The attached seminar paper, by Leslie Tukiendorf, entitled Implementation of STEM in Early Education Promotes Future Interest in Pursuing STEM, when completed, is to be submitted to the Graduate Faculty of the University of Wisconsin-Platteville in partial fulfillment of the requirements for the Master of Science in Education degree, for which 3 credits shall be allowed is hereby:

Approved: *Jodean E. Grunow, Ph.D.* (Electronically Signed)
Paper/Project Advisor

Date: *August 6, 2018*

IMPLEMENTATION OF STEM IN EARLY EDUCATION PROMOTES FUTURE INTEREST IN PURSUING STEM

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IMPLEMENTATION OF STEM IN EARLY EDUCATION PROMOTES FUTURE INTEREST IN PURSUING STEM

A Seminar Paper

Presented to

The Graduate Faculty

University of Wisconsin-Platteville

In Partial Fulfillment

Of the Requirement for the Degree

Master of Science in Education

Elementary Education

By

Leslie Tukiendorf

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Abstract

I became involved in a STEM professional development grant for teachers in the summer of 2015 at University of Wisconsin-Platteville. During this three-year grant experience, I was able to learn the definition of STEM, it's foundational principles, unique ideas to implement STEM in my daily classroom, and its importance in the early elementary classroom. Because of this experience I have since engaged kindergarten students in regular STEM experiences, and have seen, first hand, the positive influence early STEM education has on students' interest in science, technology, engineering, and math. The purpose of this research is to study the effect that implementing STEM in early-childhood classrooms has on children's interest in continuing to pursue STEM. The research found that nurturing children's inquisitive nature with appropriate STEM experiences in early childhood increases self-efficacy regarding STEM, which leads to more students pursuing further education in the STEM disciplines throughout their education.

Keywords included in the research are: Science, Technology, Engineering, and Math (STEM), Early Childhood, 21st Century Skills, Competencies.

CHAPTER I

INTRODUCTION

Statement of the Problem

The American and global economies have changed drastically in the last decade. Because of the changes, there has been a steady increase in jobs in the science, technology, engineering, and math (STEM) disciplines. The U.S. Department of Commerce reports that across all occupations, there are 3.6 people for every one job. In STEM fields, there is one person for every 1.9 jobs. "There is a mismatch between projected future jobs requiring STEM skills and the projected supply of qualified workers to fill them" (Chesloff, 2013).

The *Journal of STEM Teacher Education* (Carter, Daugherty, & Swagerty, 2014, pg. 46) reported

> In recent years, there has also been an increase in educational and political pressure to improve overall student performance in math and science. Research suggests that children's aspirations in STEM disciplines are largely formed by the time they are 10-14 years old (Archer et al., 2012; Murphy & Beggs, 2005; Tai, Qi Liu, Maltese, & Fan, 2006). Since interest in STEM subjects and STEM careers is largely formed by the time children reach the upper elementary and middle school level, it becomes increasingly critical that children's interest in these areas be captured and encouraged during the early to middle elementary grades, long before the point at which they enroll in courses leading to eventual STEM career paths during high school and college (Archer et al., 2012).

So the question that arises is, how do we get more students interested in pursuing STEM? Should this interest be started in early elementary education by implementing STEM principles and opportunities for exploration?

Purpose of the Study

There seems to be an increasing demand in the workforce for qualified workers in the STEM disciplines, yet a decrease in interest of students to study and pursue careers in those

disciplines. Literature and research were reviewed to see if implementing STEM in early education impacts student interest in STEM. The research and literature reviews suggest that engaging young learners in STEM at an early age promotes better self-efficacy, as well as, stronger math and science skills needed to pursue STEM disciplines.

Significance of the Study

Recent attention has brought to light the low numbers of students pursuing STEM disciplines and degree programs in the U.S. Many middle schools and high schools have begun implementing STEM programs and curricula, but there remain few opportunities for early elementary students to experience STEM investigations. Research shows that an early exposure to STEM investigations positively impacts elementary students' perceptions and dispositions (Bagiati, Yoon, Evangelou, & Ngambeki, 2010; Bybee, & Fuchs, 2006; as cited by DeJarnette, 2012). "By capturing students' interest in STEM content at an earlier age, a proactive approach can ensure that students are more likely to pursue the needed coursework for adequate preparation to enter STEM degree programs and careers" (DeJarnette, 2012).

Therefore, it would seem, by implementing STEM opportunities at the early elementary levels, there will be an increase in student interest in pursuing STEM education and careers. Similarly, if schools continue to offer the traditional science and math education opportunities, and only offer the majority of STEM opportunities at the middle school and high school levels, the interest levels of students to pursue STEM investigations, courses, and careers will continue at the same level, or even decline; thus continuing or growing a workforce supply issue in the STEM discipline areas.

Assumptions

Children are naturally curious and inquisitive. They often ask "why" questions, showing that science is natural and motivating for young children, as are engineering and technology (Carroll & Scott, 2017; Clements & Sarama, 2016; Milford & Tippet, 2017). It is also widely assumed that early childhood experiences and education influence later academic success (Clements & Sarama, 2016; Early Childhood Working Group , 2017; McClure, 2017).

Definition of Terms

STEM: an acronym sometimes used to refer to any one of the individual disciplines in the areas of science, technology, engineering, and math, sometimes to denote the integration of all four disciplines, and sometimes to mean a combination of two or more of the disciplines (National Academy of Engineering and National Research Council, 2014 as cited by Milford & Tippett, 2015).

Early Childhood: children who are within the age range of Birth to 8 years

21st Century Skills: cognitive and non-cognitive skills--such as critical thinking, problem solving, collaboration, effective communication, motivation, persistence, and learning to learn (National Research Council, 2012b).

Competencies: a set of defined behaviors that provide a structured guide enabling the identification, evaluation and development of the behaviors in individuals (Wikipedia.org).

Delimitation of Research

The review for this literacy review was conducted June through August 2018. In searching for information about STEM in early childhood, this author primarily used the terms STEM, early childhood, and interest to search educational databases.

Methodology

The information from this literature review included primary and secondary sources, as well as peer-review writing and literature articles from professional journals and well-established educational publications. Those sources were found by searching the Universities of Wisconsin databases such as Elton B. Stephens Co. (EBSCOhost) and Educational Resources Information Center (ERIC). The literature was reviewed and the findings are reported in this literature review.

CHAPTER II

LITERATURE REVIEW

Career Demand vs. Interest

The world is an ever-changing place, and the global economy is no exception.

> "In a globally competitive economy, employers of all shapes and sizes, are increasingly seeking workers skilled in science, technology, engineering, and math...Investing to ensure a pipeline of workers skilled in STEM competencies is a workforce issue, an economic-development issue, and a business imperative" (Chesloff, 2013).

JD Chesloff also noted "According to a 2010 study from Georgetown University's Center on Education and the Workforce, about 76 million baby boomers will soon retire, and only about 51 million people are in line to replace them" (Chesloff, 2013). To remedy the workforce pipeline discrepancy, we need to make an investment in early-childhood education by teaching and building STEM competencies and 21st Century skills. This fosters the question, how do we get more children interested in pursuing STEM disciplines?

STEM in Early Childhood

In 2011 the National Governors' Association publicized two goals. Their goals were to "increase the proficiency of all students in STEM and to grow the number of students who pursue STEM careers" (Carter, Daugherty, & Swagerty, 2014). In order to increase the number of students pursuing STEM disciplines, there needs to be an increase in interest in STEM. This can and should be started in Early Childhood so that it can be developed throughout the students' educations. Research theorizes that interest is a significant aspect in learning (Arnold, Dobbs-Oates, Doctoroff, & Fisher, 2012).

Arnold et al., (2012) conducted a study of 118 early-childhood children in a New England city at two different Head Start locations. The study was aimed to investigate the relationship between math interest and ability. The results of the study determined there was indeed a correlation that higher math interest was a factor of higher math acheivement. Similar research has been done with older children, demonstrating the comparable results. This study justifies why sparking an interest in the STEM disciplines during Early Childhood is so crutial to future achievement in those areas.

Currently, "STEM disciplines are more often given a backseat to more rote learning and developing literacy skills" (Weyer, 2018). Research has demonstrated that young children are naturally curious and are "equipped with basic capacities and dispositions to make sense of the world around them" (Rood & Shwe Hadani, 2018). These innate abilities are a solid foundation and necessary to develop understandings of STEM disciplines, but they are not sufficient without support and guidance from adults and educators.

> Elementary students have the cognitive abilities to engage in STEM content and problem solving activities which in turn will whet their appetites for more. Not only do STEM lessons and activities excite young learners, but they also build their confidence and self-efficacy in relation to their own abilities to be successful in more advanced math and science cources in later school years (DeJarnette, 2012, pp. 183-184).

High quality STEM experiences provide young children with opportunities to develop 21st Century skills and can determine how they approach learning and thinking into the future. Providing early-childhood children with STEM experiences, not only helps them understand that they are capable STEM learners, but also sparks an interest in STEM, engages their confidence and curiosity, and builds an understanding of foundational STEM practices (Rood & Shwe Hadani, 2018). The National Science Teachers Association (NSTA) "affirms that learning science and engineering practices in the early years can foster children's curiosity and

enjoyment in exploring the world around them and lay the foundation for a progression of science learning in K-12 settings and throughout their entire lives" (NSTA, 2014). "By simply allowing [young children] to investigate, by encouraging them to ask questions about the real world, you are encouraging children in STEM" (Sneideman, 2013).

"Children's earliest experiences with science, technology, engineering, and mathematics set the state for their later engagement and success in those fields" (Rood & Shwe Hadani, 2018). "An analysis of a longitudinal sample of 7,757 children indicated large gaps in general knowledge already evident at kindergarten entry" (Farkas, Hillemeier, Maczuga, & Morgan, 2016). Roughly, only 40% of U.S. children are not ready for kindergarten and continue to show lacks in math and science skills and knowledge at 4th grade (National Science Foundation, 2013). Additionally, preschool and kindergarten children's knowledge of and interest in math and science predict later success in STEM (Clements & Sarama, 2016).

Implementation Challenges

Even though current knowledge about early-childhood learning and research substantiate the importance of implementing STEM at a young age, there are different elements that pose challenges. The most influential considerations affecting STEM interest in early childhood include society's gender stereotypes, teacher confidence and training, as well as inadequate resources and curricula.

The most discussed consideration affecting STEM interest levels is the impact of society's gender stereotypes. The gender difference in young students' interest and motivation in STEM is a considerable contributor to the gender gap in STEM majors and careers (Ceci & Williams, 2010; Smith, Brown, Thoman, & Deemer, 2015; as cited by Master & Meltzoff,

2016). Unfortunately, "sociocultural stereotypes associating STEM with males act as barriers that prevent girls from developing interests in STEM" (Master & Meltzoff, 2016). Too often, even small differences in The National Assessment of Educational Progress (NAEP) report card and other studies get more publicity, which reinforces subtle and persistent societal biases (Linn & Shibley Hyde, 2006). People often believe that success in the STEM disciplines is based on innate ability, not learning, effort, or persistence. This can cause an anxiety regarding abilitites, especially in girls, resulting in girls avoiding experiences that involve math, science, or engineering (Early Childhood STEM Working Group, 2017). According to the 2014 National Science Foundation's (NSF) Science and Engineering Indicators report, the U.S.'s failure to nuture girls' interests in STEM is considered one of the main causes of the smaller female representation in STEM fields (Ngo & Richert, 2018).

Early-childhood teachers' dispositions also play a role in children's interest and attitudes regarding STEM. Many early-childhood teachers do not believe they have been trained to teach STEM and often doubt their own efficacy (Clements & Sarama, 2016). If teachers do not feel prepared or confident to teach STEM foundational skills, then children are missing out on positive STEM learning opportunities, thus hindering their interest in STEM. "Through helping adults change their attitudes, we will improve children's confidence that they can become successful STEM learners" (Early Childhood Working Group, 2017).

Currently, the majority of STEM classes and experiences are traditionally offered at the middle and high school levels, with very little offered at the elementary or early-childhood levels. "At the early elementary level, schools also vary widely in their resources, quality, effectiveness, and time spent on instruction in the disciplines related to STEM education--particularly science, technology, and engineering" (National Science Foundation, 2014). "Many

students have very limited interest in pursuing STEM careers, especially engineering, because they are not exposed to topics in these fields during their K-12 studies" (Carter, Daugherty, & Swagerty, 2014). In order to increase young children's interest and engagement in STEM disciplines, work towards influencing the education students receive in the elementary classroom needs to take place (Carter, Daugherty, & Swagerty, 2014).

Current Initiatives

Not only are researchers finding evidence that starting STEM education early will help increase an interest in continuing to pursue STEM, but many state, national, and government organizations, as well as private-sector companies are also realizing this importance. In 2004, *The Partnership for 21st Century Skills* initiative was created to help prepare American children to develop skills needed in order to compete in our global economy (DeJarnette, 2012). In support of this initiative, President Bush's National Mathematics Advisory Panel published a 2008 research review stating, "The [math] curriculum must simultaneously develop conceptual understanding, computational fluency, and problem-solving skills" (as cited by Clements & Sarama, 2016). This federal recommendation can easily be done through integrated STEM education, even in early elementary grades. Since then, President Obama created the *Educate to Innovate* campaign. The goal of the campaign is to improve children's STEM competencies through collaborative efforts of the federal government, large companies, nonprofit organizations, and education societies.

States like Massachusetts are working hard to increase STEM experiences for younger children. The Massachusetts Department of Early Education and Care have encouraged professional development opportunities for early-childhood teachers, aligned state math and

science standards, and integrated daily STEM opportunities into curricula. The state has also partnered with several private-sector companies to help support the state's implementation of its *Race to the Top Early Learning Challenge* federal government grant. These companies include IBM, National Grid, John Hancock, and JP Morgan Chase (Chesloff, 2013). IBM and the Mattapan Family Service Center Head Start have also recently partnered together to incorporate special computer stations for students with computers donated by IBM (Chesloff, 2012).

Head Start on Engineering (HSE) was created as a National Science Foundation (NSF) research and practice project in order to develop a model of early childhood engineering interest development. The project focuses on low-income, Head Start families, with the goal to increase STEM understanding, competencies, and interest. Through this project, the HSE has published a framework for describing early childhood STEM interest development and how to shift parent and family STEM dispositions (Benne, Dierking, Greenough Corrie, Nunez, Pattison, Svarovsky, & Verbeke, 2016).

According to the Office of the Press Secretary at the White House (2016), many federal agencies are growing in support for early STEM learning. A few of these agencies and initiatives include:

- Department of Education, Department of Health, and Too Small to Fail: created a set of early STEM resources for families and educators called Let's Talk, Read, and Sing about STEM!
- The Bay Area Discovery Museum: launched *Empowered Engineering* initiative to bring high-quality engineering experiences to young children.

- Girl Scouts of the USA: promotes programming connected to early STEM education including social media posts and resource guides for parents on engaging young girls in STEM opportunities and experiences.
- The National Head Start Association and Lakeshore Learning: offer access to *Recycle Your Way to STEAM* nationwide by providing a set of activities to every child enrolled in Head Start to introduce science, technology, engineering, art, and math concepts to early learners.
- The National Association for the Education of Young Children (NAEYC): provides new low-cost STEM-related content for parents and educators of children birth through age 8.
- The National Science Teachers Association (NSTA): created *NSTA Initiative for Learners 0-5,* full of resources to preschool and elementary schools to promote engagement in young learners, including children's books, hands-on teacher-led activities, and tips for parents.

Several television programs have now begun to make commitments to support early STEM learning. The Corporation for Public Broadcasting (CPB) and Public Broadcasting Service (PBS) are increasing STEM content. As stated by the Press Secretary at the White House (2016), by 2020, a series of new, engaging, and evidence-based media experiences will be available free to families and educators. These resources will include new STEM television programs, parent apps, and classroom curriculum-aligned STEM resources to supplement preschool-third grade classrooms. Ready Jet Go! is a new STEM series for children ages three to eight through a free app in both English and Spanish, promoting astronomy, earth science, and technology. Additional STEM apps are also in the process of being created by groups like Versame and WGBH Boston (Office of the Press Secretary: The White House, 2016).

CHAPTER III

SUMMARY, CONCLUSIONS and RECOMMENDATIONS

In summary, careers in science, technology, engineering, and math are continuing to increase. In order to prepare students for these future careers, studies show early exposure to STEM is one of the largest factors in whether students will continue to pursue STEM (Przywara, 2016). Not only do children need early exposure to STEM, but attention must be paid to societal stereotypes, which often negatively influence young girls' interest in STEM. To appropriately implement STEM in early childhood, teachers also need support, preservice training, and on-going professional development (McClure, 2017).

There are numerous initiatives and organizations already supporting early STEM education, but more research and funding are required to increase awareness of the positive impact that early STEM education can have. The Joan Ganz Cooney Center recommends increased parent engagement, teacher support and training, community organization involvement, and reprioritized research of early STEM education (Bales et al., 2017).

The National Research Council's Framework for K-12 Science Education (2012) lays out a plan for further research and development. The National Research Council hopes this framework will guide the future development and design of early science standards, including STEM competencies, curricula development, teacher and administrator development, and assessments (National Research Council (2012a).

Already valuable research has been done showing support for STEM education with older children. Additional research has been done to support STEM education in early elementary, but more is needed. Additional applied research, conducted in authentic early

childhood settings is needed to ensure the implementation of high quality early-childhood STEM education. “Such research will reduce the gap between research and practice and it is more likely to influence early STEM teaching and learning practices” (Early Childhood STEM Working Group, 2017). With more research to support the importance of early childhood STEM education, the more parents, educators, administrators, as well as public and private-sector groups will be able to receive training and funding to implement STEM experiences and opportunities for the younger ages, thus increasing children’s interest in STEM.

CHAPTER IV

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