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EXPLORING STEM BEYOND SCIENCE, TECHNOLOGY, ENGINEERING AND MATH THROUGH AN ENGLISH LANGUAGE ARTS NOVEL STUDY

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Synopsis: This case study discusses how STEM learning can be infused into non-traditional STEM curricular areas to encourage and ignite interest in STEM related fields.

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Exploring STEM Beyond Science, Technology, Engineering and Math through an English Language Arts Novel-Study

Abstract

This case study explores the integration of Science, Technology, Engineering and Mathematics (STEM) curriculum in English Language Arts (ELA) through hands-on STEM activities related to a novel-study. Members of a STEM youth outreach program co-developed lesson plans with a grade 9 teacher. The goal of the project was to increase student engagement and success in an ELA novel-study through hands-on STEM learning experiences. The project was successful in developing cross curricular skills and increased engagement for both Arts and Humanities-inclined and STEM-inclined students.

Introduction

Science, Technology, Engineering and Math (STEM) are generally thought to have space within their respective curriculum content areas, or introduced within Applied Design, Skills, and Technology (ADST) themes. Westcoast Women in Engineering, Science, and Technology (WWEST) staff collaborates with classroom teachers across British Columbia (BC) and the Yukon to break down barriers and challenge thoughts on "expected" STEM spaces, to demonstrate the ease and ability to incorporate STEM learning into non-traditional/atypical subject areas. Working with one teacher and three different classrooms in her charge, WWEST developed and facilitated STEM lessons within English Language Arts (ELA) curriculum. The goal of integrating STEM components into ELA, was to increase engagement and success of Arts and Humanities inclined learners with STEM concepts. The novel, The Boy Who Harnessed the Wind: Creating Current of Electricity and Hope (Kamkwamba & Mealer, 2010) was used as a backdrop to weave literacy skills with STEM learning.

STEM and STE(A)M Learning: (A-Arts)

STEM education is often defined as solving problems using two or more concepts or procedures from science and mathematics, as well as engineering and technology (Sanders, 2009; Shaughnessy, 2013). Integrated STEM is the idea of bringing together any two or more of the STEM subjects and one or more other school subjects (Ortiz-Revilla et al., 2020; Sanders, 2009)

There is no consensus on the exact framework of how STEM is achieved (Aguilera & Ortiz-Revilla, 2021); however, previous research has demonstrated the benefits of integrated STEM. For example, teaching science concepts as systems achieves increased knowledge gain, engagement, and retention (Mehalik et al., 2008) and STEM problem situations are closer related to real life with multiple factors and needing other disciplines to solve (Altan et al., 2018). To

increase engagement with STEM, learning activities need to integrate knowledge and skills across disciplines (Newhouse, 2017) and have relevance to students (Bissaker, 2014).

The benefits of incorporating Arts into STEM education are the creativity, approaching problems in multiple ways, and cooperative problem solving (Herro & Quigley, 2017; Ozkan & Umdu Topsakal, 2021). STE(A)M educational activities provided cross curricular skill building including "problem-solving skills, via the presentation of difficult concepts through more easily understood visual or auditory channels" (Harris & Hays, 2022) and interdisciplinary collaboration (Peppler & Wohlwend, 2018). STE(A)M introduces "new ways of understanding complexity and representing knowledge" (Peppler & Wohlwend, 2018). It brings together both divergent thinking used in Arts and Humanities with convergent thinking often used in STEM (Land, 2013). These benefits create the opportunity to engage those who are not STEM inclined (Falloon et al., 2020).

Program Structure

Background

WWEST STEM Curriculum Supports programming is available to teachers at no-cost throughout BC and the Yukon. During the pilot year in 2021, a North Okanagan teacher connected with WWEST to determine if programming could be applied to her non-traditional classroom. This classroom was a combination of students in two different classes, who did not "fit" in traditional learning classrooms and were placed together in her care to learn various skills and competencies within the BC Education ADST outcomes. These trial classes and the year that followed, incorporated lessons developed by WWEST that introduced concepts related to circuitry, construction, physics, sustainability, along with a variety of core curricular competencies.

Students involved in the two years of experimenting with STEM learning in non-traditional ways, shared self-reflection through e-portfolio entries, indicating the positive influence STEM learning had on their education. Based upon these responses and the success of these pilots, in the 2023-2024 school year, a third collaboration between WWEST and the same teacher but at a different school, was developed with the goal to incorporate STEM into a junior high ELA novel-study unit. Through discussion it was determined it would be worthy of an attempt to create hands-on STEM focused learning experiences to reinforce knowledge and skills developed in an ELA unit based on the novel "The Boy Who Harnessed the Wind," by William Kamkwamba and Bryan Mealer. It was thought that this pairing of subject matter would increase engagement and success in cross- curricular outcomes tied to STEM and ELA.

Cross-Curricular Development

Through collaboration and exploration of the BC Education outcomes for ADST, ELA, and STEM, four lessons were developed that would stitch together an opportunity (on a micro-level) to experience some of the learning that the true-life-story character, William Kamkwamba had while growing up in Malawi with very few resources. Not only were various curriculum goals achieved, but cross curricular competencies and life skills related to overcoming challenges,

working with limited resources, perseverance, resiliency, cooperation, and sustainability were also developed.

Class Composition

Twenty-four grade 9 students in a traditional ELA class participated in the 2023 STEM and ELA lessons. Students in this class were within "normal" learning levels for a grade 9 classroom in a public education system in southern BC.

Novel Choice

"The Boy Who Harnessed the Wind: Creating Current of Electricity and Hope" (Kamkwamba & Mealer, 2010) is a novel based on the true-to-life-story of William Kamkwamba who was a young boy with a passion for creating change for his family, and in his community.

William Kamkwamba's first windmill

Photo by Eric Hershman, 2002

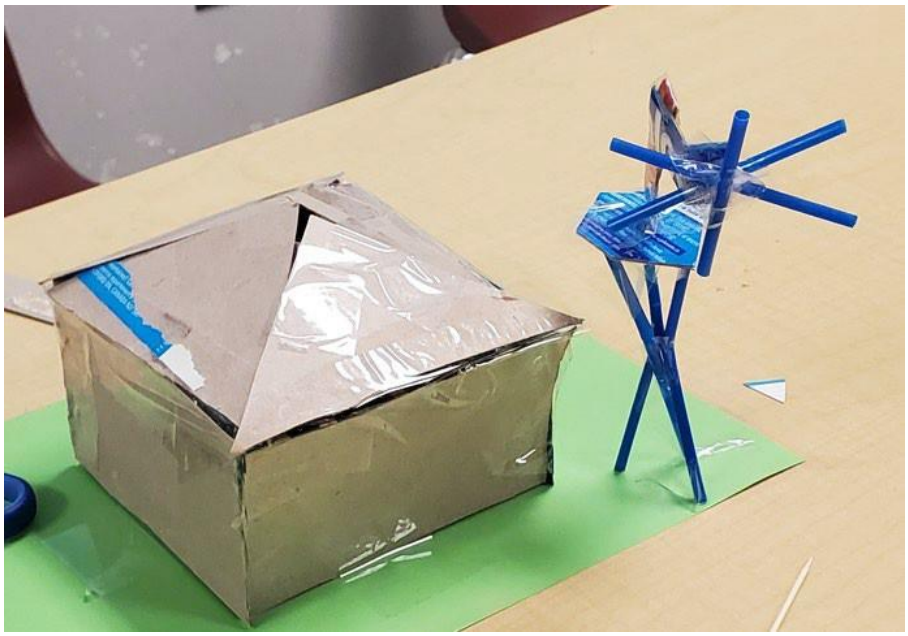
Living in a low-socioeconomic country and having few resources, William was driven by curiosity, determination and resiliency to create a way to harness wind and solar power which would support, and educate, his family in sustainable farming and survival. Through a series of life experiences, he was successful in his endeavours and went on to attend post-secondary school in the United States, to further his knowledge and skills. Had he not had passion, vision, resiliency and determination, the outcome of his life and that of his family and community may have been different.

Curricular Integration & Collective Experience

Novel Connections and Cross Curricular Skills Gained

The connections to the novel were both broad as well as detailed as students completed a four-part lesson series that intertwined STEM and ELA outcomes. Students read the novel, and at appropriate markers tied to the story, were given an opportunity to create a model of a working windmill using limited resources, as a way to empathize with the experience of William Kamkwamba. This lesson required students to use many STEM-based skills to build a windmill-type structure which would support a small motor, and moving parts. Participants were given a variety of basic materials to choose from, and then were given instruction on how to build a small motor.

Example of the beginning stages of the project, prior to adding a working motor:



Example of students attempting to build a working motor for their windmill:

If I didn't think of how our design worked with physics it wouldn't have worked, we talked about how to solve problems and overcome them, we played with it until it worked and had no problems. - Grade 9 Student

Building the motor, took a large degree of resilience, patience, design revision, trial and error, collaboration and cooperation before success was achieved. This experience and process of utilizing STEM learning to relate to a novel-study, created impact and increased both engagement with the novel and interest in STEM activities, as was shared by students through reflection portfolios. When prompted with "What learning or competencies were used in this novel-study and STEM activity", one student responded:

We had to use all three core competencies. We used communication to problem solve and ask questions, we had to use creative and critical thinking to figure out how to make the windmill work, and we used personal and social connection, to be respectful of the instructor. – Grade 9 Student

Technology

Digital literacy is a key part of the BC Education curriculum, and this project aligned with many opportunities to infuse related competencies and development of skills throughout. Students not only used computers for researching design, building knowledge of small motors, geography and gaining knowledge of William Kamkwamba and his lived experience, but to also create e-portfolios for reflection and gain a sense of equity in accessibility as depicted in the novel and contrasted with personal experience. Further, design-skills using technology allowed students to express creativity beyond the tangible materials available in the classroom.

STEM Solutions to Climate and Socio-Economic Issues

As students progressed through this project, they gained a stronger sense of the struggle described in the novel, while participating in the hands-on STEM components. Learning to design and construct a working model of a windmill with limited resources, knowledge and skills, created challenges before successfully achieving a goal. William Kamkwamba learned engineering, technology and physics skills by reading outdated books, scavenging through piles of discarded or abandoned materials, collaboration with others, and taking apart and rebuilding radios, which is in sharp contrast to the way in which Canadian students typically learn. Generally, Canadian students have access and transportation to classrooms and resources and do not have to choose between family survival and attending school. For these Western-living students, having to engage in simple challenges and overcome struggles was a gateway to rich conversation about inequities and the vast differences between education systems, acquisition of useable resources, and sustainability in Western learning and other regions of the world.

The lessons were also connected to sustainable housing and community care through the lens of First Nations Comprehensive Community Plans. In this way, the socio-economic issues in the novel where STEM was used as a solution, were connected to local issues. Students were able to see how STEM solutions apply to, and impact nearby communities, making the learning more realistic and sustainability issues relevant.

Equity, Diversity, Inclusion (EDI)

Teaching through a lens of EDI was conducted throughout all three projects. Students did not receive the same materials or supports and had to overcome barriers and create collaborations with their peers in order to successfully achieve curricular goals and outcomes. This group achieved a state of equity within a diverse group, by being inclusive and cooperative. As reported by their teacher, prior to participation in the STEM infused ELA novel-study, this group of students did not have a large degree of social interaction outside of their small cluster of peers. As the lessons unfolded, and they found themselves needing to rely on each other's expertise, an

inclusive community was formed. Again, in response to the prompt, "What learning or competencies were used, one students' reflection was recorded as:

> *Today we used all the core competencies, Thinking, Commutation, Personal and Social. My partner and I collaborated to make the double decker balance and got ideas from other people in the classroom. We also used creative and critical thinking as we needed to think about how we wanted to combine our models and make it look good at the same time. – Grade 9 Student*

Reflection – Cros-curricular STEM

As students reflected on their experience and core competency connections, it was established that this STEM-ELA experience took a common novel-study experience and made it truly remarkable. This project allowed students to try new things and provided an opportunity to embrace differences to enhance and create new communication pathways between diverse groups of students. The visual story created by reading the novel, combined with hands-on cross-curricular learning engagement, created resiliency, excitement, confidence, pride in their abilities, and a desire for pursing STEM learning opportunities. As a final task, students were asked to reflect on the project. An example shared included:

> *It took a cup of trial and error with a pinch of problem solving, mixed together with my genius brain to come up with the idea. Then the rest went by pretty quickly. Having it finished was super satisfying because it worked great. I was really proud of it. – Grade 9 Student*

It was anticipated that students who were Arts and Humanities-inclined would become more engaged, but a pleasing reciprocal effect also occurred: students more STEM-inclined became more engaged in the novel and ELA related curricular outcomes. According to the classroom teacher, and based on the quality of final projects along with the richness of discussion and collaboration, the STEM-inclined learners became more engaged with the story and discussions; while the ELA-inclined learners became more engaged with STEM while experimenting with building models based on elements from the story. Infusion of STEM activities into the ELA lessons created increased engagement for all students.

Conclusion

STEM integration is defined as merging two or more STEM topics, such as Math and Engineering. The Boy Who Harnessed the Wind was an example of successfully combining STEM and ELA curriculum to increase engagement and interest across curriculum. In addition to gaining STEM content knowledge, students increased curricular and competency skills including resilience, cultural understanding, and collaboration.

STE(A)M learning activities that support students as they integrate knowledge from across disciplines as they solve real life problems increase interest by creating community solutions (Newhouse, 2017). The Boy Who Harnessed the Wind lessons engaged the students by requiring cross discipline skills, collaboration, and creativity; but most importantly it created excitement and pride and sparked individual passion for STEM based learning.

"I went to sleep dreaming of Malawi, and all the things made possible when your dreams are powered by your heart." - William Kamkwamba ~The Boy Who Harnessed the Wind

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