

From fearing STEM to playing with it: The natural integration of STEM into the preschool classroom

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The article describes the process of developing and implementing a STEM Summer Camp that allowed Preschoolers to experiment and investigate with materials while learning basic concepts of science, technology, engineering, and mathematics (STEM) through play as part of the educational process. The participants were presented with problems that they needed to solve together. Although the camp emphasized engineering skills and explored gender differences in preschoolers' performance in those activities, the main focus was to incorporate play in all the activities. This camp was a perfect example of how children learn more complex skills easily through play.

Introduction

“Oh no...this is a disaster!” said a 4 year old boy, halfway through the STEM summer camp, when he arrived at school and discovered that the classroom was in total chaos; the reason...a leprechaun came to visit the night before and was mischievous! To the teachers' surprise, the 10 preschoolers took control of the situation, started to clean up, putting everything in place, and discussed between them what had happened. Bottom line, they realized they “needed to do something”. Were they playing, learning, or were they working?

Play can be considered the universal language of childhood, the most efficient resource by which children understand each other and the world around them (Uduchukwu, 2011). But defining play is not an easy job. One point of view describes play as an enjoyable, self-amusing activity and another describes it with an

educational focus (Youngquist & Pataray-Ching, 2004). What is or is not play depends entirely on how we frame the situation (Johnson, Christie, & Wardle, 2005). Play is what children want to do and work is what they have to do. Play can consist basically of “work” such as building, housekeeping, or picking up toys, but if children want to do that, they are playing (Teaching tolerance project, 1997).

Observing the preschoolers taking control of their actions and applying what they have learned until that moment made the teachers very proud. But the purpose of the STEM (Science, Technology, Engineering, and Math) Summer Camp was not to make teachers proud but to encourage STEM skills through play and develop a mind set in children in the early years. The STEM Summer Camp encouraged children to “work” solving real problems but in a fun and pleasant way, to make it play. Also, the camp aimed to explore the different ways that

engineering skills emerged in play episodes and how that information allowed teachers to create playful moments in early childhood settings.

This article is directed to early childhood teachers, administrators, families, college educators, and policy members who are interested in moving early childhood education to a new level and to make a difference in the lives of children and their families. It is important to make an impact on them by trying to establish clear understandings of how crucial and critical are the first eight years in the life of a human being. Understanding that early years are the most important ones, it is our responsibility to prepare joyful, constructive, hands-on and play-based activities that enable children to learn in a natural way all the necessary skills that will prepare them to develop successfully through school and life. Therefore, it is essential to involve preschoolers in STEM activities through play in order to develop the abilities they will need to succeed in the future. In summary, the question that was answered through the STEM Summer Camp research was how do young children learn the basic concepts of STEM (specifically engineering) through play, as part of the learning process?

Review of literature

The Maryland State Department of Education (2003) defines STEM education as an approach to teaching and learning that integrates the content and skills of science, technology, engineering, and mathematics. The STEM Summer Camp emphasized engineering because preschoolers, like engineers, are curious, process-oriented, and creative, who, during the summer camp, used their knowledge of science, math, and technology to solve problems, make things work better, and turn ideas into reality.

It is common to read how STEM curriculum areas are receiving more attention in K-12 education because of the concern that the United

States is declining in scientific innovation (Sharapan, 2012) and the lack of interest in STEM-related fields (Brown, Brown, Reardon, & Merrill, 2011). Because of the recent and growing recognition of the role of stimulation in early brain development (Blair, 2002), it becomes clear that preschool programs provide the best place to start focusing on STEM in order to obtain positive results in the future. Katz (2010) indicated how significant it is when instead of assuming a receptive role, preschool children adopt an active one by engaging in research projects, asking questions, collecting data, presenting and reporting it (Katz & Chard, 2000) while having a skilled teacher guiding the experience.

It is significant how literature is increasingly supporting the importance of earlier exposure to STEM. "Children are engineers, problem solvers, and collaborators at heart- with boundless potential for leadership, creativity and innovation" (Stone-MacDonald, Bartolini, Douglas, & Love 2012, p. 2). Focusing on the "E" of STEM in the earlier years has been researched as the perfect moment to start engineering education (Bagiati & Evangelou, 2009), and consequently, it is essential for future teachers to understand how to integrate engineering education into their practice (Bagiati, Yoon, Evangelou, & Ngambeki, 2010). Incorporating engineering in Early Childhood Education could increase the interest in STEM career fields (Dejarnette, 2012) and also help with the issue of underrepresentation of women in engineering professions (Katehi, Pearson, & Feder, 2009). Teachers need to realize that the common belief that girls are good at reading and boys are good at math is a gender stereotype (Vandell, Hyde, Secada, Chen, 2010) and that it is crucial to encourage girls in the very early years to fully participate in STEM (engineering) activities (McLaughlin, 2009). The Organization for Economic Co-operation and Development (OECD) Gender Initiative (2011) considers that it is extremely important to encourage teachers to motivate girls to pursue interests in STEM

areas by creating more appealing activities while avoiding gender stereotyping.

Early childhood education has evolved rapidly in recent years as a result of the remarkable increase in knowledge about how young children learn (Morrison, 2012). This new understanding leads educators to see children in different ways and to acknowledge a more holistic view of the child instead of seeing him or her as an empty vase. Consequently, teachers are changing their methods and are starting to value play as a key element in early childhood learning (Torres-Crespo, 2009). During the early years, play is fundamental because it motivates children's development. Through it we can perceive the child's emerging sense of self, cognitive processes, socialization, and physical coordination. In play, children decide between activities and make their own choices. (Van Hoorn, Monighan, Scales, Rodriques 2011). Nell, Drew, and Bush (2013) believe that children learn to make sense of their world gaining a complete and more solid understanding through hands-on and open-ended play experiences, which are a key component in STEM education.

Relating it to STEM and the reasoning behind the STEM Summer Camp, it is important to understand that the best way to inspire young children to become interested in learning about STEM is by incorporating play into the equation. Play encourages children's development and interests in a school setting. Also in play, children integrate what they have learned in a cooperative and creative environment. Some believe that preschoolers learn in isolated subject areas, but through play, children actively link science, mathematics, technology, engineering skills, literacy, the arts, while interacting socially and emotionally, in their learning process (Van Hoorn, Monighan, Scales & Rodriguez, 2011).

The bottom line is that "as long as the focus remains on the needs and developmental stage of each child, nurturing early STEM learning need

not be an "either/or" proposition. When teachers intentionally plan STEM experiences—focused on key concepts and skills—let children take the lead in exploring, and ask open-ended questions that cause children to reflect, form theories, ask questions, and explore more" (STEM Smart: Lessons Learned From Successful Schools, 2013, p. 2).

STEM Summer Camp

One of the objectives of the Onica Prall Child Development Laboratory School (OPCDL) at Hood College is to provide real classroom experience for college students to increase their understanding about how preschoolers develop and also offer preschoolers high-quality early care and education. In addition, the Lab School provides faculty members from the Education Department an educational setting to do research. Based on that, the STEM Summer Camp (funded and sponsored by Hood College) was designed by a faculty member as a two week summer camp for preschoolers at the OPCDL, in which the teachers were two college students/future teachers from the Education Department. STEM Summer Camp's unique goal: play while learning about engineering doing STEM activities.

The STEM Summer Camp had ten four years old participants, five boys and five girls. In their daily activities they were presented with problems that they had to solve together. It's a common misconception that teachers struggle to incorporate STEM activities every day because it requires more work or more equipment. After reading this article the reader will understand that teachers are probably doing STEM activities without realizing it. STEM skills are not taught in isolation. It is not about teaching one subject at a time, but integrating Science, Technology, Engineering, and Math, while encouraging students to think outside the box. A STEM mindset is used to empower students, to think critically, logically, and ultimately to be an active

member of the community and society as they solve real world problems.

As part of the STEM Summer Camp, preschoolers were allowed to experiment and investigate with materials while learning basic concepts of STEM through play, emphasizing engineering skills, as part of the educational process. In addition, to be “real engineers”, the preschoolers and teachers needed to wear an engineering lab coat, and for some activities, a safety hat and security goggles, because teachers were continually linking every STEM activity with a real STEM job and real life.

As part of the research and before the beginning of the camp, every one of the participants took a pre-test in which they needed to answer: “What do engineers do?” Then they had to circle yes or no in statements like “Engineering is a profession for boys. Engineering is a profession for girls. Engineering is a ‘helping’ profession (i.e. like nurses, teachers, and doctors), and Engineering is a ‘creative’ profession (i.e. like artists, architects).” Those pre-tests were saved to compare with a post-test at the end of the summer camp. Other methods used to collect data were notes from the researcher, photos, videos, and online surveys to family members.

The STEM Summer Camp’s duration was two weeks and ran between 9:00am to 11:30am. During those two weeks the camp dedicated two days to each of the following engineering areas: Structural, Mechanical, Aerospace, Chemical, and Electrical Engineering. The day was divided into different slots of time to give the children the opportunity to complete all the steps. The first period was engineering free play, in which they were able to use blocks to build whatever they wanted. Then the teachers proceeded to Briefing time for direct instructions about the topic of the day. After that, children went to the STEM centers (Science, Technology, Engineering, and Mathematics) in which they

did specific and concrete activities related to the day’s topic. Next it was time for Snacks, where the teachers also incorporated STEM concepts. Finally, Engineering 101 was the moment of the day when the problem was presented and which the children had to solve. In order for the reader to have a better understanding of how this was implemented, the article will describe one day at the camp dedicated to Electrical Engineering.

Electrical Engineering Day

When the children arrived in the morning it was time for the Engineering Free Play Time. Children had around twenty (20) minutes to play freely with blocks and they were able to build different structures, play collaboratively or individually, ask for help or try on their own. It was their time to explore and be creative. They were immersed in their make believe world, playing and at the same time “being real engineers” by building different structures. One of the purposes of this area was for them to understand the importance of creating a good foundation for a structure to stand still. Also, they had to work together if they wanted a tall structure.

Then it was time for Briefing Time, in which they all got together on the carpet (boys and girls) for fifteen (15) minutes and listened to a story called *The Magic School Bus and the Electric Field Trip* by Joanna Cole. The teachers integrated the hard copy of the book and the internet link from the story on the iPad to be able to incorporate technology and language arts. The story was about a class who went on a magic fieldtrip to learn about electricity, how electric current travels through towns, lights up a light bulb, heats up a toaster, and runs an electric motor. While listening to the story the participants saw a problem and learned how it was solved. That time was also dedicated to present the problem of the day, which in that particular day was to understand electricity and why it is important for real life. Also, they

discussed the STEM Cool Job of the Day: Electrical Engineer. Some of the specialized areas in which electrical engineers might work include telecommunications, electronics, signal processing, and control systems. They became familiar with electrical engineering, the study of electricity and the design of electrical systems like circuits and computer chips.

After that, boys and girls went to separate classrooms to do exactly the same activities (the teachers had a script for the day to ensure consistency and reliability). The next section of the day was called STEM Centers. Each group had to rotate through two learning centers. In the first center the participants followed a set of instructions to be able to create conducting dough (which they will need in Engineering 101). They had to add ingredients (water, flour, salt, cream of tartar, oil, and food coloring), mix them up, feel the textures, talk about it, and make predictions. (For the teachers' purpose, an article called Squishy Circuits: A Tangible Medium for Electronics Education (Johnson & Thomas, 2010) was used to understand the conductivity process through that dough.) To stimulate interest, the students could choose the color dye to mix into the dough, which also encouraged free choice and decision making. Then, each one saved their conducting dough with the color of their choice in a plastic baggie. In the second center they were introduced to the concept of static electricity and explored it concretely with balloons, a piece of wool fabric, and powdered gelatin. Again, they had to use their hands to carry out the activity and make predictions.

Then it was snack time! Time for a break? Not really. During that time they also applied engineering skills and mathematics. That day they received fruits and a skewer. First they had to build/design their own fruit kebab, while counting and creating patterns with the fruits. This also required using fine motor skills.

Finally, for the Engineering 101 part of the day, the students were exposed to a circuit hardware kit. They had to design and understand an open and a closed circuit using a variety of electrical tools such as LED bulbs, a battery operated power pack, conducting dough, and a buzzer. This kit provided them with the opportunity to replace wires with malleable conductive and non-conductive dough. Johnson and Thomas (2010) stated that the inclusion of play in the learning process has repeatedly been shown to be an effective method. Exciting learning experiences can occur when children are engaged with materials, not just through simple interaction, but through designing, creating, and inventing. In order to work with this kit, the students had to use the conducting dough they had previously prepared in the learning centers. At the end of the day they were familiar with the concepts of closed circuit, open circuit, conducting dough, bulbs, etc.

The previous description of a day was a glimpse of all the experiences these preschoolers had during two weeks. At the end of the camp, not only was the knowledge they gained evident, but also the learning/playful community they built.

Findings

This research focused mainly on answering the following question: How do young children learn the basic concepts of STEM (specifically Engineering) through play? From the researcher's perspective, it was evident how the participants easily incorporated the skills the STEM Summer Camp offered. At the beginning of each the day the camp provided time to play freely with blocks. During that time participants were able to build different structures, play collaboratively or individually, ask for help or try on their own. It was their time to explore and be creative. One of the research findings was that through photos, it was easy to observe children's growth in using blocks to build. During the first three days at the camp, the block structures were simple, less

complex, and the children worked individually. At the end of the two weeks, the structures were more complex, taller, and they all worked together.

During the Briefing time the teachers used songs, stories, videos, posters, and group games to introduce the concept of the day and made it pertinent to real life connecting it to the STEM Cool Job of the day. The STEM centers were a fun moment for them because they were playing and exploring with different materials like creating forms with tangrams, creating shapes with small cubes, having balloon races, mixing liquids and solids to create a mass, and the use of appropriate engineering apps in the iPad. After that was the Snack time, in which the participants were invited to create patterns, use fine motor skills, and put ingredients together to make their own snacks. Engineering 101 was the longer part of the day and the children had the opportunity to get together, establish a plan of action and solve the presented problem as a group. The teachers' role was to guide the process, exposing the children to new experiences while teaching them the basic STEM skills. At the end of Engineer 101 they all sat together to discuss the steps they followed and the results.

Based on the pre and post-test findings, children went from not having an idea of what an engineer is and what they do, to having a basic understanding of their role in society by designing, planning, building, and creating. Ten children completed the test before the beginning of the program and then 10 days later. Comparing total scores, the results indicated significant differences in pre and post responses. The pre/post-test had 8 questions. In the pre-test the first question was What does an engineer do? 60% of the responses were "I don't know" or something not related to engineering. In the-post test 100% of the responses were "An engineer designs, plans, makes, and builds". Before the Summer Camp only 60% thought that engineering could be a helping profession vs. 90% at the end of the

camp. The same happened with being a social profession: before it was a 60%, after the camp 100% considered it a social profession. But the most significant finding was that in the pre-test 50% thought engineering was only for boys. In the post-test 100% of the participants answered that engineering was a profession for boys AND girls.

The parents' evaluations gave the researcher and teachers a window to validate that preschoolers gained greater comprehension with a broad range of activities. The parents received via email a link for an online survey. Responses from the online survey highlighted the impact of the STEM Summer Camp for the participants' understanding of the field of engineering and its role in society. 90% of the parents answered Yes to Compared to when you started taking your child to the STEM Summer Camp, have you noticed him/her using more engineering vocabulary? 100% of the parents answered Yes to Do you consider that your child learned engineering skills and concepts during the STEM Summer Camp? Based on the online survey, 90% of the parents "strongly agree" and 10% "mildly agree" that their child had fun while learning at the camp. In summary, parents' comments were highly positive. All of them expressed that Engineering 101, Technology, and using Snacks as a STEM activity, were their child's three favorites sessions. The activities included electric circuits, balloon rocket races, designing and building, using chemicals to clean pennies, making "flubber", and exploring with tangrams. Finally, one parent wrote "My child was talking about words like construction, destruction, structure... it enabled him to observe things from other angles. The kids were able to connect what they learned in the classroom to their daily life". That quote alone summarized the purpose of the STEM Summer Camp.

Also from both teachers' perspective, children's growth in knowledge was evident and their cognitive, social, emotional, motor,

and linguistic development improved during the camp. Through the constant exposure to new vocabulary and challenging activities, both students and teachers were eager to complete new and exciting tasks through play. It was clear how natural it was to incorporate and integrate STEM into daily activities and incorporate all subject areas in ways that were entertaining and engaging for the students and teachers. Teachers need to have fun too! STEM is not an additional chore or more work in the classroom. Upon reflection, many teachers will notice that the STEM process is something that they have already started to implement. Increasing awareness of STEM and all that it encompasses is just a way to open the door to future integration and encourages problem solving, critical thinking, inquiry based learning, and natural experimentation with students.

In addition to changing the age in which they usually start experimenting engineering and STEM activities, the STEM Summer Camp provided additional tools and techniques to incorporate the appropriate preschool activities to encourage both boys and girls to consider the STEM field as a future profession.

At the end of the summer camp, one of the participants said that “we need to keep trying because engineers never give up!” With a similar mindset, teachers need to feel the same way about STEM and its implementation. It’s an effortless practice to integrate STEM with different subject areas, such as social studies, art, language arts, reading, writing, physical education... as well as its alignment to the national and state standards.

Implications

Although this was a pilot study, it provided a foundation for future projects to explore how to develop similar camps and after-school programs, in order to expose preschoolers to STEM related activities in the early years. One concern was teachers’ misapprehension about preschoolers being too young to learn engineering skills. We

are optimistic that this study will impact their views about introducing STEM concepts in early childhood settings. The motivation for this camp was not only to demonstrate the importance of exposing four year old children to STEM related activities, but also to encourage teachers to be more interested and more enthusiastic about teaching and learning about STEM in the early years. Using play as a way for children to construct their engineering knowledge was a key element in the STEM summer camp success. Like a parent said, “I am impressed by how the teachers achieved the perfect balance between teaching and keeping kids amused”.

Conclusion

The title of this article states that early childhood education teachers need to go from fearing STEM to playing with it and venture to integrate STEM into their classroom. As has been emphasized, teachers don’t have to be apprehensive about incorporating STEM in the early years since they are probably applying parts of it without realizing it. It is the educators’ responsibility to work with children during those years by using educational arrangements and play to foster STEM skills, especially engineering ones.

Kids know how to play and enjoy life. They play among them or by themselves, but they know how to do it. Play is like a beautiful gift that they receive when they are born, but sadly is usually lost in their journey to adulthood. Everyone related to the early childhood field needs to be an advocate for play in the early years’ classrooms and at the same time empowers play as a vehicle and tool to learn, understand, and acquire STEM basic knowledge and skills.

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