Board 122: Using Engineering Design to Increase Literacy and STEM Interest Among Third Graders (Work in Progress, Diversity)

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ABSTRACT

Literacy is the key to a student's success as it is a critical skill required for learning all other subjects, including science and engineering. Additionally, early exposure to Science, Technology, Engineering and Mathematics (STEM) is critical for getting students interested in these subjects. Therefore, the objective of the STEM Stories project is to provide highly integrated STEM and literacy activity modules with detailed instructions for facilitation that can be used by schools to create afterschool reading intervention programs. During the 2017-2018 school year, 13 STEM Stories activity modules were developed, piloted and assessed. The activity modules were facilitated at an urban school, directly impacting 18 students, two K-12 teachers, two undergraduate engineering students and an undergraduate teacher education student. Reading scores and post engineering interest data suggest that the activity modules may have contributed to an increase in student reading scores. The activity modules have been placed on a website for use by other teachers. During the 2018-2019 academic year, the activity modules are being facilitated and assessed at three urban schools.

INTRODUCTION

It is well understood that the United States (US) needs a strong Science, Technology, Engineering and Mathematics (STEM) workforce (Bagchi-Sen, 2001). There is significant research that shows that early exposure to STEM is a critical factor in encouraging students to pursue these fields (Murphy, 2011, U.S. President's Council of Advisors on Science and Technology, 2010). However, most K-3 classrooms include little to no science, technology or engineering, and instead focuses on reading and mathematics. The focus on reading is justified as a child's ability to read by the end of third grade is a critical predictor of their future success, including high school graduation, earning potential, and general productivity (Annie E. Casey Foundation, 2010; Hernandez, 2012). Reading is a foundational skill that is critical to learning all other subjects including STEM. In Ohio, the Third Grade Reading Guarantee mandates that schools identify at-risk readers through diagnostic assessments and provide specific interventions such as intensive reading instruction and afterschool programs (Ohio Department of Education, 2016). Although Ohio has mandated this, there is little state funding available to support these interventions. Therefore, the problem is multifaceted. How can an under-resourced school district: (1) ensure all third grade children have proficient reading skills and meet grade-level expectations so that these children can do well in all subjects, including STEM; (2) provide the interventions required through the Third Grade Reading Guarantee mandate with little to no funding, and (3) provide children early experiences through STEM activities so they are inspired to pursue a STEM career to meet future STEM work force needs and to give these children equal access to future in demand and high paying jobs? Research suggests that when school subjects

such as STEM and literacy are taught in an integrative manner, students have gains in both areas (Cervetti, Barber, Dorph, Pearson & Goldschmidt, 2012; Guthrie & Ozgungor, 2002; Sterling, 2014).

PROGRAM OBJECTIVES AND GOALS

The objective of the STEM Stories project is to provide innovative, engaging, fun and highly integrated STEM and literacy activity modules with detailed instructions for facilitation that can be used by schools to create afterschool reading intervention programs. Specifically, the goals of this project are to: (1) modify existing, and develop new STEM Stories activity modules that incorporate research based best practices and principles for attracting underrepresented students to engineering; are mapped to the Ohio Academic Content Standards; and are infused with culturally relevant literature, project based reading and writing activities, and innovative forms of communication such as sketch notes and graphic notes (National Academy of Engineering, 2013; Pinnell, Kurup, Stock, Turney, Wendell, 2018); (2) facilitate the STEM Stories activities in afterschool enrichment programs for second and third grade students at under resourced schools with diverse populations where the University of Dayton (UD) has existing relationships; (3) assess the efficacy of the program at: (a) enhancing the participant's interest in STEM; (b) enhancing the literacy of the participants by comparing the pre- and post- reading scores of the participants; (c) collecting data on the "user-friendliness" of the activity modules through teacher and facilitator feedback sheets; and (4) share the activities and detailed instructions for implementing the activities for use by the broader K-3 community through a website. A key component of these activities is the incorporation of culturally relevant literature defined as, "literature where they [students] are able to see themselves, their families, their cultures, and experiences similar to what they have experienced will give them the opportunity to connect with the literature they read," (Oumet, 2011).

YEAR ONE ACTIVITIES

During the first year of this project, thirteen STEM Stories activity modules and kits were developed. The activity module descriptions are provided on the UD website (STEM Stories, 2018). The modules were facilitated at the STEM Stories afterschool program at an area school by two teachers, an undergraduate engineering student, and an undergraduate teacher education student. The STEM Stories afterschool program began in September and ran through April. It met twice a week for two hours each day at the school.

EVALUATION

The evaluation was approved by the UD's Institutional Review Board (IRB). The evaluation included pre- and post- survey data, attendance data, and reading scores.

Participants: Fifty-five grade 2 and 3 students registered for the afterschool program. Attendance records reflect that six students attended between 66% and 100% of the time; four students attended between 51 and 65% of the time, eight students attended between 31 and 50% of the time, and 37 students attended between 0 – 30% of the time. The school has a 54 %

minority enrollment, with 90% of the students qualifying for free or reduced lunch (DPS Success Stories, 2018). Challenges to regular participation included student transportation issues, competing programs, and illness. Additionally, the school district faced a teacher strike at the beginning of the school year which had a slight impact on the recruiting efforts for this program.

Student STEM Interest Surveys: The AWE (Assessing Women and Men in Engineering, 2017) Pre- and Post- Upper Elementary Survey was used to assess students' interest in STEM. A total of 24 students completed the survey in April, 2018. Of the 24 students who completed the spring 2018 post-survey, seven completed the pre-survey in September 2017. For that reason, pre-post analyses were not appropriate given the small number of students for whom there were pre/post data.

At the end of the STEM Stories program, the students generally 'agreed' or were 'not sure' in response to each question with a range of 10 to 22 'agrees' and a range of 1 to 7 'not sure.' Responses to three questions revealed that 25% of the students responded 'disagree' to wanting to pursue STEM careers: 3a and 3b and 3c. The questions centered on the desire to be a scientist, an engineer or an inventor. Question 1c, regarding 'I am good at engineering', reflected that nearly 30% of the students were not sure they were good at engineering. However, the responses to questions that described characteristics of engineers reflected that students rated themselves 'interested in' or 'good' in these characteristics (i.e., Questions 1d, 1e, 3c, 3d, 3e). Question 1d is the best example of this conflicting information.

Table 1. Results from the AWE Survey

Statements	Agree	Not Sure	Disagree	Missing
1a. I am good at science.	16	5	2	1
1b. I am good at math.	19	1	3	1
1c. I am good at engineering.	10	7	4	3
1d. I like learning how things work.	22	2	0	0
1e. I am creative.	19	2	3	0
3a. I would like to be a scientist.	16	2	6	0
3b. I would like to be an engineer.	10	6	8	0
3c. I would like a job where I invent things.	16	3	5	0
3d. I would like to design machines that help people walk.	20	2	2	0
3e. I would enjoy a job helping to make new medicines.	18	3	3	0
3f. I would enjoy a job helping to protect the environment.	18	5	1	0
3g. Scientists help make people's lives better.	17	4	3	0
3h. Engineers help make people's lives better.	17	4	3	0
3i. I know what scientists do for their jobs.	18	2	4	0
3j. I know what engineers do for their jobs.	15	7	2	0

Student Fall and Winter MAP Reading Scores: The school uses the MAP (Measures of Academic Progress) student growth program to monitor their students' academic progress throughout the school year. Northwest Education Assessments (NWEA, 2018) MAP

assessments allow schools to track academic progress multiple times throughout the school year. The third-grade students completed a MAP assessment three times (fall, winter and spring). For each student who attended the STEM Stories program at least 40% of the time, the MAP reading test scores in the areas of vocabulary, informational text skills, and literature skills were studied over this time period. Using the MAP data, 5 of the 15 students who attended at least 40% of the time scored higher than projected in the fall. Using the MAP subcategories, one student scored higher than projected in the understanding of literature, one student scored higher than projected on understanding informational text, and one student scored higher than projected regarding vocabulary acquisition. Since these subcategories were targeted in the STEM Stories project, it is possible that the STEM Stories Program may have contributed to the higher than projected scores. In addition, the end of year state reading and math test scores were collected for all students who attended the STEM Stories program. Using the Ohio State testing scores of those who attended at least 40% of the time, 10 of the 15 (67%) students passed the state test for math and 14 of the 15 (93%) students passed the state test for reading. This is compared to the district where 34% of the students passed the state reading test, and 38 % passed the state mathematics test (Ohio Dept. of Education, 2017). It is believed that the STEM Stories program attendance may have contributed to the higher scores of the STEM Stories participants.

Document Analyses: Undergraduate engineering and teacher education students, and teacher facilitators reported anecdotal feedback regarding improved problem-solving skills and writing skills they witnessed. Journal entries were analyzed using document analysis to determine themes and patterns in responses. For example, the facilitators compared journal entries from the beginning of the program to the end of the program and saw an increase in the amount and content of the writing, Figure 1.
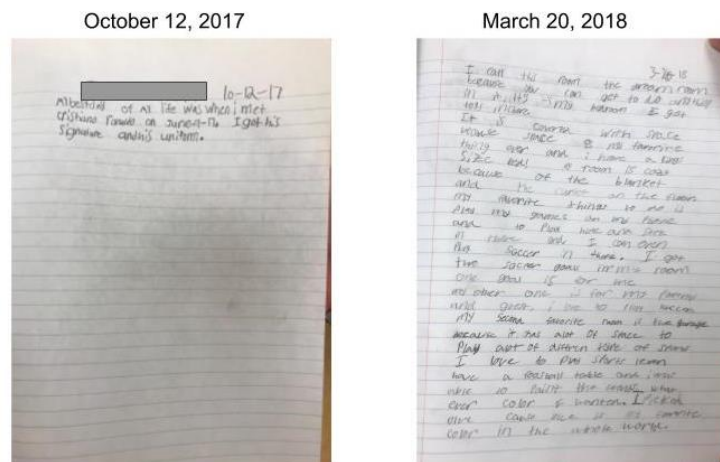

Figure 1. Example of journal entries from near the beginning of the program and near the end of the program.

YEAR 2 ACTIVITIES
During the second year of the project (2018-2019 academic year), the STEM Stories program was expanded to two additional schools in the same public school district. For the two additional schools, the STEM Stories program was integrated into existing afterschool programs. As such, the STEM Stories activities were facilitated approximately an hour each day, Monday through Thursday at these two schools. For the remaining school (the school that participated in Year 1), the STEM Story program was facilitated as a standalone program that met two days a week for approximately two hours. At all three of the schools, the program was facilitated by classroom teachers, undergraduate engineering students, and undergraduate teacher education students. Evaluation of the year 2 activities is ongoing. In addition to expanding to three facilitation sites, existing modules were modified using the feedback from the Year 1 activities, and additional modules are being developed.

SUMMARY
The objective of the STEM Stories project is to provide innovative, engaging, fun and highly integrated STEM and literacy activity modules with detailed instructions for facilitation that can be used by schools to create afterschool reading intervention programs. During the 2017-2018 school year, 13 innovative, fun and highly engaging STEM Stories activity modules were developed, piloted and assessed. The activity modules were developed using research based best practices for attracting underrepresented students to STEM, to show how STEM can make a difference and impact people's lives and to incorporate culturally relevant literature and targeted literacy activities (National Academy of Engineering, 2013; Oumet, 2011; Pinnell, Kurup, Stock, Turney, Wendell, 2018). The activity modules were facilitated at an urban school directly impacting 18 students (10 who attended more than 50% of the sessions, 8 who attended more than 31% of the sessions), two K-12 teachers, two undergraduate engineering students and an undergraduate teacher education student. Preliminary data suggest that the STEM Stories program may have been helpful at improving reading scores, however the STEM interest data was inconclusive with regards to the efficacy of the program at increasing the students' interest in engineering. The STEM Stories modules developed during year one of the project have been shared on a website for widespread distribution and use. During year two, additional modules were developed, and the STEM Stories program was expanded to three urban schools in the same public school district.

ACKNOWLEDGEMENTS

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