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The Impact of Utilizing Learning Centers to Promote STEM Development in the Early Childhood Classroom

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Abstract

This literature review explores the research on incorporating STEM in the preschool classroom, in particular, learning centers. Research from the past decade shows developing the four areas of science, technology, mathematics, and engineering (STEM) in the early years is beneficial for students' science abilities in the later grades. Studies from this review shine a light on teacher attitudes about science, the classroom environment, and approaches to learning and how they influence students' learning of STEM in preschool.

Keywords: STEM, Preschool, Early Childhood Education, Learning Centers

The Impact of Utilizing Learning Centers to Promote STEM Development in the Early Childhood Classroom

STEM, which stands for the four disciplines of Science, Technology, Engineering and Mathematics allows young children to explore their world giving them familiarity with these subjects. STEM is trending in early childhood education, and it is important to get students involved where they can learn 21st-century skills, increase science literacy, and be involved in real-world experiences. STEM connects other contexts and across all disciplines (Moomaw and Davis, 2010). Experts note that cross-curricular integration exposes students to reasoning, predicting, hypothesizing, problem solving, and critical thinking; this integration is more apt to drive students towards careers in the STEM field (Ashbrook, 2019; Dejonckheere, De Wit, Van de Keere, & Vervaet, 2016). Children are curious learners, ready to explore their world around them. It is up to educators to develop their student's curiosity and inquiring attitudes (Dejonckheere, De Wit, Van de Keere, & Vervaet, 2016).

The problem is the lack of STEM education in early childhood classrooms; research revealed a lack of STEM education in early childhood classrooms and the need for it to be integrated into early childhood curriculum rather than isolated teaching moments (Dejonckheere, De Wit, Van de Keere, & Vervaet, 2016). Experts agree for young students to develop 21st-century skills, they need to be exposed to opportunities in the classroom that will activate their curiosity and increase their science literacy, skills that will stay with them as they progress through the K-12 school years. During President Barack Obama's presidency, STEM was incorporated as a priority in the Department of Education (Handelsman & Smith, 2016). The Trump Administration also continued STEM as a priority with the Department of Education

investing nearly 540 million through discretionary and research grants in the 2019 Fiscal Year (U.S. Department of Education, n.d.).

The purpose of this paper was to highlight STEM's importance in the early childhood classroom. Research that purposefully focused on incorporating STEM into early childhood education was studied. There is a growing body of evidence in the past 10 years in the United States and around the world that shows incorporating STEM into the preschool curriculum prepares students for K-12 education. The United States ranks 25th in the world according to PISA rankings of reading, math, and science emphasizes our country's lack of STEM fluency (PISA, 2018). Familiarity with STEM skills, especially early math skills are a strong predictor of later school achievement (McClure, 2017). The research frequently pointed towards the importance of starting with STEM in early childhood education because of its impact on shrinking achievement gaps.

There is significance in incorporating STEM into classroom learning centers whether it is an inclusive setting or regular education setting. STEM-based learning centers that are carefully planned, allow children to learn, explore, create, and collaborate amongst themselves (Ashbrook, 2018). Young children with delays or developmental disabilities are supported through planning that provides specialized practices, enabling them to participate with their peers during learning centers (Donegan-Ritter, 2015). Researchers agree that STEM-based learning centers foster creativity and exploration, giving students opportunities to cultivate their inquiry skills in a shared learning environment.

Engaging student's natural curiosity in STEM in the early childhood years helps build upon the foundations of the four core disciplines (Moomaw & Davis, 2010). Children are curious learners and need their thinking processes stimulated within the context of age-

appropriate materials (Dejonckheere, De Wit, Van de Keere, & Vervaet, 2016). Because STEM learning centers are incorporated in the early childhood classroom, students develop twenty-first century skills from this foundation that will stay with them as they progress through K-12 school years.

Themes that emerged while researching included teacher attitudes on teaching STEM in preschool; incorporating STEM in classroom learning centers; the impact of teaching STEM in the Preschool classroom; and encouraging a STEM mindset. Educators play an important part in the themes established in this literature review. Positive teacher attitudes solidify a STEM mindset when they are supported in the mastery of their experiences. Thus, if teachers feel prepared to teach science content, they can see the value in incorporating STEM education into their classrooms (Pendergast, Lieberman-betz, & Vail, 2017).

Gaps in science and math education happen when STEM is not introduced in the early childhood years. Researchers noted that science achievement gaps in the U.S. were present at Kindergarten entry (Morgan, Farkas, Hillemeier, & Maczuga, 2016). Therefore, establishing STEM as part of early childhood learning centers help students in achievement later in their K-12 school years. The review of this literature identified research for early childhood STEM education and - best practices for integrating it into early childhood learning centers.

Literature Review

Teacher Attitudes on Teaching STEM in Preschool

Research shows that teachers believe that teaching STEM, especially science, and incorporating it into the curriculum is an important part of early childhood education. A recent quantitative research study by Pendergast, Lieberman-Betz, & Vail (2017) was conducted to study the teacher-attitudes on teaching science in their preschool classroom. Data were collected

using a survey measuring the participants attitudes and beliefs towards teaching science to preschool children. The study consisted of 112 prekindergarten teachers from strategically selected counties in Georgia. Teachers remarked in surveys that they were comfortable with teaching science with 79% of educators stating they "strongly agree" or "agree" that they had enough scientific knowledge to teach science. Teacher attitudes are an important part of including STEM in the preschool classroom. When teachers are willing to see the value of teaching and incorporating STEM into their preschool classrooms, educators were able to successfully promote other areas of learning such as language, math, and social skills. This research reveals educators saw the importance of integrating STEM concepts in their classrooms.

A current policy report on early childhood STEM education developed by scholars, policymakers, curriculum developers, and educators from around the United States who share a common goal and vision to discuss ways to support early childhood STEM education, illustrating one of four of its guiding principles, found policymakers and educators need to promote positive attitudes in STEM education to improve children's confidence in STEM learning experiences (Early Childhood STEM Working Group, 2017). The authors noted preschool teachers should be encouraged to value effort and persistence instead of fixating on being "good" or "not good" at STEM concepts. This research reaffirmed the need to promote positive attitudes in STEM education to improve children's confidence in STEM learning experiences.

Educators are more likely to have positive attitudes when teaching STEM in the classroom when there is professional development to support them according to a research study by Lippard, Choi, Lamm, & Tank (2018). This mixed-methods, multiple case design research study focused on nine preschool classrooms located in suburban Midwest school district. Researchers wanted to gain a better understanding of pre-engineering habits of mind.

Researchers found that over half of the teachers mentioned did not experience professional development related to engineering or the broader topic of STEM. Although engineering habits of mind were noticed during observations in the classrooms, creativity was not detected.

Teachers who are involved in hands-on experiences during professional development were likely to develop mastery from the experience according to Thibaut, Knipprath, Dehaene, & Depaepe (2018). A qualitative case study designed to interpret teacher professional competence in STEM professional development on their STEM classroom activities studied 20 preschool teachers and their classrooms. Eighty hours of STEM teacher professional development (STEM-TPDP) was provided to the participants of the study.

In Yıldırım's (2020) multifaceted study, teachers were involved in training; engaged their students in classroom STEM activities; and interviewed on their views on the (STEM-TPDP) training. Teachers expressed they experienced improvement in content knowledge and planning after the (STEM-TPDP). When teachers are confident about the subject they are teaching, they are more likely to be successful. Personal attitudes towards teaching STEM affected professional attitudes in positive ways (Thibaut, Knipprath, Dehaene, & Depaepe, 2018).

Simoncini & Lasen's (2018) qualitative study of 117 Australian preschool teachers collected surveys from educators who attended a professional development workshop on STEM. Sentiments among 93 of the participates who had categorized responses in response to their opinion on the importance of STEM education echoed the fact that STEM was important in preparing students for future careers. Responses on the importance of STEM also included developing habits of mind; setting up students to be successful in STEM education; and providing exciting learning experiences.

Researchers recognize that teacher attitudes towards STEM are also met with frustration. In a mixed-methods study that explored dynamics that impacted teacher practice, one question answered by teachers asked how their beliefs affected their science teaching (Milner, Sondergeld, Demir, Johnson, & Czerniak, 2012). While teachers remarked positively on teaching science in the classroom, it was also noted that they were not confident on external control factors such as time, supplies, and equipment. In this example, Milner, et el (2012) argued that although teachers understood the importance of teaching science topics in the classroom, they recognized outside factors may hamper their efforts to properly integrate the science curriculum. Nearly ten years later, Yıldırım's research on (2020) preschool teachers' views of the STEM teacher professional development program (STEM-TPDP) on their STEM activities found teachers were still facing the same challenges which included difficulty in planning, lack of materials, resources and time, inadequate classroom environments, and overcrowding. Both studies highlighted the lack of STEM education for teachers in preschool and the insufficient time and resources needed to be successful.

Evidence pertaining to other skills also tied in with teacher-attitudes on STEM education. In Simoncini & Lasen's (2018) study on the importance of STEM education, 91% of teachers ranked social-emotional skills as most important curriculum area followed by literacy and STEM skills. The research demonstrated teachers believed STEM education was important, although they also stated social emotional learning was far more important. However, The Early Childhood STEM Working Group (2017) mentioned in their policy report, social emotional learning and STEM experiences should be taught simultaneously because they are equally important. Furthermore, a separate study designed by Garner, Gabitova, Gupta, & Wood (2018) infused the arts and social emotional-learning into a summer-based STEM content with the

objective of providing K-8 students with hands-on learning experiences while learning social-emotional competencies. The result was a program developed around theory and research called the STEAM Social-Emotional Life Skills Program which focused on social emotional learning with STEM. Comments from the participants, which included experts, teachers, and students, said infusing social emotional content with STEM was an excellent suggestion. As a result, these studies all pointed to the importance of incorporating social emotional learning with STEM, making it appropriate for teaching soft skills such as empathy and teamwork, skills important for 21st-century jobs.

Incorporating STEM in Classroom Learning Centers

In a classroom, the environment plays an important part in learning. Just like in Reggio-inspired classrooms, it becomes the third teacher as it is just as engaging as the educators themselves. During a mixed methods study by Hong, Shafferm, & Han (2017) examining Reggio-inspired learning groups, researchers investigated a group of five children which consisted of three typically developing students and two children with special needs in small group setting in a separately designed space. In the study, Hong, et el (2017) observed the children benefited from the Reggio approach because they were able to contribute to the group based on their abilities. The researchers indicated an environment that is nurturing, inviting, and well-prepared leads to student participation. In an ethnographic study on how natural sciences were presented in a comparable Reggio-inspired classroom, scholars observed a single preschool classroom in the Midwest (Inan, Trundle, & Kantor, 2010). Researchers noted teachers who saw their student's excitement for the topic they were interested in, returned their enthusiasm by providing learning opportunities through an interactive environment; inquiry was top priority in the classroom which affected the teacher's planning. Facilitating students' interests in Reggio-

inspired groups were a key component and led to the success of cognitive and social development (Hong Shaffer, & Han, 2017). In the qualitative component of Gencer and Gonen's (2015) study, they concluded that the Reggio-approach had an effect on preschool students' creative thinking skills because the projects were developed on the interests of the students. The literature demonstrated an importance in the preschool learning environment where educators planned well-thought-out materials and activities therefore, enabling students to participate in peer interactions.

Learning centers in preschool may include Blocks, Dramatic Play, Toys and Games, Art, Library, Discovery, Sand and Water, Music and Movement, Cooking, and Technology, as well as an outdoor play area. Donegan-Ritter (2017) said giving students open-ended, semi-structured, or structured materials to interact with within the different learning centers gives students opportunities to explore STEM concepts that they might not have explored on their own. Furthermore, free play time, a time when students interacted with their peers during their choice of learning center, gave students time to explore and interact with materials in their choice of center. In a study that gathered evidence by naturalistic field observations of a mixed-year age group of 18 preschoolers, Bairaktarova, Evangelou, Bagiati, & Brophy (2011) examined children's interactions with artifacts and looked to identify engineering-related behaviors. Researchers found the study demonstrated the benefit of using artifacts during free play and noted artifacts facilitated comprehension and cognitive development. Therefore, student interaction fostered early STEM concepts, especially engineering concepts that were examined during Bairaktarova (2018) and her team's study. Consequently, STEM experiences gathered from free play time during classroom learning centers engage students in scientific inquiry skills and later achievement in STEM areas. McClure (2017), who is a research specialist in creativity

and learning at the LEGO foundation and lead author in the previously mentioned report, STEM Starts Early: Grounding Science, Technology, Engineering and Math Education in Early Childhood mentions in an NAEYC publication, integration of STEM topics within the classroom learning centers promoted a deeper understanding of concepts and how they were applied in the real world.

The Impact of Teaching STEM in Preschool

Scholars have noted the importance of teaching STEM in the classroom, especially regarding gaps in science achievement. Jackson and Ash's (2011) 3-year study developed a professional-development initiative with the purpose of closing achievement gaps. The study included a combination of purposeful planning, scientific inquiry, and multisensory vocabulary activities in the early education years. K-5 teachers from two elementary schools in separate districts within Texas received professional development. Teachers reported the project had a positive impact on their planning and delivery of the science curriculum. Consequently, Jackson & Ash's research revealed an improvement in test scores after students took the 5th grade high-stakes science test. Additionally Morgan, Farkas, Hillemeier, & Maczuga (2016) revealed results on science achievement gaps also supported evidence of early childhood STEM education. Researchers analyzed a large-scale longitudinal study of science achievement gaps of students entering Kindergarten during 1998 who were nationally represented in the United States (Morgan, Farkas, Hillemeier, & Maczuga, 2016). Morgan and his team (2016) noticed during the nine years of the study students who entered Kindergarten already had gaps in science achievement and gaps persisted throughout the elementary and middle school grades. This study highlighted the impact of starting STEM in the early years which may have helped with closing achievement gaps, especially with economically disadvantaged student populations. Morgan and

his team (2016) noted achievement gaps in later elementary grades can be explained by factors that can be adjusted during the primary years therefore, making an important point to implement interventions in the early childhood years.

Visual and play-based experiences are needed in early childhood practices to promote STEM learning in the classroom. Students make connections during learning to everyday experiences. In a recent study, play-based activities were provided to preschool students along with teacher interactions to support concepts of magnification (Adbo & Vidal Carulla, 2020). In this example, the teacher's participation made it possible for students to access scientific language to define the student's observations during play-based activities. Children's scientific investigations helped them develop concepts of science and connect it to content taught at their grade level, noting that children as young as five years improved their scientific literacy (Akerson, Buck, Donnelly, Nargund-Joshi, & Weiland, 2011).

Research data from a 2-year ethnographic study on young children's early science investigations suggested scientific investigations support young children's development and understanding of science through discourse that frames their actions (Siry, Ziegler, & Max, 2012). Lippard (2018) and her team's previously mentioned study found that engaging students intentionally during free play interactions with adequate materials and time lead to pre-engineering habits of mind. The results emphasized the impact STEM education can have on preschool classrooms especially when educators used children's previous experiences; allowed students explore in the moment, challenged student's conceptions of a topic; and presented in the moment during student explorations (Andersson & Gullberg, 2012).

In an inclusive classroom, children with varying abilities which included students with disabilities, are included within an accessible learning environment where all children

participated in the same routines and activities. Teachers who worked in early childhood inclusive settings understood the needs of their students ensuring that barriers were removed from the curriculum and the learning environment was accessible to all children (Donegan-Ritter, 2017). STEM activities provided occasion for all learners as it lends itself to inclusion, giving students direct opportunities to the natural and man-made world (Early Childhood STEM Working Group, 2017). Experts recognized STEM education was supported with collaboration through daily norms during class group time. Collaboration among peers increased discourse, moving students from parallel play to collaborative play (Linder, Emerson, Heffron, Shevlin, Vest, & Eckhoff, 2016). STEM promoted interactions between peers, therefore, incorporating it in an inclusive classroom provided an accessible environment for learners of all abilities.

Encouraging a STEM Mindset

The attitudes and behaviors of children and adults, including parents became more perceptive when given the chance to engage in STEM education. In a three-year study that collected comments from parents of children who were enrolled in a STEM achievement program, researchers found after analyzing their qualitative data, the attitudes of the children and their parents changed when the students were engaged in STEM learning experiences (Tay, Salazar, & Hyeseong, 2018). The feedback from parents, Tay and her colleagues (2018) observed, changed parent perspectives commenting that their children were excited and eager to participate in the program. In a separate study, attitudes and the mindsets of 10-year-old girls also changed after participating in an out-of-school authentic STEM program. Wieselmann and her team (2019) studied the interviews of 30 elementary girls, who participated in the Designs in STEM, found students were more engaged and the content more meaningful because the process of learning required them to participate in real-world experiences instead of learning out of

context on a worksheet. The girls' mindset also changed during the time in the program, consequently, making them see themselves as a "scientist" or "engineer" (Wieselmann, Roehrig, & Kim, 2019). While both studies showed a change in STEM attitudes and mindset, inclusivity for girls in STEM needed to begin in the early childhood years.

A cultural-historical research study by Fleer (2020) which consisted of a multi-age classroom of 3 girls and 10 boys ages 4-5 years old, found changing up the traditional preschool classroom to a Conceptual PlayWorld model led to new possibilities for the girls to participate in areas of the room that were often taken over by boys. Fleer's (2020) research findings showed the need for change in the early childhood classroom and noted when girls were given the time and space for STEM related play, it allows girls to stay on the same trajectory as boys in ability and competency.

Conclusion

The purpose of this literature review was to illuminate the importance in preschool STEM education and the impact it had on students, especially in K-12 education when it is incorporated into classroom learning centers. The research found incorporating STEM into the early childhood classroom, especially in the learning centers, promoted learning through relevant experiences and materials. Research found children were curious of the natural and man-made world; therefore, teachers need to select artifacts and offer guided experiences. Furthermore, research found STEM opportunities in the preschool classroom closed achievement gaps in later school years.

The results of the literature discovered there was a need for STEM in preschool. When starting STEM in early childhood years, the research showed, although limited, the benefits of

later school achievement. The Early Childhood STEM Working Group (2017), as mentioned previously, states there was not enough longitudinal research to track the effects of STEM education in the preschool years. Preschool teachers agree that STEM needed to start early as there are benefits concerning cognitive skills, fine and gross motor skills, and social/emotional skills (Yıldırım, 2020). Benefits of incorporating STEM in preschool have shown to develop critical thinking skills, executive functioning skills, and problem-solving skills (The Early Childhood STEM Working Group, 2017). Research indicated the need for more after-school programs since there was a lack in STEM education. Including girls in these programs changed attitudes towards STEM education (Wieselmann, Roehrig, & Kim, 2020).

Included in the literature review was the acknowledgement of the necessity of STEM professional development for teachers. While teachers noted professional development had a positive effect on their teaching, many commented saying they lacked an understanding of STEM concepts. Few instances where common where teachers did not receive any STEM training or had a limited amount of time in STEM professional development. Consequently, teacher attitudes were a key component for effective training which was essential when engaging teachers in STEM professional development (van Aalderen-Smeets & Walma van der Molen, 2015).

Research calls for more studies in early childhood STEM education. The literature review revealed the research is ongoing, but the rate has shown little advancement in STEM education in the past decade. Policymakers and experts need to provide early interventions at the preschool level to close the achievement gap, especially with girls and minorities (Morgan, Farkas, Hillemeier, & Maczuga. (2016).

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