JOURNAL OF EDUCATIONAL AND INSTRUCTIONAL STUDIES
IN THE WORLD
June 2016, Volume: 6 Special Issue 1 Article: 07 ISSN: 2146-7463

STEM EDUCATION IN EARLY CHILDHOOD IN TURKEY

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Abstract
After a decade of intense focus on developing literacy skills in early childhood programs, today the attention is shifting to the significance of teaching mathematics, technology and science in the early years. The need for emphasizing science, mathematics, technology and engineering subjects in school settings to enhance 21th century skillsof individuals, starting with early childhood by using a developmentally appropriate approach is declared by a great number of research. Even though the significance of early introduction to STEM subjects is being discussed recently by many researchers, serious initiative for national regulations, curriculum development, teacher preparation, and setting standards is still lacking for Turkey. This paper aims to provide an initial glimpse of the state of the STEM education in early childhood in the world and the current state of STEM education in early childhood level in Turkey. The paper will conclude with suggestions regarding to integrating STEM in early childhood education, especially for Turkey.

Keywords: STEM education, STEM in early childhood, Turkey.

INTRODUCTION

After a decade of intense focus on developing literacy skills in early childhood programs, today the attention is shifting to the significance of teaching mathematics, technology and science in the early years (Moomaw, 2013). The need for emphasizing science, mathematics, technology and engineering subjects in school settings to enhance 21th century skills (such as, critical thinking, creativity, curiosity, and collaboration) of individuals, starting with early childhood by using a developmentally appropriate approach is declared by a great number of research (Brophy, Klein, Portsmore, & Rogers, 2008, Moomaw & Davis, 2010, NASE, 2010, Akgündüz et al., 2015, Katz, 2010, Linderman, Jabot & Berkley, 2013, NRC, 2011, Raju & Clayson, 2010). The notion of STEM (Science, Technology, Engineering, and Mathematics) education is aroused based on this need, the need of raising citizens who can contribute to nations' economic and cultural competency, in the new information era that we are living. STEM is an acronym that refers to the education-related programs in the disciplines of science, technology, engineering, and mathematics, which is first aroused by US National Science Foundation (NSF) (Kumtepe & Kumtepe, 2013). STEM education is an approach that aims to teach these disciplines as an integrated whole, and it covers the whole process from early childhood to higher education (Bybee, 2010). While some educators regard STEM as implication of any of the STEM disciplines individually, they should rather be integrated as a whole and the power of STEM should come from integration of science and math skills into an engineering or problem solving process that entails utilization of developmentally appropriate technologies (Merrill & Daughery, 2010, Carnegie Mellon University, 2008). Even though the significance of early introduction to STEM subjects is being discussed recently by many researchers, serious initiative for national regulations, curriculum development, teacher preparation, and setting standards is still lacking (Akgündüz et al., 2015).

This paper aims to provide an initial glimpse of the significance of STEM education in general and the importance of introducing STEM disciplines at early childhood level. The state of the STEM education in early childhood in the world and the main issues for applying STEM in early childhood will be elaborated. Afterwards, the current state of STEM education in Turkey, will be mentioned and the necessity of enhancing the practices of STEM education in Turkey for early childhood settings will be discussed. The paper will conclude with suggestions regarding to the steps to be taken for integrating STEM education early childhood education,

especially for Turkey considering the international studies regarding the practices of STEM education in the early years.

STEM Education and Its Significance

In recent years, STEM education has become a focus of interest in the United States. There are several reasons behind that phenomena. In 2009, National Center for Education Statistics reported that U.S. students trail their peers in many developed countries especially in science and mathematics. In addition, it is reported that content knowledge and skills for STEM disciplines, such as processing information to make societal decisions, is increasingly required in jobs at all levels from all over the world for the next 20 years. Also, STEM education has been linked to scientific leadership in the future world and to prospective economic growth (National Research Council, 2011). STEM education target economic advancement, nurture creative leaders who accommodate the information age. In addition to these aims, STEM education highlights the equity in education. Hence, STEM education should be equally delivered for all, regardless of their socio economic status, or gender (Beede et. al., 2011). STEM education also focuses on a learner centered education. While dealing with STEM subjects, students engage in real life issues and use questioning, problem solving, collaboration, and hands-on activities to figure out the solution. Teachers facilitate classroom by guiding students through planning projects and solving problems in STEM education. Students who are STEM proficient seek answers for complex real life questions, explore global problems, through applying their science, technology, engineering, and mathematics knowledge (Bybee, 2010).

It is obvious that STEM education is a crucial tool by providing opportunities to transforming inert content knowledge into practice (STEM Smart Brief, 2013). The new era expects individuals to be productive, and that necessitates engineering abilities to use content knowledge for creating new solutions. STEM especially emphasize technology and engineering, intend to promote an interdisciplinary viewpoint starting by early childhood, and enable to transform knowledge into products to solve daily life problems, therefore it has a significant role for the information age (Akgündüz et al., 2015). STEM education has a crucial role for education not only by supporting scientific and technological development, but also contributing to the sustainability of innovativeness (Clark & Button, 2011). Individuals in information age should have certain knowledge and skills on science and technology, besides knowing how to use the knowledge has further significance. They should also have abilities such as engaging in inquiry, logical reasoning, and working collaboratively to use their inert knowledge to productively (Agustine, 2005). Therefore today's children should not only focus on pursuing careers on science and technology, they should also become citizens who can think critically, solve problems creatively, and pursue an innovative approach regardless of their professions. The sooner students engage in the real-world application of science, technology, engineering, and mathematics content the better they master such kind of abilities (Boston Children's Museum, 2013). For this reason, STEM education should better begin in early years (Moomaw & Davis, 2010, Katz, 2010, Forman, 2010, Moomaw, 2013, Sanders, 2009).

STEM EDUCATION IN EARLY CHILDHOOD

Children are innately curious and eager to explore the world around them and avid to solve problems with using trial and error method. They are active learners and creative inquirers just like science people (Katz, 2010). Thus, it is significant to offer resources and opportunities for them to explore, investigate and develop their inborn abilities. However, traditional formal science education can stifle their interest and can affect their attitudes towards learning science negatively (OECD, 2006). Research shows that supporting children to gain first hand experiences trough formal and informal science activities in early childhood will have a positive effect on their future academic science performance and skills that are necessary for scientific thinking such as observation, investigation, inference, interest and curiosity, also their attitudes towards science will be affected positively (Eshach & Fred, 2005). STEM education targets to raise students envisioning and developing solutions to challenges that interest them, applying their mathematic and scientific content knowledge in the context of technological designing and problem solving through using problem based learning and authentic scientific inquiry (Sanders, 2009). There are four basic goals that are appropriate for early childhood education in terms of the aims of the STEM program which are knowledge/understanding, skills, dispositions, and feelings (Moomaw, 2013). It is mistakenly assumed that preschool children lack the basic intellectual abilities such as to make sense of experience, to analyze, hypothesize, predict (Katz,2010). On the contrary, children are likely to

gain all four of the listed learning goals that are necessary for STEM education when they engage in in-depth investigations of phenomena around them with hands on experiences (Linderman, Jabot & Berkley, 2013). Hence, an appropriate preschool curriculum should encourage and motivate children to learn and improve basic academic abilities in the service of their intellectual pursuits which embodies the whole range of knowledge, understanding, skills, and dispositions that are related to STEM goals (Katz, 2010). Therefore applying STEM education in early childhood appropriately would be beneficial to nurture children's inborn scientific abilities and curiosity, in addition it will foster their prospective academic abilities in science and mathematics by integrating technology and engineering skills to these areas.

In addition to necessity of an appropriate curriculum, there are many other factors affecting implementation of STEM education in early childhood, such as teachers' knowledge and attitudes towards STEM disciplines and their experiences related to STEM fields, governments' development strategies and priorities, and collaborations among stakeholders. According to the current literature, the most significant challenges to applying STEM learning in early childhood around world can be explored in three main topics: Policies, curriculum /instruction, and teacher education.

Policies: Even though the long lasting contributions of early STEM education to children's schooling and professional development is evident, research indicates that early childhood is the most neglected education area for both funding and research, and until 2013, early childhood education was not included to strategic plans about STEM education, or not given importance as much as elementary or high school education worldwide (Kumtepe & Kumtepe, 2013). In 2013, Barack Obama stated the significance of implementing STEM education in early years on the 150th Anniversary of the National Academy of Sciences by declaring: "We want to make sure that we are exciting young people around math and science and technology and computer science. We don't want our kids just to be consumers of the amazing things that science generates; we want them to be producers as well." (NSTC, 2013). Consequently, National Science and Technology Council (NSTC), released 5 year strategic plan for federal STEM education, and stated that the STEM education should begin from preschool, thereby early childhood become a target group for STEM education in USA.

In 2007 European Commission, declared the need for qualified science education for students from all educational levels, to enhance the capacity for innovative development and signified the requirement of developing an influential action plan (Rocard et. al., 2007). Although the report highlight the importance of early implementation of science education, there isn't any suggestions aimed early childhood educators or early childhood education policies. The United Kingdom, Germany, Ireland and Finland also acknowledge STEM education as a priority for their national education system (Aydagül & Terzioğlu, 2014), yet investigating their education programs, early childhood education still receives minor concern in these countries. That situation signifies the salient need for political attempts to support STEM education in early childhood.The policies in Turkey regarding to STEM education will be discussed in the further pages.

Curriculum and Instruction: STEM learning is a hot topic nowadays, and as mentioned before, early introduction of these subjects has a tremendous significance for children's future academic performance, and scientific thinking skills. Enhancing children's intellectual capabilities by providing them opportunities of questioning, exploring, analyzing, and understanding is quite significant for teaching STEM in early childhood education. Research indicate that appropriate mathematics education in early years have a positive effect in later mathematics learning and narrow achievement gaps (Duncan et. al, 2007, Clements, Sarama, Spiter & Wolfe, 2011, Geary, 2013). Furthermore literature emphasize the positive impact and importance of science education in early years, and the significance of including science education to early childhood education (Eshach, 2006, Samarapungavan, Mantzicopoulos& Patrick, 2008, Bell & Clair, 2015). Children who achieve developmentally appropriate mathematics and science education in early childhood, will outperform in their future academic life (NASE, 2010). Even though there is a great amount of study conducted related to the significance of mathematics education, number sense and numerical literacy in early childhood, research on science education in preschool and kindergarten is fewer (Moomaw, 2013). Moreover, comparing to the number of research focusing on mathematics and science education in early childhood, research related to teaching technology and engineering skills in early childhood is even more lacking, and it also requires in depth studies (Bagiati, Yoon, Evangelou & Ngambeki, 2010). STEM education not only integrates all of these

disciplines and but also includes connections to each other. Thereby learning in each area reinforces the other (Linderman, Jabot & Berkley, 2013). Such integration is supported by professional teaching organizations such as National Association for the Education of Young Children (NAEYC), in the position statement on developmentally appropriate practice, NAEYC advises that early childhood teachers should pay attention to integrate these disciplines to promote children's learning within and across the disciplines while planning the curriculum experiences (Copple and Bredekamp 2009). Therefore it is necessary to develop appropriate curricula to support the enhancement of these areas. Approaches that promote hands on experience, learning by doing, and active involvement, such as project based learning and play based learning would be a suitable way to implement STEM education in early childhood. Katz (2010) suggests that while teaching scientific subject with academic instruction assign children in a passive and receptive role, project approach will foster children to be active participants who take responsibility in determination of the questions to search, how to collect the data, how to represent and to report the findings. Play based curriculum is also acknowledged to be an essential factor for effective science and mathematics learning in early childhood (Bowman, 1999, Osborne& Brady, 2001, Ginsburg, 2006). Using play or project based learning as a tool for implementing STEM subjects in early childhood would be beneficial, yet the curriculum must be well planned, and children should have the role to ask questions, investigate, think about possible solutions, take the initiative and try the solution that they select and analyze the outcomes. In order to achieve this kind of implementation, children should be familiar with scientific teaching process, otherwise it will be pointless to endeavor to pursue that attempt. In fact, some researchers asserts that direct instruction is also a necessary tool for enhancing STEM skills in early childhood especially for younger children who are not familiar with scientific thinking process, and not mature enough to take initiative (Clements, 2013, Diamond, Justice, Siegler & Synder, 2013, Sarama & Celements, 2009).

Regardless of the approaches used, it is essential to allocate adequate effort for instructing all STEM areas (not only science and mathematics) in the early childhood learning. National Research Council assert that children have their mindset about physical, biological, and social facts before entering school. With using appropriate teaching methods, education can build on the already existing knowledge and abilities of children (NRC, 2012). Besides, the current research indicate that more effort is necessary to apply all the STEM areas in early childhood to nurture STEM smart generations (Rockland et. al, 2010). Therefore, developing age appropriate curriculum and instruction tools that integrate all STEM areas with real life problems, allocating enough time for exploration, provide hands on experiences for children and enhance their inborn capacities of creative thinking is a crucial necessity to promote STEM education in early childhood settings.

Teacher Education: Teachers play a crucial role in ensuring effective STEM learning in early childhood, since they need to plan developmentally appropriate, play based, hands on and meaningful integrated activities to introduce STEM areas in the classroom. For this reason, they need to be well prepared, and have profound knowledge about the subject areas as well as ability to mesh the knowledge with experience (Whitebook & Ryan, 2011). Children who are stimulated by attractive, meaningful, and discerning activities in early years will become immersed in scientific inquiry in their later life. In addition, they will develop the desire to explore, experiment and learn throughout life (Gelman & Brennenman, 2004, Genç- Kumtepe, Kaya & Kumtepe, 2009). Hence, early childhood teachers should develop abilities of teaching STEM topics and stimulating children's thinking.

Although STEM is an acronym for four disciplines, early childhood teachers are most engaged with science and mathematics. Nevertheless, many early childhood teachers fail to capitalize on the science opportunities that are embedded throughout the day (Moomaw, 2013). Research depicts that early childhood teachers' attitude towards mathematics and science, and their knowledge of scientific concepts is a key indicator of implementing related activities with a qualified manner (Faulkner-Schneider, 2005). Despite the key role of teachers on children's STEM learning, recent reports portray that teacher preparation systems are insufficient, and that young children's educators do not receive the adequate training in STEM fields that they need to support children's achievement (Whitebook & Ryan, 2011, Bornfreund, 2011). Early childhood teachers do not trust themselves as capable of teaching mathematics, even though they appreciate mathematics as a crucial component of the early childhood curriculum. Teachers indicate that they feel uncomfortable with mathematics, and their math anxiety is generally affiliated with their own elementary school experiences

(Philipp, 2007). Furthermore, Hedhes and Collin (2005) states that early childhood teachers' content knowledge and experiences related to science is an essential indicator of applying science activities frequently and accurately in the classroom. However, early childhood teachers generally have poor subject knowledge in science and unaware of the impact of this lack of knowledge on their ability and willingness to provide appropriate opportunities for learning science for their students (Garbett, 2003).

It is evident that the early childhood teachers do not have adequate content knowledge about STEM areas and they do not know how to promote children's learning in these areas and that has a significant effect on their attitudes towards creating opportunities for bringing these subjects to classroom (Chalufour, 2010). These results depicts that early childhood teachers need more support to develop their content knowledge on STEM areas and they need pre-service and in service trainings to learn how to implement STEM subjects in classroom with an integrated and developmentally appropriate approach in order to nurture children's learning.

STEM EDUATION IN TURKEY

The developing technology and economy requires individuals who can think analytically and have skills to solve problems creatively. STEM education plays a key role to promote sustainable development for countries. Policy makers, economists, and educators realized the severity of the situation. Discussions related to the significance of STEM education in Turkey has been accelerated recently. In this age of innovation, countries who have global economic powers such as the United States, Germany, United Kingdom and China transform their education systems in accordance with the technological developments in order to be able to develop their economic powers and stay competitive (Fensham, 2008). According to PISA 2012 report Turkey was the 44th among 65 countries and 31th among 34 OECD countries (Anıl, Özkan & Demir, 2015) . In addition, according to the TIMMS 2011 report, Turkey was below the average both for mathematics and science proficiency of 4th and 8th graders (Oral & Mcgivney, 2013). Since Turkey's innovation productivity falls behind the other economically developed countries, making reforms in teaching STEM disciplines is especially essential (Corlu, Capraro & Capraro, 2014). These reforms should target all levels of the education units, starting from early childhood to higher education (Akgündüz et. al., 2015). Many research depicts the necessity for a well-developed STEM education for Turkey, and signify the role of teacher education, and governmental policies for this purpose (Özden, 2007, Corlu,Capraro & Capraro, 2014, Akgündüz et al., 2015, Corlu, 2012).

STEM in Turkish Early Childhood Education

The 2013 early childhood education program signifies child based, play centered learning with using developmentally appropriate approaches and integrated curriculum, which are stated before as necessary tools for implementing STEM in early childhood. In addition, there should be mathematics and science learning centers in the classrooms, even though engineering and technology learning centers are not listed in the program, teachers have the flexibility to add different learning center or integrating learning centers with using various materials. Despite the fact that importance is given to science and mathematics education in the program, teachers' capabilities of arranging appropriate learning centers to promote those skills, and content knowledge related to STEM fields should be examined by researchers. The 2013 early childhood education program also signifies the partnerships among school and society. Providing extracurricular activities for children is also suggested by the program. One of the best ways to provide extracurricular scientific experiences for children is establishing science centers and science museums (Moomaw, 2013). Kayseri Provincial Directorate for National Education, started a STEM project in 2014 to promote the implication of STEM disciplines in various education levels, they initiate 35 projects yet there was only two projects targeting early childhood education. In 2012, Science and Experiment Center is put in service in Eskişehir (there is also a space house inside) to provide scientific experiences for children aged between 7- 12, also in 2013 Feza Gürsey Science and Ankara Children Museum and Science Center is put in service in Ankara however there isn't any activities targeting early childhood years supports STEM learning for children in these museums. Even the enthusiasm of these initiatives worth admire, it is not enough solely. It is seen that projects and initiatives for STEM education in early childhood is lacking in Turkey.

DISCUSSION AND SUGGESTIONS

Considering the demands of the new information era, ensuring every child to receive a qualified STEM education starting from early childhood would be a logical investment for a country which intend to enhance its capability of sustainable development. As mentioned before, there is a large amount of research point out the significance of enhancing practices of STEM education starting with the early childhood. Unfortunately the studies regarding to the STEM education in Turkey do not signify the key role of early childhood institutions in terms of enhancing children's scientific thinking skills and their attitudes towards scientific disciplines.

Children are inherently curious and eager to learn. Education should be designed to promote these innate motivations of children. Keeping them exploring and ensuring their prospective success should be the prior aim of the full array of early childhood stakeholders. Educators, policy makers, initiators, businesses should cooperate to create a smooth continuum of STEM education for early childhood field, in order to raise citizens who are capable of critical and analytical thinking and using their knowledge to solve daily life problems to be able to compete with other countries in the 21th century. That can be ensured by integrating these fields with each other, constructing connections with children's daily life, utilizing age appropriate approaches, supporting pre-service and in-service training of teachers in STEM areas, building quality network among academicians, teachers, policy makers, companies, and community.

In order to achieve the goal of being capable of competing with developed countries both economically and culturally, children should be raised with an approach to nurture the skills that are necessary for creativity, problem solving and critical thinking. Since STEM education has the potential to enhance these skills, teachers, educators, scientists, engineers, government, and entrepreneurs should work in collaboration and support early introduction of STEM disciplines with an appropriate approach. Steps that should be taken may include:
STEM education for early childhood in Turkey should be coordinated with the developed countries such as United States and United Kingdom. Partnerships and projects should be established with these countries. Early childhood teachers should receive quality education to enhance their content knowledge on STEM subjects. Early childhood education departments in universities should offer courses related to STEM fields both for undergraduate and graduate level. Also, in service trainings should be provided in regular basis to enhance content knowledge of teachers about STEM disciplines and promote teaching practices of STEM disciplines in an integrated manner with a developmentally appropriate approach. Universities, schools, government, businesses, and community should work in collaboration to enhance STEM learning of early childhood children. Pilot STEM schools can be established for investigating the opportunities, and elucidate the phenomena. By that way a research based STEM curricula can be developed which use learning trajectories that build upon children's needs, abilities, and knowledge. For providing informal learning experiences science museums or science centers should be established in every city by government or by private companies. By that way STEM education should be given all children regardless of their gender or socioeconomic status.

Achieving these goals will require a serious commitment, coordination, and effort, but it will yield tremendous outcomes such as raising citizens capable of 21th century skills.

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