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Incorporating Engineering and Renewable Technologies into the K-5 Classroom Through Culturally Relevant Literature and Design Challenges

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incorporating engineering and renewable technologies into the K-5 classroom

through
culturally relevant literature
and design challenges

by Lisa B. Bosman, Kelli L. Chelberg, and Greg J. Strimel

1. introduction

Understanding the need to increase STEM interest and participation across all populations from primary school through higher education, an Engineering professor collaborated with faculty from Teacher Education and Humanities to submit a grant proposal to do just that. The college was awarded funding to (1) develop culturally relevant engineering and renewable energy-based curriculum for primary school teachers, (2) pilot the curriculum through YMCA after-school programs, and (3) offer K-5 educators and YMCA instructors professional development workshops to allow for individual exploration and engagement on how one might implement engineering curriculum into their classrooms. The purpose of this article is to provide an overview of the project and provide experiences for teachers to further implement engineering within their classrooms.

2. curriculum development

The curriculum and instructional materials for this project were developed by undergraduate engineering students as part of their first-year engineering experience. The goal of this development process was twofold: first, introduce undergraduate students to the various engineering disciplines and renewable energy technologies through the curriculum development process, and second, leverage the college students' own experiences to produce engaging instructional resources for children in Grades K-5. The aim of the resulting curriculum was to provide children the opportunities to engage in and explore the activities related to the various engineering disciplines/renewable energy technologies while allowing them to explain to others the disciplines/technologies in terms of future career opportunities.

2.1 Engineering Curriculum Development (K-2nd Grades)

First, culturally relevant engineering-focused children's books were developed

by the undergraduate engineering students to engage elementary students in discussions about the different engineering disciplines. An example of one of these books, within the aptly named Future Engineer in Training Series, can be seen in Figure 1. This example focuses on engaging students in biomedical engineering within a relevant context related to the culture of the Menominee Indian Tribe of Wisconsin. Next, LEGO-based design challenges were created to offer students hands-on experiences to explore the actions of those working in each discipline (see Step 1 of Figure 2). Lastly, worksheets, such as the one provided in Figure 2 were used to encourage students to explain the activities of the engineering discipline.

2.2 Renewable Energy Curriculum Development (3rd-5th Grades)

The curriculum for Grades 3-5 focused on renewable energy. Similar to the engineering curriculum for Grades K-2, culturally relevant children's books were created and used to engage students in conversations about renewable technologies (Figure 3), K'Nex-based design challenges offered students the ability to explore a renewable technology within the context provided in the children's book (Figure 4), and worksheets were used to encourage students to explain the opportunities

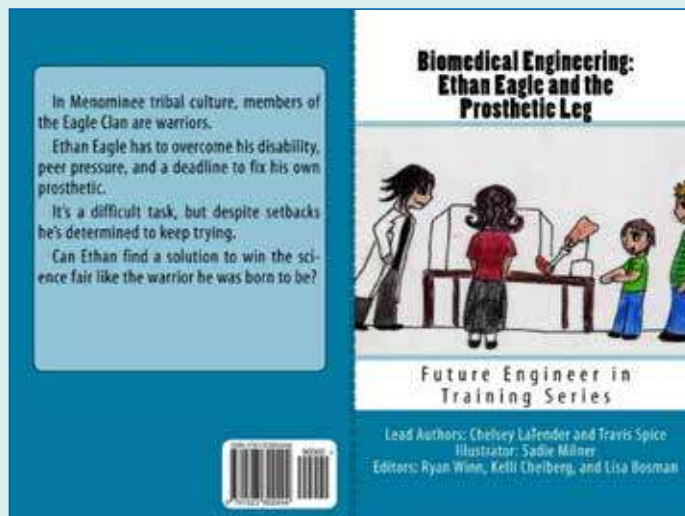







Figure 1. Engage – Children's book created by undergraduate engineering students to engage young pupils in engineering through culturally relevant design scenarios.

Name _____ **Biomedical Engineering Activity**

A biomedical engineer could...

Design an artificial disc to replace damaged discs	Design a better heart valve replacement	Design safe ultrasound technology
		

Step 1: Use the Legos to build something that a biomedical engineer might design. For example:

 Knee Walker	 Prosthetic Leg
---	---

Step 2: Use the back of this paper to draw the design that YOU built!

Today's Biomedical Engineering Activity is brought to you by the College of Menominee Nation. Visit CMN at www.menominee.edu.




Figure 2. Explore (Step 1) – Biomedical engineering design challenge related to the culturally relevant children's book provided in Figure 1. Explain – Biomedical engineering worksheet to guide elementary students in explaining the activities of a specific engineering discipline.

related to and functions of the highlighted technologies.

2.3 Lessons Learned / Teacher Tips for Curriculum Development

How can others adapt this work?

Engage: Engineering-focused children's

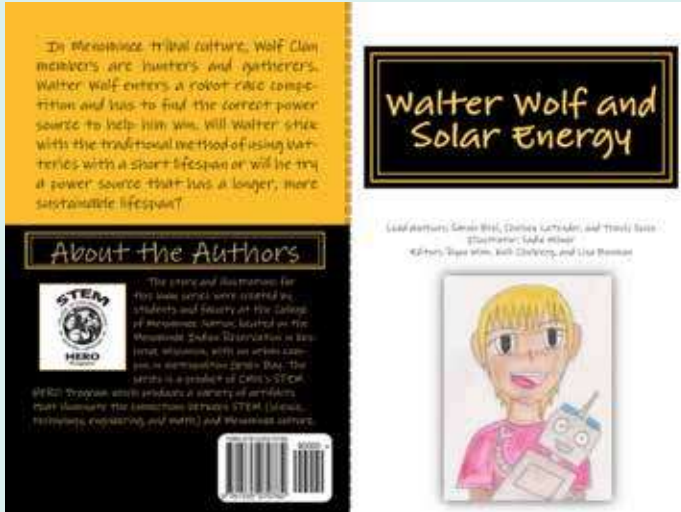


Figure 3. Children's book and corresponding design activity created by undergraduate engineering students to engage young pupils in renewable technologies through a culturally relevant context.

books were used to engage the K-2 students, and renewable energy children's books were used to engage the Grade 3-5 students. To achieve the objective of incorporating humanities into higher education STEM courses, the books were developed by first-year college engineering students. Details of the book-writing process can be found here: www.wiete.com.au/journals/GJEE/Publish/vol19no3/10-Bosman-L.pdf. The books were formatted and published using freely available online tools, CreateSpace.com and Amazon.com. Through these resources, teachers can either create their own books or find a relevant, "engaging"

design for students to replicate can aid in the development of visual-spatial skills. Design challenges allow students the flexibility to think outside the box and can aid in the development of creative-thinking skills. Teachers can leverage older students to play a role in creating design challenges. In addition, K'Nex provides extensive opportunities to extend the lesson in their 69-page teacher guides, and there are many free resources available online (see below for a list of resources).

Explain: Worksheets were used to encourage students to reflect on activities and explain what was learned. The worksheets were developed with assistance from a variety of free resources available online (see below for a list of resources).

What are potential pitfalls?

The children's books required about 20 minutes to read. Since the attention span for this age group is limited, the project leaders decided to read half the book during each session. For the LEGO curriculum, initial LEGO designs were printed in black and white, which provided difficulty in recreating. Thus, the project leaders recommend printing in color to improve the visual-spatial skills. In addition, individual work appeared

book to use in their classrooms.

Explore: Design challenges were used to offer students the ability to explore the engineering disciplines and renewable technologies; LEGOs were used with the Grades K-2 students, and K'Nex were used with Grades 3-5 students. At this young age, providing a picture of a

optimal for the design challenges. For the K'Nex group, working in groups of 2-3 students is ideal. Furthermore, hydro-electric lessons should be done outside during warmer weather, as there is a high potential for making a mess. If there is poor weather, a lamp can be used for solar lessons to simulate the sun; for wind lessons, a fan can be used to simulate the wind.

What costs are involved?

The largest cost is associated with the K'Nex; each K'Nex renewable energy kit costs about \$200. All the books developed through this project are available on Amazon.com for less than \$10 per book; links to the books can be found here: www.cmnstemhero.com/childrens-book-development.

free engineering resources

- Engineering is Elementary (www.eie.org/)
- Teach Engineering (www.teachengineering.org)
- www.educatingyoungengineers.com/lego-club-activity-ideas/
- <https://thestemlaboratory.com/lego-stem-activities/>
- <https://manitowoc.uwex.edu/files/2013/09/The-Great-LEGO-Challenge.pdf>
- <https://kidssteamlab.com/lego-boat-engineering-project-for-kids/>

free renewable energy resources

- www.eia.gov/kids/
- <https://climatekids.nasa.gov/menu/renewable-energy/>

3. curriculum pilot – YMCA after-school program

The curriculum was piloted at five different at-risk metropolitan-based after-school programs impacting over 120 elementary school participants. The



Figure 4. The renewable energy design challenge encourages students to explore renewable technologies through hands-on experiences.

Engineering curriculum was delivered to Grades K-2 students, and the Renewable Energy curriculum was delivered to Grades 3-5 students. Upon completion of the program, students received a certificate (Figure 5).

4. teacher professional development workshops

Two different workshops were offered to local K-5 teachers, one in December 2016 and the other in January 2017. The workshop was about three hours long, and teachers received hands-on guidance towards using the curriculum. Six different schools were represented, with a total of 42 teacher participants with grade distribution as follows:

K	1	2	3	4	5	Coordinator	Preservice
2	0	3	11	10	13	2	1

4.1 Standards Alignment to Next Generation Science Standards

The teachers were shown how potential demonstration of student outcomes could occur through the implementation of curriculum in the classroom.

K-2: Engineering and LEGOs	Standards
(1) Engage (Book Reading)	K-ESS3 Earth and Human Activity
(2) Explore (Design Challenge)	K-PS2 Motion and Stability: Forces and Interactions
(3) Explain (Worksheet)	2-LS2 Ecosystems: Interactions, Energy, and Dynamics
	2-ESS2 Earth's Systems
	K-2-ETS1 Engineering Design

3-5: Renewable Energy and K'Nex	Standards
(1) Engage (Book Reading)	4-ESS3 Earth and Human Activity
	4-PS3 Energy
(2) Explore (Design Challenge)	5-PS3 Energy
(3) Explain (Worksheet)	5-LS2 Ecosystems: Interactions, Energy, and Dynamics
	3-5-ETS1 Engineering Design

As an alternative to deploying the curriculum to the entire class, based on teacher feedback, some educators recommend using the curriculum (books, design challenges, and worksheets) as a means of differentiated instruction. A second grade teacher noted, "I have four students that are particularly creative and high achieving academically that could benefit from working with this kit to challenge them in engineering and problem solving." A 5th grade teacher stated, "I plan to use this as a tool for my students who excel and need differentiated instruction. They will first read the book, talk about it, make the model, report about it, and show the class." Lastly, another 5th grade teacher mentioned, "I plan to use this resource for students who may not otherwise be engaged normally to spark their interest in math and science concepts."



Figure 5. Certificates awarded to students upon completion of the activities.



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