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Adopt-A-Classroom

Session 1: Leadership Role for Technology and Engineering

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Program Description

How can integrated STEM content and problem/project-based learning influence change, increase student interest, improve student performance, and increase academic achievement in a local elementary school? The Adopt-A-Classroom project paired a doctoral student, specializing in integrated STEM education, with second grade teachers in a partner school's classroom one day a month for an entire school year. The project introduced second grade students and second grade teachers to integrated STEM content lessons as well as problem/project-based teaching. Throughout the school year, numerous integrated STEM lessons were taught that targeted specific content from second grade STEM standards. These lessons delivered content in a real-world context while providing hands-on learning and 21st Century skills including problem solving and communication. Using data from two different second grade classrooms, the research attempted to determine whether the integrated STEM lessons impacted student's engagement among the STEM disciplines, their personal efficacy related to the STEM fields, as well as their career aspirations within STEM fields.

Introduction

The acronym STEM (science, technology, engineering, and math) has become a well-worn descriptor in the American educational lexicon during the past 15 years. The U.S. Bureau of Labor Statistics projects that there will be nine million new jobs before 2022, however most of those jobs will require individuals to have a strong STEM education and related technical skills (Vilorio, 2014). Subsequently, policy makers and political leaders have placed the responsibility for preparing American citizens to accept such new jobs on the public school system. The answer to this new shift has called for a vastly increased treatment of STEM content within the K-12 educational system. In addition to increased STEM content and programs, there is an equal push for preparing adept citizens for the 21st Century (Owens, et. al, 2012).

The goal of STEM programs within the elementary grades is to attract and maintain student interest in STEM subjects while increasing student performance within the STEM subjects—especially with science and math content (Havice, 2015). However, there does not appear to be one clear solution or simple answer on how to implement a successful STEM program at the elementary level. Although, there is agreement on best practices for teaching integrated STEM content (Katzenmeyer & Lawrenz, 2006). Some of these best practices include implementing challenge-based learning curriculum, which includes problem-based and project-based learning, cooperative learning, integrated disciplinary STEM content, and design-based curriculum materials/lessons that appear relevant to the student's interest and needs (Smith, Douglas, Cox, 2009).

The Elementary Student

One critical and important element that needs be considered when seeking to expand student engagement and interest in STEM subjects is the student's current disposition for learning. Recent literature implies that elementary students develop beliefs and dispositional attitudes toward science and math content by the end of the fourth grade, further implications show that almost half of students decide to avoid continued or advanced STEM subject matter learning before reaching the eighth grade (Murphy, 2011). In a study conducted by Archer, et al (2012) the researchers discovered that once a student develops a negative disposition toward STEM subjects, that attitude will influence decisions throughout his/her educational experience and ultimately influence their career choices. Therefore, efforts must be taken to develop curricular programs and instructional approaches that reach these impressionable students while they are still open to the possibility of a continued acceptance of and engagement in STEM subject matter learning and investigation.

Research suggests that primary students are more willing to participate in and remain engaged in learning STEM content when they have positive connection and experience some level of success with the content (Capobianco, Yu, & French, 2015). These crucial experiences are most commonly created when students are engaged in thought provoking challenges and student relevant learning activities (Ainley & Ainley, 2011). While engaging students through meaningful and relevant instruction is not a new pedagogical concept it is important to remember that it is the heartbeat of STEM teaching and learning.

Another factor influencing student engagement in STEM is gender bias. Research has proven that young girls rely heavily on role models when developing their interest and future career aspirations. These factors have been known to have a stronger emphasis on decisions than the student's achievements in mathematics and science (Catsambis, 1995). A student's gender can also affect how they approach learning and demonstrate understanding about STEM subjects (Murphy & Elwood, 1998). Masculine and feminine societal expectations can play a role in how students respond to and participate in certain subjects. A study by Virtanen, Räikkönen, & Ikonen (2015) found that girls were more likely to concentrate on the environment and making decorative projects, where boys were more interested in using tools. This study also showed that boys were more confident in their ability to learn new things in comparison to their female peers who required encouragement from the teacher to continue. In turn, the teacher's misconceptions and unawareness of gender bias can also make a large influence in the way those students especially girls approach STEM subject learning. Berekashvilli (2012) found that female student's skills and talents were often underrepresented and praised within the classroom. This research also showed that teacher's expectations unknowingly were lowered for girl student achievement in math and science but raised in English and reading. Often, this was not done with malice but rather happened without forethought. The implication for teachers to engage all students, but especially females is a necessity for these students to continue their pursuit of STEM learning and achievement.

However, increased math and science content is not the only skill students need to be successful in STEM, they also need to know how to work and communicate effectively with others inside and outside their immediate area of influence. It is a focus on 21st Century skills such as cooperative learning, problem solving and critical thinking that seem to be driving some of the most promising STEM education programs (Brusic, & Shearer, 2014). Macpherson (2008) defines cooperative learning within the classroom as an interaction between students in which inquiry and communication come together to increase mutual understanding. He asserts that the difference between individualized instruction and cooperative learning strategies makes a substantial difference in learning outcomes. In traditional small or individualized instructional groups there is no structured interdependence, individual accountability, or active communication between learners. This requires the teacher to incorporate cooperative learning methodologies that require students to think critically, cultivate a deeper understanding, defend their positions, and practice social interaction skills to successfully promote proposed solutions and communicate ideas that may solve the given problem.

Children do not come by these skills naturally, and a cooperative learning classroom can create a safe environment for novice students to practice using cooperative learning strategies, build confidence in themselves and their abilities, and exercise social interaction practices. Furthermore, cooperative learning allows educators to put the emphasis back on the student. This may allow the student to acknowledge and identify helpful group behaviors, promote effective teamwork, and force the creation of group and individual accountability toward an end goal of team success (Sahin, Ayar, & Adiguzel, 2014). Successful outcomes with cooperative learning may be attributed to the promotion of continuous team discussion, debate, and clarification that is critical for successful team problem solving. Ultimately, cooperative learning creates a student-centered learning environment that allows students to engage with new content while resolving conflicts by using research and acquired knowledge as the foundation to negotiate solutions (Cohen, 1994).

STEM in Elementary

Within the elementary grades; science, technology, and engineering have not historically held a customary place within the curriculum, as a result the content from these subjects have not been introduced to most American students during these important developmentally critical years. While a few elementary schools have begun to address some aspects of science in the elementary school, content from the fields of technology and engineering are rarely included in the curriculum. This results in elementary students not being exposed to concepts like design, problem solving, invention, and creative thought (Catterall, 2012). Judson (2012) suggests that most elementary teachers focus their curriculum primarily on literacy and the content identified on the yearly benchmark tests that includes scant science, technology, or engineering content or learning experiences. Archer, et al, (2012) found that elementary classrooms are introducing science as a content subject area after the fourth grade. Unfortunately, this is when many students have already begun to form decisions about their interests and future in STEM.

Research indicates positive learning gains for STEM programs when classrooms incorporate challenge-based STEM learning delivered through cooperative learning methodologies within the elementary grades. This allows the programs to target and influence students while they are still exhibiting innate problem-solving inclinations, embracing their creativity, viewing hands on projects and challenges as a fun learning and experience, and are open to learning new content (Allendoerfer, Wilson, Kim, & Burpee, 2014). Integrated STEM lessons or content-rich STEM challenges that arise from the student's perspective seem to be most effective in attracting and maintaining student engagement. In a study conducted by Habashi, T Graziano, Evangelou and Ngambeki (2008), the researchers found that teachers were more effective at directing elementary students' interest toward integrated STEM content when the student's personal interests were explored though tangible objects rather than abstract thoughts or feelings. Similar conclusions were drawn from DeFraine, et al. (2014) research study that asserts that student success will occur if the teacher delivers a content-rich learning challenge integrating STEM content through a hands-on project or challenge. Additionally, the hands-on challenge should relevant to the real world, have demonstrated or clear content importance to the student, and finally have a central relevance to the student's needs currently and in the future. These researchers discovered that the personal connection to tangible artifacts was a motivational influence for engaging in integrated STEM learning activities, while confirming that students exhibit increased levels of engagement and become more engrossed in the exploration of the content as well as the life application of what they are learning when the content is delivered through an authentic problem with which they can relate. Such methods are creating realistic learning opportunities for students that they may never receive in a traditional classroom or individualized learning experience (Goeke, & Ciotoli, 2014).

Recently we have seen a refined focus for The Technology for All Americans (TFAA) standards, the Common Core State Standards (CCSS), and the Next Generation Science Standards (NGSS) within our public school systems. These learning standards are all designed to promote college and career readiness by using integrated content learning during the early grades (Stage, et al, 2013). For example, the NGSS standards impact student learning and the development of 21st Century skills through the inclusion of engineering practices and design-to-demonstrate core concepts, such as problem solving, multi-discipline learning, and the use of models and hands-on projects (Cardno, 2013). These standards call on the elementary teacher to deliver the content standards by developing STEM lessons and challenge-based learning experiences that draw out the connections between the content of these four fields of study. In turn, students are able to expand on multiple subject matter knowledge areas to solve problems and design creative solutions in a collaborative learning environment. Students in programs driven by integrated content standards should experience a level of learning that easily transfers to the workplace and to society in the 21st Century.

Elementary STEM Teacher

In a recent study examining the teaching methods for STEM content Capobianco and Rupp (2014) affirm that the elementary teacher's ability to develop integrated STEM lessons or design challenges that draw connections to the content from all STEM subject matter as well as making connections to student's personal interests was greatly needed in order to make an impact on the student for continued pursuit of STEM learning. However, it is not uncommon for elementary teachers to feel apprehensive about teaching integrated STEM lessons in their classrooms (Goodnough, Pelech, & Stordy, 2014). After all, most have not had deep educational experiences or training in the STEM content areas. Rittmayer & Beier (2008) noted that teaching integrated STEM content in the elementary school may be hampered by the teachers' lack of confidence and content knowledge as well as general discomfort with ill-structured, inquiry-based, or problem-based learning methodologies. In similar findings, Boulay and Van Raalte (2013) found that teachers were lacking the ability and resources to create real-world application of STEM content for their students. Essentially, elementary teachers need to be prepared to design and implement ill-structured theme-based design problems that cause elementary students to solve engaging problems directly related to STEM content standards. There is a great importance on modeling appropriate best practices for teaching and implementing new integrated STEM programs within the elementary classroom. Without this support and direction, the teachers and classrooms will likely have unsuccessful results leading to frustration for the teacher and the students. (Teo, and Ke, 2014).

However, there is a general consensus calling for increased STEM content and practice of 21st century skills within our schools, as well as the need for elementary teachers to include such studies and practices as a part of their daily curriculum (Lamb, Akmal, & Petrie, 2015). Epstein (2011) proposed that there is an urgent need to develop elementary teacher education programs and projects to prepare highly skilled STEM teachers who have the ability and confidence to provide engaging integrated lessons that deliver core content from the STEM disciplines in a realistic manner. Given the circumstance that most existing and future elementary grade teachers are not likely to have extensive content knowledge or practical experience in the STEM disciplines or extensive experience developing STEM lessons and activities, modeling best practices of exemplary STEM programs might be the most appropriate change agent. Pinnell, et al (2013) suggested that for elementary teachers to fully understand and implement integrated STEM lessons and projects with real-world applications, they will need to have appropriate practices modeled. This modeling could be carefully crafted to illustrate methods by which current curricular practices could be modified to increase the treatment of STEM in the elementary classroom.

Methodology

This study was coordinated through the University of Arkansas's Education Renewal Zone. The Arkansas Education Renewal Zone was established 2003, with the overarching goal to address the current needs of community schools by providing resources, strategies, and tools to improve school performance and academic achievement for all students. Adopt-A-Classroom is one of the Education Renewal Zone's programs that connects a content expert such as a professor, staff member, or doctoral student specializing in a specific area, into a partner school's classroom several times throughout the school year.

This study was conducted in a second grade classroom within a Northwest Arkansas community school. The classroom teacher was primarily concerned with her students reading scores, particularly inferential reading as the majority of the class was below benchmark expectations. The researcher used inferential reading as a catalyst to introduce the integrated STEM content. The researcher also made sure that the STEM lessons delivered the content in a real-world context while providing hands-on learning and 21st century skills including problem solving, and communication. In addition, each lesson developed for the research included a sense of relevancy and excitement to ensure that the participating student was engaged in not just the project but in the learning content.

Three interventions were developed and they consisted of three integrated STEM lessons delivered to the participating students. The first intervention lesson included a design problem that asked students to work in teams to modify a shelter to keep the popular *Olaf* from the movie *Frozen* cold enough to visit their school. This lesson targeted three main learning goals, which included the design process, understanding of water properties, and the use of measurement. The students were given a themed newsletter, which required them to explore materials and demonstrate understanding before building their shelter. The students were assigned to teams and were required to complete the engineering journal, explaining their contributions and rationale for their final design. The students were provided with an assessment rubric, and were assessed, not only on the overall design, but also on their understanding of the content. At the conclusion of the lesson, students were asked to share their design and experience from the project.

The second intervention lesson, allowed students to work as electrical engineers. The students in this lesson were required to complete a simple switch circuit to illuminate Rudolph's nose and guide Santa's sleigh. In order to complete this project successfully, the students were required to demonstrate understanding within science through energy transfer, technology and engineering via energy forms and troubleshooting, and mathematics via fractions. The students were provided with content, which was directly applied to the project.

The third intervention lesson, required students to work as a mechanical engineer to build a fishing pole that could hold the most weight. The narrative text *Jangles* was used in this lesson to engage students and draw them into the project. The students were required to complete an engineering journal, including rationales for their designs and explanations for any modifications to their designed fishing pole. The students demonstrated understanding of science content through their explanations and project designs to minimize the force and weight of the fishing pole, technology and engineering via their design journals and redesign of their projects, and mathematics through their calculations of the weight held on the balance scale.

The researchers' participation in this project allowed her to model and share exemplary practices for integrated STEM in the elementary classroom. The classroom teacher, always present in the classroom during interventions, was also able to increase her knowledge of STEM methodologies useful in the elementary classroom. This project served as the first time that cooperative learning integrated with problem/project-based teaching had occurred within this elementary school. Following the three interventions, the classroom teacher noted that the project helped her develop the confidence that led her to continue developing and teaching additional integrated STEM lessons throughout the school year.

Preliminary data was collected using a student interest survey. The student interest survey was completed by students participating in the research as well as students in another 2nd grade classroom within the same school. Although the research is ongoing, initial findings reveal that the integrated STEM design challenges delivered through the three interventions did influence the student's current interest in STEM subjects as well as their career aspirations within STEM fields after treatment, in comparison to the class that did not participate in the Adopt-A-Classroom project. The preliminary data showed a significant difference for the students assessment of being good at science $t(36)=2.25$, $p=.031$; math $t(36)=2.43$, $p=.020$; engineering $t(32)=6.41$, $p<.001$; learning how things work $t(36)=3.66$, $p=.001$; solving problems than are not familiar $t(34)=7.56$, $p<.001$; enjoys building and making things $t(36)=4.77$, $p<.001$; career aspirations in engineering $t(25)=9.28$, $p<.001$; career aspirations for inventing $t(36)=3.553$, $p=.001$; career aspirations for designing machines to help people $t(36)=3.78$, $p=.001$; belief that scientist make peoples lives better $t(36)=5.75$, $p<.001$; belief that engineers make peoples lives better $t(36)=3.10$, $p=.004$; self knowledge of what a scientist does for their job $t(36)=2.75$, $p=.009$. Furthermore, the researcher was able to demonstrate that STEM content when paired with cooperative learning can both engage and create interest among students in STEM learning and likely foster dispositions for continued interest in the STEM fields.

Conclusion

STEM is increasingly important to our society and elementary teachers can affect student interest by engaging students in the study and application of these disciplines at an early age. By engaging students during the early years, educators can supply them with the tools necessary to keep them engaged throughout elementary, secondary and postsecondary education. This will require attention to standards, enthusiasm for finding and exploiting the connections between disciplines, real-world application, and centering our teaching on the student and their world. We must communicate information, utilize differing teaching methods, adopt a willingness to develop and teach content that may be inching towards uncharted territory, and have a commitment to teacher professional development. While there are various STEM programs and initiatives which have shown the ability to garner interest in K-12 students by integrating the STEM content with real-world and student centered instruction and design it is most important to make sure our teaching practices, are ensuring that our student's environment connects with their learning. This preliminary research suggests that teachers can influence STEM interest by ensuring that our students are involved in problem solving, critical thinking, collaboration, planning, and presentation on a regular basis. This can be accomplished by providing elementary-aged students with engaging, positive, and successful experiences within the STEM disciplines, thereby creating an environment where children yearn for more information, search for solutions to human problems, regularly blend disciplinary boundaries, willingly conduct research, seek answers, and continue learning well beyond the classroom. Delivering integrating STEM education in the elementary classroom is another step towards creating a more involved and more intellectually curious society and an insurance policy for the future of our nation. This process begins by preparing elementary teachers who are capable, comfortable, and enthusiastic about implementing integrated STEM education in the elementary classroom.

References

Ainley, M. & Ainley, J. (2011). Student engagement with science in early adolescence: The contribution of enjoyment to students' continuing interest in learning about science. *Contemporary Educational Psychology,* 36, 4 – 12.

Allendoerfer, C., Wilson, D., Kim, M. J., & Burpee, E. (2014). Mapping beliefs about teaching to patterns of instruction within science, technology, engineering, and mathematics. *Teaching In Higher Education,* 19(7), 758-771.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B. & Wong, B. (2012). Balancing acts: Elementary school girls' negotiations of femininity, achievement, and science. *Science Education*, 96(6), 967-989.

Berekashvili, N. (2012). The role of gender-biased perceptions in teacher-student interaction. *Psychology Of Language And Communication*, *16*(1), 39-51.

Boulay, R., & Van Raalte, L. (2013). Impacting the science community through teacher development: Utilizing virtual learning. *International Journal of Technology, Knowledge & Society*, *9*(4), 13-24.

Brusic, S. A., & Shearer, K. L. (2014). The ABCs of 21st Century Skills. *Children's Technology & Engineering*, *18*(4), 6-10.

Capobianco, B. M., & Rupp, M. (2014). STEM teachers' planned and enacted attempts at implementing engineering design-based instruction. *School Science & Mathematics*, 114(6), 258-270.

Cardno, C. A. (2013). New K-12 science, engineering standards unveiled. *Civil Engineering, 83*(6), 26-27.

Catterall, J. (2012). *The arts and achievement in at-risk youth: Findings from four longitudinal studies*. Washington, DC: National Endowment for the Arts.

Catsambis, S. (1995). Gender, race, ethnicity, and science education in the middle grades. *Journal of Research in Science Teaching*, 32(3), 243-257.

Cohen, E. G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research*, 64, 1-35.

DeFraine, W. C., Williams, W. M., & Ceci, S. J. (2014). Attracting STEM Talent: Do STEM Students Prefer Traditional or Work/Life-Interaction Labs?. *Plos One*, 9(2), 1-7.

Goeke, J. L., & Ciotoli, F. (2014). inclusive STEM: making integrative curriculum accessible to all students. *Children's Technology & Engineering*, *18*(3), 18-22.

Goodnough, K., Pelech, S., & Stordy, M. (2014). Effective Professional Development in STEM Education: The Perceptions of Primary/Elementary Teachers. *Teacher Education And Practice*, *27*(2-3), 402-423.

Habashi, M. M., Graziano, W. G., Evangelou, D., & Ngambeki, I. (2008). Age related gender differences in engineering. *Journal of STEM Teacher Education*, (49)1.

Havice, W. L. (2015). Integrative STEM education for children and our communities. *Technology & Engineering Teacher*, *75*(1), 15-17.

Judson, E. (2012). When science counts as much as reading and mathematics: An examination of differing state accountability policies. *Education Policy Analysis Archives*, *20* (26).

Katzenmeyer, C., & Lawrenz, F. (2006). National science foundation perspectives on the nature of STEM program evaluation. *New Directions for Evaluation*, (109), 7-18.

Lamb, R., Akmal, T., & Petrie, K. (2015). Development of a Cognition-Priming Model Describing Learning in a STEM Classroom. *Journal Of Research In Science Teaching*, *52*(3), 410-437.

Macpherson, A. (2008). *Cooperative Learning Group Activities for College Courses*. British Columbia: The Centre for Academic Growth, Kwantlen University College.

Murphy, Tony. (2011, August 29). STEM education - - It's elementary. *US News and World Report*. Retrieved from http://www.usnews.com/news/articles/2014/12/01/stem-education--its-elementary

Murphy, P and Elwood, J (1998) Gendered experiences, choices and achievement – exploring the links. *International Journal of Inclusive Education,* 2(2), 95-118.

Owens, E. W., Shelton, A. J., Bloom, C. M., & Cavil, J. K. (2012). The significance of HBCUs to the production of STEM graduates: Answering the call. *Educational Foundations, 26*(3-4), 33-47.

Pinnell, M., Rowly, J., Preiss, S., Franco, S., Blust, R., & Beach, R. (2013). Bridging the gap between engineering design and PK-12 curriculum development through the use the STEM education quality framework. *Journal of STEM Education: Innovations & Research*, 14(4), 28-35.

Rittmayer, A. D., Beier, M. E. (2008). *Overview: self-efficacy in STEM*. Retrieved from http://www.engr.psu.edu/awe/misc/ARPs/ARP_SelfEfficacy_Overview_122208.pdf

Sahin, A., Ayar, M. C., & Adiguzel, T. (2014). STEM related after-school program activities and associated outcomes on student learning. *Educational Sciences: Theory & Practice,* 14(1), 309-322.

Smith, K. A., Douglas, T. C., & Cox, M. F. (2009). Supportive teaching and learning strategies in STEM education. *New Directions For Teaching & Learning*, (117), 19-32.

Stage, E. K., Asturias, H., Cheuk, T., Daro, P. A., & Hampton, S. B. (2013). Opportunities and challenges in next generation standards. *Science, 340*(6130), 276-277.

Teo, T. W., & Ke, K. J. (2014). Challenges in STEM teaching: Implication for preservice and inservice teacher education program. Theory into Practice, 53(1), 18-24.

Vilorio, D. (2014). STEM 101: Intro to tomorrow's jobs. *Occupational Outlook Quarterly, 58*(1), 2-12.

Virtanen, S., Räikkönen, E., & Ikonen, P. (2015). Gender-Based Motivational Differences in Technology Education. *International Journal Of Technology And Design Education*, *25*(2), 197-211.