEM education like STEAM and STREAM, future research should examine the integration of other disciplines like the different disciplines like arts and social sciences.

The research examined in this review indicated that STEM education contributes preschool children's ability and learning in STEM concepts (e.g. Kazakoff et al., 2013; Kermani & Aldemir, 2015; Moomav & Jaumall, 2010). In fact, all these disciplines are interrelated and learning in one of them can support learning in another. For instance, as in Kazakoff et al. (2013), a child can improve his/her ability in sequencing by engaging with robotics and programming or reinforce his counting ability by using iPad apps (Aronin & Floyd, 2013). Besides, research indicated that STEM practices help children with disabilities to learn STEM concepts and transfer their learning into future experiences (Moomav & Davis, 2010). Therefore, regardless of their ability children should be supported in these crucial years by means of a developmentally appropriate curriculum which integrates STEM disciplines, makes connections between these fields and the real world, lays the foundations of STEM fields by providing children concrete experiences and encouraging their natural curiosity and creativity. Furthermore, as the natural component of their education, integration of arts into such a curriculum may make preschoolers more motivated and fun for science-related activities (Ludwig, Marklein, & Song, 2016). Furthermore, arts integration may give preschool children the change of illustrating STEM concepts in innovative and imaginative ways and expressing their own thoughts with regard to the world via music and dance, illustrating opinions by using crayons and markers, establishing models, creating graphs and communicating with the people by using a descriptive language (Sharapan, 2013).

On the other hand, as Riley (2016) stressed, a successful arts integration can only be achieved through a well-planned program and professional development of teachers. Turkish ECE curriculum (MoNE, 2013), emphasizing child centered, developmentally appropriate and integrated activities, gives preschool teachers

the opportunity of practicing arts integrated STEM activities in their classrooms. However, research conducted by Öztürk and Erden (2011) indicated that preschool teachers tended to use visual arts activities as a reinforce activity or an independent activity rather than integrating it into other disciplines. As Bequette & Bequette (2012) stressed, preschool teachers may keep away from performing STEAM activities due to their lack of pedagogical content knowledge. In this manner, in-service training and workshops addressed preschool teachers may be organized by MoNE and researchers to support teachers' content knowledge in STEAM fields. In these trainings, by taking into consideration their different backgrounds and working conditions, preschool teachers can be informed how they integrate and practice STEAM activities in their classrooms. Furthermore, such training may guide teachers in the matter of how they support those early learners in terms of inquiry-based, critical, innovative and creative thinking in these fields. In this way, preschool teachers may have more positive attitudes toward and higher self-efficacy in teaching science related activities (Atile et al., 2013). In a similar way, pre-service preschool teachers should be supported in their STEAM knowledge and implementation. Indeed, the findings of this study revealed that none of the scientific research handled within the scope of this study examined pre-service preschool teachers' STEM or STEAM related knowledge, attitude, skills or practices. Therefore, future studies should focus on prospective preschool teachers to find out their current equipment for STEAM education and improve their STEM knowledge and skills. To that end, STEAM related courses may be added to teacher training programs of the education faculties. In these courses, they should experience their own STEAM investigations in order to look at the learning in these disciplines from the eyes of the preschool children. As a stakeholder of curriculum implementation (Bagiati, 2011), not only teachers but also parents, should be introduced about how they encourage their children's improvement in STEAM knowledge and skills.

In addition, by considering literature (Crespo et al., 2014; Şahin et al., 2014), it can be suggested that workshops, summer camps and after-school activities and STEAM laboratories enabling preschool children to engage in STEAM activities can be organized by school administrations, researchers or volunteer educators. As another way of providing children informal learning, as Soylu (2015) suggested, both science museums and science centers can be established in the four corners of the Turkey by the government or private institutions with the purpose of accessing all children from different backgrounds and socioeconomic status.

Lastly, STEM education is taken place in many country's education systems like the United States, China, Korea, Japan, and Germany nowadays (MoNE, 2016), however, STEM education is an emergent field for the Turkish education system. Fortunately, objectives relation to strengthening STEM education takes place in Turkish 2015-2019 Strategic Plan (MoNE, 2016). In this process, the importance of arts in teaching and learning of STEM subjects should not be missed, and

curriculum developers, universities, institutions which can provide economic support for new projects, school administrations, teachers, teacher educators, researchers, and parents should collaborate with each other. This may be a new but a big step for growing our future scientists.

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GENİŞ ÖZET

Giriş

Son yıllarda eğitim ve iş gücü alanlarında küresel ilgi uyandıran STEM eğitimi (English, 2016), ekonomik gerileme ve gelişmekte olan ülkeler arasında artan rekabet sonucunda (Guyotte, Sochacka, Constantino, Walther & Kellam, 2014) Amerika'da (ABD) ortaya çıkan bir eğitim reformudur (English, 2016). Öğrencileri 21. yüzyılın küresel ekonomisine hazırlamayı hedefleyen bu eğitim reformu (Yakman & Hyonyong, 2012), son on yıldır eğitimcilerin ve araştırmacıların odağı haline gelmiştir (Sousa & Pilecki, 2013; Soylu, 2015).

Sürekli keşif halinde olan, deneyimlemeyi ve çeşitli materyallerle meşgul olmayı seven, problem çözen, kıyaslamalar yapan (Sharapan, 2013), gerçekleri ve kuralları sorgulayan birer birey olarak okul öncesi dönem çocukları, STEM eğitimi için hazır ve isteklidir. STEM etkinliklerinin uygulandığı okul öncesi eğitim ortamlarında, çocuklar bilimsel ve matematiksel ilişkileri materyaller aracılığıyla yaptıkları keşifler sayesinde yapılandırırlar. Böylece, gelecekteki öğrenmelere temel oluşturan anlamlı öğrenmeler gerçekleşir (Moomav & Davis, 2010).

Bazı araştırmacılar STEM'in birbirini tamamlayan bileşenlerden oluşan bir yapboz olduğunu, sanatın da eklenmesi ile bu yapbozun tamamlanacağını savunmaktadırlar (Kim & Park, 2012; Sharapan, 2013; Sochacka, Guyotte, Walther, 2016). Sanatın STEM eğitimi ile bütünleştirilmesi, okul öncesi dönem çocuğunun STEM disiplinlerinde daha başarılı olmalarını sağladığı gibi (Schirrmacher, 2002; Wynn & Harris, 2012), onların bu alanlarda öğrenmeye yönelik motivasyonlarını ve katılımlarını artırmaktadır (Henrkisen et al., 2015). Bunun yanı sıra, görsel sanatların bilimsel disiplinler ile bütünleştirilmesi çocukların el becerilerinin, ince motor kaslarının ve bilimsel konularda başarılı olmak için gereken görsel uzamsal becerilerinin gelişimini destekler (Newcombe, 2010).

Diğer yandan, STEM eğitimi ve sanatın STEM disiplinleri ile bütünleştirilmesi, okul öncesi eğitimde oldukça yeni iki çalışma alanıdır. Rabalais (2014)'in de belirttiği gibi, bu iki önemli çalışma alanına yönelik bulgular, okul öncesi eğitim uygulamalarına ışık tutacaktır. Bu çalışma, okul öncesi eğitimde STEM ve STEAM konularını ele alan, son on yılda yayınlanmış çalışmaları incelemekte ve bu inceleme doğrultusunda Türkiye'de okul öncesi dönemde STEM ve STEAM uygulamalarını güçlendirmeye yönelik öneriler sunmaktır.

Yöntem

Bu çalışmada, okul öncesi dönemde STEM ve STEAM eğitimini konu alan, 2006-2016 yılları arasında yayınlanmış, ulusal ve uluslararası bilimsel araştırmalar, Orta Doğu Teknik Üniversitesi Online Kütüphanesi kullanılarak sistematik olarak incelenmiştir. İlk olarak, "Eğitim" başlığı altındaki altı veri tabanı (American Research Complete, EBSCOhost, Education Source, ERIC,

Teacher Reference Center ve ULAKBIM) çalışmalara erişmek için taranmıştır. Daha sonra, bu altı veri tabanı okul öncesi dönemde STEM eğitimine yönelik çeşitli anahtar kelimeler kullanılarak taranmış ve toplamda ulaşılan 24 çalışmadan, tam metnine erişilebilen 22 tanesi araştırmaya dahil edilmiştir. Ulaşılan çalışmalar yayınlandıkları yıl, katılımcılar, gerçekleştirildiği ülke, odak noktası ve temel bulguları açısından betimsel olarak analiz edilmiştir.

Bulgular

STEM eğitimi okul öncesi dönemden doktora sonrasına kadarki sürece yönelik eğitim etkinliklerini kapsayan disiplinler arası bir yaklaşım olmasına rağmen (Gonzalez & Kuenzi, 2012), son on yılda yayınlanan çalışmaların incelenmesine dayanan bulgular okul öncesi dönemde STEM eğitimine yönelik sınırlı sayıda çalışma olduğunu göstermektedir. Bu çalışmada ulaşılan 22 bilimsel araştırmanın 16 tanesi uygulamaya dayalı çalışmalar iken, altı tanesi okul öncesi eğitimde STEM uygulamalarına yönelik stratejiler önermektedir. Bulgulara göre, 2006-2010 yılları arasında STEM veya STEAM eğitimini konu alan herhangi bir çalışmaya rastlanmamıştır. Diğer yandan, özellikle 2013-2016 yılları arasında okul öncesi dönemde STEM konusunu işleyen çalışma sayısında, toplam çalışma sayısı göz önünde bulundurulduğunda, önemli bir artış gözlemlenmiştir. Bu çalışmaların büyük bir kısmı (n=9; 56.2%) ABD'de gerçekleştirilmiş olup, Türkiye'de sadece bir çalışmanın (Soylu, 2015) okul öncesinde STEM eğitimine değindiği bulgusuna ulaşılmıştır. Çalışmalar temel aldıkları konular açısından çeşitlilik gösterse de, mühendislik, STEM müfredatının planlanması ve uygulanması ve teknolojinin mühendislik ile bütünleştirildiği programlama ve robotik konuları sırasıyla en sık işlenen üç konudur. İncelenen deneysel çalışmaların katılımcıları ziyadesiyle okul öncesi dönem çocukları ve okul öncesi öğretmenleridir. Bunun yanı sıra hem okul öncesi çocukları hem de okul öncesi öğretmenlerine odaklanan çalışmalar da bulunmaktadır. Diğer yandan, incelenen 16 deneysel çalışma arasında okul öncesi öğretmen adayları ile gerçekleştirilen herhangi bir çalışmaya rastlanmamıştır.

Çalışmaların bulguları genel olarak, STEM eğitim uygulamalarının okul öncesi dönem çocuklarının STEM'i oluşturan disiplinlerdeki öğrenmeleri üzerinde olumlu etkiler yarattığına (Evangelou vd., 2010; Torre-Crespo vd., 2014; Verdine vd., 2014) ve okul öncesi dönem çocuklarının STEM disiplinlerini öğrenmeye hazır olduklarına işaret etmektedir (Lyons & Tredwell, 2015; Moomav & Davis, 2010). Çalışmalar, aynı zamanda, STEM uygulamalarının okul öncesi öğretmenlerinin sınıf ortamlarında bütünleştirilmiş etkinlikler uygulamaya yönelik tutumları, özgüvenleri ve STEM disiplinlerine yönelik alan bilgileri üzerinde olumlu etkisi olduğunu da ortaya çıkarmıştır (Bers vd., 2013).

Sonuç ve Tartışma

Diğer eğitim seviyelerinde STEM eğitimine odaklanan araştırma sayısının önemli ölçüde arttığı düşünüldüğünde, bu çalışmada erişilen sınırlı sayıdaki bilimsel araştırma STEM eğitiminin okul öncesi eğitim araştırmacıları için yeni bir alan olduğuna işaret etmektedir. Benzer şekilde, ulusal alan yazında STEM'i

konu alan oldukça az sayıda çalışmaya rastlanmıştır (Soylu, 2015). STEM eğitiminin okul öncesi dönem çocuklarının öğrenmeleri üzerindeki olumlu etkisine yönelik araştırma bulgularından yola çıkarak, bu çalışmada okul öncesi eğitim müfredatında STEM alanlarının disiplinler arası çerçevede değerlendirilmesi ve her bir disipline dengeli, birbiri ve gerçek hayatla ilişkili şekilde yer verilmesi önerilmektedir. Okul öncesi eğitimin doğal bir parçası olan sanatın böyle bir müfredatta STEM disiplinleri ile bütünleştirilmesi, çocuklara STEM kavramlarını yenilikçi ve yaratıcı şekillerde görselleştirmelerini ve çevrelerindeki dünyaya yönelik düşüncelerini ifade edebilmelerini sağlayabilir (Sharapan, 2013). Diğer yandan sanat ve diğer disiplinlerin bütünlüğü iyi planlanmış bir eğitim programı ve öğretmenlerin mesleki gelişimleri ile mümkündür. Bu nedenle hem okul öncesi öğretmenleri hem de öğretmen adayları, çeşitli disiplinlerin bütünleştirilmesi ve okul öncesi eğitim ortamlarında uygulanması konusunda çeşitli eğitimler aracılığıyla desteklenmelidir.

Okul öncesi öğretmen adaylarına odaklanan herhangi bir çalışmanın bulunmayışı göz önünde bulundurularak, gelecek çalışmalara, okul öncesi öğretmen adaylarının STEAM'e yönelik mevcut bilgi, tutum ve becerilerini ortaya çıkarmaya odaklanması önerilebilir. Öğretmen adaylarının bu alandaki bilgi ve becerilerini artırmak amacıyla planlanacak ve uygulanacak olan, öğretmen adaylarının STEAM etkinliklerini deneyimleyip, STEAM disiplinlerine okul öncesi dönem çocuğunun gözünden bakabilmelerine olanak tanıyan STEAM dersi öğretmen eğitim programlarına eklenebilir.

Son olarak, STEM eğitimi çok sayıda ülkenin eğitim sisteminde yer alsa da (MoNE, 2016), Türk eğitim sistemi için yeni ve gelişmekte olan bir alandır. Öyle ki, 2015-2019 Stratejik Planı'nda STEM eğitimini güçlendirmeye yönelik hedeflere yer verilmiştir (MoNE, 2016). Bu süreçte, sanatın STEM disiplinlerindeki öğrenmeler için önemi göz ardı edilmeden, müfredat geliştiren kişiler, üniversiteler, yeni projeler için maddi destek sağlayabilecek olan kurumlar, okul yönetimleri, öğretmenler, öğretmen eğitimcileri, araştırmacılar ve aileler birbiri ile iş birliği içinde çalışmalıdır. Bu adım yeni fakat geleceğimizin bilim insanları için büyük bir adım olabilir.