Enhancing Literacy Skills through STEM Activities: A Case for STREAM

BY MARYANN TATUM TOBIN

The current buzz around STEM and the increased push towards programs that feature mathematics and the sciences give those of us in the literacy world pause, as we see the research funding pendulum swinging away from us and towards this shiny and new curriculum paradigm. But, what is presented here is an olive branch between literacy and STEM instruction and a perhaps a new way to view cross-curricular pedagogy. STREAM (Science, Technology, Reading, Engineering, Arts, and Mathematics) is a robust, multimodal approach for improving science, mathematics and literacy skills by embedding dynamic and artistic literacy-building activities into Science, Technology, Engineering and Mathematics (STEM) units (Breiner, Harkness, Johnson, & Koehler, 2012).

Proof of Concept

Since the Common Core standards were released nationwide in 2010, students have been required to develop much broader literacy skills that are transferrable across all content areas than previous years, especially in the "science and technical subjects" of the STEM disciplines (Bybee, 2010; NRCCSEPP, 2006; Stanovich, 1986; Stanovich & Stanovich, 1997). Therefore, we sought to establish a model for accomplishing this that aligned with developmentally appropriate STEM activities and fostered the development of language both about the activity and about the subject matter. What emerged was a model for developing STREAM units, centered around the Jamerson Design Process (Barger, Gilbert, Douglas, & Douglas, 2005) and Vygotsky's principle of the Zone of Proximal Development (ZPD) (1978). Our STREAM lessons included whole class direct vocabulary instruction, small group guided reading, and a collaborative project in which students were required to plan, design, check, and share their solution to a content-specific design challenge, and demonstrate their understanding of knowledge through the creation of a digital story.

According to Vygotsky (1978), development is primarily influenced by socio-cultural interactions between children and adults where language is the main tool for learning and communication (Cole, 1996). Language, in this case, content-specific vocabulary words, is internalized into an inner "meta-language" that is used for self-regulation: planning, monitoring, and evaluating the task they are completing, all skills which the students used throughout the development and planning of both their engineering design challenge and their digital stories. The mechanism that mediates the use of this meta-language in a group setting is the ZPD, which is the developmental area between the child's independent performances of a task and those tasks performed with a more skilled peer or adult's assistance (Thomas, 1985). Within the ZPD, participants are able to develop and use specific language for and about the activity.

To facilitate development of the STEM design challenge, the Jamerson Design Process (Barger, et al., 2005) was selected as a framework to guide the activities within the STEM units, as it is a modified version of the engineering design cycle adapted for use with elementary students in grades K to 5. In order to fully-support the STREAM model, the four phases of Jamerson's Design Process align with the four phases of active reading proposed by Dole, Duffy, Roehler, & Pearson (1991) in which readers make a plan for reading a new text, monitor their comprehension while reading, clarify their understanding by asking questions, and summarize learned information into meaningful units (see Appendix A). In this STREAM example, Vygotsky's principles are instantiated by both the engineering design challenge and the digital storytelling activity in which students are required to think metacognitively about their activity pre-, during, and post-engagement. Likewise, to create an environment for fostering ZPDs, both engineering design challenges and digital storytelling activities required students to work in small groups, externalizing their thinking with language and mediating their interactions with language and instrumental tools. The outcome for students is a reconstructed literacy system, including the means of acquiring new vocabulary that can be transferred to any content area (Blanton, Pilonieta, & Wood, 2007).

Setting

During the 2014-2015 school year, a large, private university in partnered with an underperforming, public elementary school, to target content area reading skill development with struggling fourth grade students, specifically with science and technical texts. The partnering school received an "F" grade on the state-wide assessment and was identified as a FOCUS-D school by the Elementary and Secondary Education Act (ESEA). Of the 608 students enrolled in grades PK-5, 96% are on free or reduced lunch. Additionally, the school serves a predominately minority population, with 91.7% of the students identifying as Black/

African-American and 5.42% as Hispanic. In 2013, this Title I School had failed to make Adequate Yearly Progress (AYP) for the previous two years and had been consistently in the bottom 20% of all schools in the state. In low-SES, urban schools such as this one, students often have not had the same access to quality resources and may fall farther behind their peers (Au, 1991; 1997; Ogbu, 1987; Stanovich, 1986; Taylor & Dorsey-Gaines, 1988). However, evidence has shown that students in underperforming schools who are given access to quality instruction and research-based learning strategies across the content areas can be successful in their school careers (Alvermann, Phelps, Ridgeway, 2006; Duke, 2007).

Grade four is a pivotal year for young readers when they are expected to have transitioned from "learning-to-read" to "reading-to-learn," which is colloquially referred to as the "fourth-grade slump" (Torrance, 1967; Hirsch, 2003). Students who do not successfully acquire the skills necessary to navigate increasingly difficult vocabulary in the content areas are at greater risk of falling into the slump, thus precipitating the need for interventions as this crucial stage (Graves & Slater, 1987; Stockard, 2010). However, little research is available to guide development of activities that address the recent implementation of the Common Core State Standards (CCSS) and the cognitive demands placed on students to navigate disciplinary text of increased complexity (Tobin & Blanton, 2014). To that end, research is needed to promote the transfer of strategies learned in reading classes with the content area strategies necessary to succeed in reading science and technical subjects (Mooney & Laubach, 2002; Biancarosa & Snow, 2006; WWC, 2010).

Implementation

Groups of students were given the design challenge of creating a boat with various pre-selected, recycled materials that would float and hold a designated amount of weight. The initial challenge presented to the student groups included a storyline in which their principal was stranded on a deserted island with no supplies except specific materials that would wash up on shore as a result of marine pollution. After cycling through the Jamerson Design Process, groups were then asked to create their own digital story in which they told a narrative about their principal using their design process to create a means of survival and escape.

Phase One: Plan. In the Plan phase, students developed their ability to research by investigating marine pollution via multiple resources, in this case, facilitator selected texts at varied levels. As the students prepared to read, they were led through standard pre-reading practices, such as prediction and schema activation. In this school setting, a Title I grant allowed for the purchase of iPads and rich, printed informational leveled readers on marine pollution to be used for this activity. At the end of the plan phase, each group collaboratively decided on a prototype boat design to be constructed based on their research.

Phase Two: Design. In the Design phase, students simultaneously collaborated on their boats and their digital story. They engaged in discourse using their newly-acquired vocabulary and STEM content knowledge to negotiate design decisions as they built their boats and began storyboarding their digital stories (Lindeman, Jabot, & Berkley, 2013). The parallel interactions between informational knowledge and the narrative construction of story instantiates the principles of the STREAM model.

Phase Three: Check. During the Check phase, students tested whether their boats could hold the required weight. Groups with boats that did not float returned to phase one or two of the design cycle to problem solve, thus developing their ability to think critically and continue using vocabulary to negotiate and collaborate (Molina & Rivera, 2015). Groups with boats that did float then knew which materials to include in the narrative of their digital stories in which their principal successfully constructed a

boat out of marine litter and escaped the island. To complete their digital stories, students documented their boats' construction using the iPads to take pictures and Powerpoint to create a slideshow of images and animation, affording students a creative outlet for artistic expression and another medium for demonstration of their ability to plan, monitor, negotiate and evaluate their understanding cooperatively (Hull & Katz, 2006; Tobin, 2012).

Phase Four: Share. In the Share phase, groups presented both their final boat, including an accounting of their design process, and their digital story. This sharing requires them to practice their vocabulary, convey challenges they encountered, and make recommendations and for the next time they would attempt this project. Facilitators asked content-specific predicting and clarifying questions to help solidify student knowledge and assess their overall understanding.

Evidence of Effectiveness

The purpose of this documentary account was to explore the ways in which a STREAM approach impacted the content area vocabulary development of struggling fourth graders. A combination of both quantitative methodologies (a paired t-test) and qualitative methodologies (triangulation of field notes and student work samples) were utilized to accomplish this task.

Quantitative Data Sources. Data sources included pre and post vocabulary assessments from the Vocabulary Knowledge Task (VKT) subtest of the state's progress monitoring assessment were used to establish this proof of concept (Florida Department of Education, 2009b). To analyze the results of the VKT assessments, a paired t-test was utilized. A Type 1 error of was set, so that statistical significance would be found at $p < .05$.

The VKT subtest is aligned to the state standards for language arts and assesses a student's ability to complete sentences using the appropriate content area vocabulary word, similar to the well-established cloze assessment model (Taylor, 1953). Students must also identify the morphologically correct vocabulary word based on context clues and the options provided. The VKT is administered three times a year on computer. For this study, we analyzed the growth between the second and third administrations of this assessment.

Qualitative Data Sources. Data sources include student created storyboards, digital stories, field notes from classroom observations of the students involved in the STREAM activities, and qualitative questions on the student survey. Qualitative artifacts will be coded in a three-step process as described by Miles and Huberman (1994) and analyzed for themes. An a-priori list of codes for first-level coding, including pertinent vocabulary, will be developed and expanded as needed during the data analysis.

Preliminary Findings. Results of the paired t-test comparing the pre and post VKT assessment was found to be $p < .01$ ($p = 0.003$) indicating there was a significant difference in participants' vocabulary knowledge after engaging in STREAM units that included the elementary engineering design cycle. Other data sources will be analyzed to further understand the impact of participation in STREAM activities on fourth grade students' vocabulary development.

Scholarly Significance

Preliminary quantitative findings suggest there is value in incorporating literacy into STEM activities with elementary students in order to enhance their vocabulary knowledge. Research indicates that students in underperforming schools often lack access to a technology-rich learning environments, resulting in lower achievement in reading, specifically in their content area vocabulary knowledge (Beck, McKeown, & Kucan, 2002; Kamil, Borman, Dole, Kral, Salinger, & Torgesen, 2008; Riddle-Buly & Valencia, 2002; Slavin, Lake, Chambers, Cheung, & Davis, 2009). Since low-SES schools are often also under-resourced, multi-disciplinary literacy approaches, such as STREAM units, can positively affect students' vocabulary development across subject areas (Kamil, et al., 2008; Slavin, et al., 2009). The STREAM approach offers 21st century educators a dynamic way to engage students in activities that promote literacy development, provide all students with collaborative opportunities that integrate technology into the curriculum, and promote multidisciplinary learning, irrespective of their socio-economic status or the classification of their school under ESEA. (International Literacy Association, 2000).

Conclusion

Perhaps the most compelling argument for the STREAM approach is a need to keep literacy at the focus of all instruction, even in content-rich, cross-curricular paradigms such as STEM learning. Reading is the key to unlocking all content areas, and should not be taught or viewed as an isolated skill set. Without the ability to read and write, students will be unprepared for future STEM challenges, regardless of the robustness of their subject area knowledge or their facility with technology. Critical analysis, reading for meaning, and the abstract thinking provided by engaging in visual literacy and the arts are essential to graduating well-rounded, fully-prepared students who can meet the demands of college and the workplace.