

Work in Progress: Afterschool STEM/Literacy Program—A Description of the Process

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Abstract

During the 2015-2016 school year, existing engineering activity modules were modified and facilitated as part of a pilot afterschool Science, Technology, Engineering and Mathematics (STEM)/Literacy program. The goal of this program was to increase the reading scores of third grade students. The engineering activity modules modified for this pilot project were developed as for use by undergraduate engineering students to engage in outreach with K-12 students at area schools. For the STEM/Literacy afterschool program, the existing modules were modified to include significant literacy components. Examples of these components included fictional stories that served as the basis or hook for the engineering design challenge, informative reading from books and the internet that helped the children solve their engineering challenge or that provided historical information about a related challenge, use of an interactive science notebook for recording results and observations and innovative communication strategies such as “speed talk” where a student was asked to tell their partner everything they learned in 20 seconds. The afterschool program met two days a week from October through April with 13 regular participants. Preliminary results of this pilot project showed that the STEM/Literacy afterschool program helped provide significant gains in the reading scores of the third grade student participants. This paper will not focus on these preliminary results, but instead describe how the modules were modified to include the literacy components. It will also provide recommendations for a future program that will include the culturally appropriate reading materials.

Introduction

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.¹ Many states have passed legislation requiring schools to identify at-risk readers and provide interventions to help increase the reading scores of these students.^{2,3} For example, Ohio has the Third Grade Reading Guarantee which requires that students achieve a minimum score on the Ohio Achievement Assessment (OAA) in order to advance to the fourth grade. Schools are using a variety of different intervention strategies to improve the reading skills of at risk readers. One such strategy is afterschool literacy programs. Another very promising strategy is the integration of literacy with other school subjects. There is a great deal of research to support the efficacy of integrated learning for increasing the literacy of students. In particular, innovative strategies that combine Science, Technology, Engineering and Mathematics (STEM) with literacy have been found to provide beneficial gains in reading as well as in STEM subjects.⁴⁻¹³ One example of this is the Seeds of Science, Roots of Reading (Seeds/Roots) curriculum which integrates literacy with scientific knowledge to provide a fun and authentic context for learning both subjects.^{5,6,14} Another example is the Engineering is Elementary Curriculum which has a story book that goes with each of the STEM activities.¹⁵

Pilot Integrated STEM/Literacy After-School Program

In 2014, the University of Dayton, School of Engineering developed “pick-up and go” engineering modules/kits to make it easier for engineering students to engage in effective outreach to K-12 students. The activities developed for the kits focused on the engineering design process and incorporated researched based, best practices for encouraging females in engineering such as emphasizing the creative aspects of engineering, incorporating an interesting hook that showed the social relevance of engineering and by highlighting the collaborative nature of the engineering profession.¹⁶⁻²¹ As such, all of the activities were developed to be fun, team-based and hands-on, to foster creative thought and show the social relevance and everyday applications of engineering. Each activity was linked to specific academic content standards so that the teachers could expand the outreach activity into classroom learning if desired.²² During the 2014-2015 academic year, these kits were facilitated to over 1200 K-12 students, primarily in grades 3 through 6. Assessment of this project showed that the outreach activities were effective at increasing the K-12 students’ attitudes, interest and awareness towards STEM, but they were more effective for the females.²¹ A full description of the engineering outreach kits developed and piloted through this project is provided at the website.²³

In 2015, the University of Dayton partnered with Kiser PK-8 School, Learn to Earn Dayton/Ready Set Soar and the Dayton Regional STEM Center to develop and pilot a STEM/Literacy afterschool program targeted at third grade students who were at risk to not pass the third grade reading test. The activities developed for engineering outreach kits described above served as the basis for this afterschool program. Two Kiser STEM instructors modified these activities to incorporate strategic literacy components based off of an instructional planning report provided by the vendor reading assessment, STARS. Examples of these components include fictional stories that served as the basis or hook for the engineering design challenge, informative reading from books and the internet that helped the children solve their engineering challenge or provided historical information about a related challenge, use of an interactive science notebook for recording results and observations and innovative communication strategies such as “speed talk” where a student was asked to tell their partner everything they learned in 20 seconds.

The target population for this program were 40 third grade students from Kiser PK-8 with the intent of reserving at least 50% of the places for the highest need students who scored below a scaled score of 300 on the STARS reading assessment. However, only 22 students actually enrolled in this pilot program with 13 of these students attending on a regular basis. The program participants included nine female students and 13 male students. Eleven of those students were Black or African American, eight were White or Caucasian, two were mixed race, and one was Hispanic. The STEM/Literacy afterschool program met twice a week from 4-5:30 pm at Kiser PK-8 School from October through April. The program was facilitated by two Kiser STEM instructors and two undergraduate engineering students from the University of Dayton.

Although the engineering activities were initially designed to be facilitated in a single, 30-60 minute classroom session, the addition of the literacy component and incorporating more time for reflection and redesign made it such that a single activity was generally facilitated over four,

90 minute sessions. On the first day of the activity, the students engaged in a read aloud and engagement activity focusing on the STEM design project. The lessons included a reading and writing component based on the science concept. This component required instructors to prepare a reading and writing lesson not only based on the science concept aligned to the challenge but also tailored to the ability level of each reading group. Students were frequently tasked with using manipulatives during this time to encourage them to find evidence to support what they read in the text and to also encourage them to read the text carefully and to ask and answer questions on the topic.

On the second day of the activity, the students engaged in a guided research activity focused on Ohio Revised Science Standards for online research of the science concept. This plan was formulated to ensure students were given multiple opportunities to discover the science behind the engineering project through the use of inquiry as opposed to traditional classroom instruction. Reflecting on the ideas embedded in the guided discovery learning theory, students were directed to a variety of websites to assist them in discovering the content knowledge aligned to the challenge. Additionally, the students were encouraged to take notes on key information they discovered through this process that could impact their designs.

On the third day, students engaged in a short informational text-reading task. This task was developed to engage students in literacy while preparing them for the challenge. The purpose was to provide an anticipatory task that would engage the readers in the applicability of the challenge to the real world. With guidance, students defined the problem to be solved and identified the design objectives and constraints. Students thought of possible solutions and brainstormed ideas in their journals prior to writing a plan, listing materials, and drawing a diagram of their final design. If time allowed, students were encouraged to work collaboratively in groups to brainstorm, develop ideas, design, and build.

On the final day of the activity, the students completed the building portion of the project and tested their design. Scaffolded questioning was used to check for knowledge and lead students to a deeper understanding. Students wrote their test results and improved their design by thinking about, planning in their STEM journals, and making modifications. They followed the modifications with a retest and reflection on the results. Students closed the lesson by presenting their designs to the group, communicating their results, and sharing what they learned through multiple modes of communication such as the “speed talk” described above. The activities facilitated for this program included: The Three Little Pigs; Zip line; Building Bridges; Save Max; Filtration; Save the Building; Cracker Catapult; Assistive Devices; Smooth Operators; Program a Friend and Marble Ramp.²³

The method used to assess if the reading scores were impacted by the third grade students’ participation in the STEM/Literacy afterschool programs was a comparison of the students’ scores on the STAR assessment. The STAR assessment is a tool used to identify students in need of early intervention prior to them taking the more time-consuming and expensive OAA.¹¹ The mean STAR Reading Scale Scores of the third grade student participants were compared before (fall and winter 2015) and after participating (spring 2016) in the STEM/Literacy afterschool program. This data was compared with the fall 2015, winter 2015, and spring 2016 STAR Reading Scale Scores of third grade students from Kiser PK-8 School who did not

participate in the STEM/Literacy afterschool program. Full details of this assessment are summarized in Pinnell, et al.²⁴ Although the sample size was very small (n=13) for this pilot program, statistically significant results were obtained from the analysis that showed that the third grade students who participated in the program on a regular basis had a STAR Reading Scale Score increase of 42.3 points when compared to those third grade students who never attended the afterschool program or did not attend on a regular basis. The increase in reading scores demonstrated by the regular STEM/Literacy afterschool program participants corresponds to a nine-month grade equivalent gain. This can be compared to those students who did not participate in the STEM/Literacy afterschool program on a regular basis who gained only six months in grade equivalent terms. Additionally, prior assessment on the engineering activity kits found that they were effective at increasing the K-12 students' attitudes, interest and awareness towards STEM, but they were more effective for the females.²¹

Summary and Future Work:

Previously developed engineering outreach kits/modules were modified and facilitated as an afterschool STEM/Literacy program for third grade students that had been identified as being at risk for not passing the third grade reading test. The activities included reading assignments, specific writing and reflection tasks, use of an interactive science notebook for recording results and observations and innovative communication strategies such as "speed talk" Although the group was small (n=13), significant gains were found in the participant reading scores when compared to those students who did not attend the afterschool STEM/Literacy program.²⁴ This preliminary data suggests that the STEM/Literacy integrated approach for after school programming may be a promising intervention strategy for at risk readers.

Key stakeholders are currently pursuing opportunities to leverage the promising results from the pilot program to further develop and expand the reach of the STEM/Literacy afterschool program and to incorporate the use of culturally relevant literature as a core component of the engineering activities. Culturally relevant literature is 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."²⁵ Expansion will include incorporating specific instructions for the literacy components into the engineering outreach activity directions already available on-line as well as the development of new engineering outreach activity kits. Furthermore, additional assessment including assessing the efficacy of the STEM/Literacy activities on both reading scores and STEM interest, determining if the program has a greater

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