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Integrating Social Studies Education with Mathematics: Pre-service Teachers' Use of the Pyramids of Giza to plan a STEM Lesson

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Abstract

Pre-service teachers (PSTs) often struggle to teach STEM (Science, Technology, Engineering, and Mathematics) content effectively due to lack of training on how to plan a STEM lesson in meaningful ways as well as which subjects to integrate. This dilemma often results in an avoidance of STEM methodology altogether. This paper describes a productive method for training PSTs to successfully teach STEM lessons by using Social Studies content to integrate with Mathematics and Science and to provide context and connection to real-world applications. Along with providing a STEM lesson, the article demonstrates the critical role Social Studies can play as the "glue" for some integrated lesson plans.

Keywords: STEM, Social Studies, pre-service teachers, lesson plan

Introduction

For more than 30 years, educators have looked for ways to integrate different content areas in their lessons (Drake & Burns, 2004). Integrated lessons offer students the opportunity to learn about a topic or theme in a way that connects ideas across disciplines. In particular, students can benefit from lessons which integrate STEM topics in a way that illuminates how Mathematics is situated in authentic, real-world applications (Ryu, Mentzer, & Knobloch, 2019). Middle school Social Studies curriculum can offer a meaningful opportunity to connect socio-historical real-life concepts with STEM. Unfortunately, integrated STEM lessons are far from commonplace in K-12 education. Because of this, pre-service teachers (PSTs) often have little experience with STEM learning and are therefore limited in imagining how these kinds of lessons can be implemented in their future classrooms (Ryu et al., 2019).

Integrating Social Studies with STEM activities can help PSTs develop critical thinking, active citizenship, and problem-solving skills that allow them to address complex world problems (Manfra, 2013; Hartshorne, Waring, & Okraski, 2019). Maguth (2012), even suggested that Social Studies is the "essential 'glue'" that holds the STEM disciplines together. Though integration is the goal, it is not often achieved. However, more attention to integrating Social Studies with STEM activities has a host of benefits. In particular, it encourages PSTs to create lessons that are interdisciplinary, are relevant/have a real-world context, and would be engaging to early adolescents.

The purpose of this article is to provide an example of a pilot module from an undergraduate Mathematics methods course which allowed PSTs to integrate Social Studies with STEM lessons. We worked with PSTs to create a learning segment (a series of 3 consecutive lessons) around a real-life geometrical and construction marvel, namely the Pyramids of Giza. The Pyramids of Giza provide a practical example of integration of geometry (area and volume) and Social Studies due to their geometrical shape, and a world monument that has stood throughout time (Lloyd, 2014). The Pyramids provide an authentic Social Studies topic that naturally integrates multiple subjects such as Mathematics, Science, Engineering. The next section explains the pilot module.

A STEM Lesson Plan for 6th Grade: Mathematics in the Ancient Egyptian Pyramids

In a Methods of Teaching Mathematics course, PSTs used the Mathematics of the Golden Pyramid (one of the Pyramids of Giza) to construct a Learning Segment (a plan for 3 consecutive lessons around the same topic). The Learning Segment was designed to promote the integration of Social Studies with Science, Engineering, Mathematics, and Design. Ten PSTs were divided into pairs, each pair focusing their Learning Segment on one of the subjects listed above. The lessons each team designed had a rich Culminating Task, namely constructing a model of the Great Pyramid of Giza.

To begin planning an interdisciplinary lesson, we thought it was important for PSTs to gather background information about the Great Pyramid of Giza. This enabled them to situate their work in historical context. One important point that helped guide PSTs' work is that scholars and engineers are certain that the ideal dimensions and the construction technique used in the Great Pyramids of Giza did not happen by chance (Hemeda & Sonbol, 2020). Infusing historical information about the Pyramids of Giza offers a context to the Mathematics and Engineering concepts involved and helps to make connections to the importance of Mathematics real for the PSTs and their future students.

What follows is a detailed list of the objectives for the course assignment as well as a description of some of the ways PSTs used these objectives to inform the design of their Learning Segment. The essential question for the learning segment was: *How have Giza's pyramids survived natural disasters such as earthquakes for thousands of years?*

The Pilot Module

Following are the goals and objectives the PSTs will accomplish by the end of the assignment. PSTs will be able to:

1. Research and respond to the essential question from the disciplinary lens of the subject area of their group: Social Studies, Mathematics, Science, Engineering, or Design.
2. Select components of their research to drive pedagogical decision making for their STEM lesson plan.
3. Sequence the lessons in their learning segment to dovetail towards the summative performance task (a sugar cube replica of the Great Pyramid).
4. Write a reflection addressing how they thought their planning went, how they would make their lesson accessible for 6th graders, and how they could modify their task for their future students.

In the next section we address the process by which each team created an integrated STEM lesson to teach Mathematics standards as well as respond to the Essential Question of the Unit. We draw from the PSTs’ reflections to show in more detail each team’s thought processes, the questions they asked, and how each team described the ways in which their lesson connects to the performance task of the Sugar Cube Pyramid. Finally, we describe how PSTs reported the challenges they faced, and the lessons they learned that will help them and other PSTs design future STEM lessons.

Questions PSTs Asked

Each team worked together to brainstorm questions that would frame their thinking about answering the Essential Question and designing the Learning Segment. The questions that the PSTs created were interdisciplinary. The design of the assignment allowed PSTs to marry the different disciplines together to make the lesson.

Mathematics	What are area, surface, and volume, and how do you calculate them? What is the relationship between area, surface area, and volume? What is the relationship between area, surface area and volume for the Great Pyramids of Giza? Why did the Ancient Egyptians choose these particular dimensions for the pyramids?
Science and Engineering	What is an earthquake? Does area, surface area, and volume impact building destruction from earthquakes? Can Mathematics be connected to both pyramids and Engineering? How can we make Mathematics engaging for middle school students?
Social Studies	How could we create a history lesson that would tell an interesting backstory for the Mathematics lesson? What was the purpose and symbol of the smooth angled sides of the pyramids?
Design	How many sugar cubes would we need to complete the model of the pyramid? What would be the best material to use for the pyramid? What would be the best way to divide the task of building the pyramid between middle school students in the classroom?

All PSTs asked content-based questions that related to their subject area. The teams also asked pedagogic questions that would help them to connect their subject area with how to plan and enact their lessons. In the process, many of the PSTs engaged in an interdisciplinary mode of thinking; for instance, the Science team asking, “What is an earthquake?” while simultaneously thinking about how to connect how the area, surface area, and volume of the pyramid may impact the destruction of the pyramid, allowed them to think interdisciplinarily.

Thought Processes for the Design of the Learning Segment

Each team had different thought processes that framed and guided their thinking around designing the Learning Segment. They each thought through the creation of the Learning Segment while maintaining a focus on their particular subject area. A summary of each team's thought process, taken from reflections PSTs wrote, is in the table below.

Mathematics	Re-taught themselves the content using videos, books, and other online resources. Decided what order to teach the content in.
Science and Engineering	Wanted to focus on the flow of the 3 lessons. PSTs explored the Science and Engineering aspects first, which allowed for developing motivation for the culminating task.
Social Studies	Decided to focus on the history of the pyramids. Found primary and secondary sources for their middle school students. As there was a lot of material, they chose to design stations for their students to engage with the material.
Design	First determined the dimensions of the pyramid, then calculated how to use the given materials to build it. Thought about having their students estimate the amount of materials (e.g., how many sugar cubes?)

All of the teams focused their thinking on how to connect their assigned subject area to the development of the culminating task. They sought out resources to strengthen their own understanding. With that new knowledge, they were able to carefully consider how to sequence the lessons in their Learning Segment to be most beneficial for their middle school students. Below is a summary of the lessons each team designed.

Mathematics	In Lesson 1, middle school students were introduced to and practiced finding the area of 2D geometric figures using area formulas. In Lesson 2, students learned the strategy of using a net to find the surface area of a pyramid. In Lesson 3, students looked up the dimensions of the Giza Pyramid and used the net strategy to find its surface area. As an extension, students could find the volume of the Giza Pyramid.
Science and Engineering	Lesson 1 is an introduction to pyramids and how they are built (Engineering). Lesson 2 is a continuation of Engineering with connection to Science and Mathematics. They asked middle school students to build a non-pyramid structure with provided materials (marshmallows and spaghetti) and within a given time frame during a simulated earthquake Weather Alert. In Lesson 3, they will compare how different models

	would survive a simulated earthquake. Which shape is sturdier, a pyramid or the structure built in Lesson 2?
Social Studies	First lesson provided background knowledge and the purpose and process of the construction of the Pyramids of Giza. This contextualized the second lesson where students used the net of the pyramid to create a blueprint for the sugar cube pyramid they would create in the culminating task. They would later compare the shape and dimensions of their pyramid with those of the real pyramid of Giza.
Design	Lessons helped middle school students design the sugar cube pyramids. In Lesson 1 they calculated the dimensions and used those dimensions to determine how many sugar cubes they would need to build the pyramid. Lesson 2 they started making the layers of the pyramid, starting with the base. To make subsequent layers they indented 4 cubes on each layer until they reached the vertex. Lesson 3, they glued together the layers of the pyramid and sprayed the whole structure with gold paint. In addition, they wrote each of their names in hieroglyphs to show they were the builders of the pyramid.

Challenges Faced

Some challenges that PSTs faced when designing their STEM learning segment was learning content they were not very familiar with. For example, the Mathematics team had to learn about the difference between surface area and area; (i.e., area is for a 2D shape and surface area is for a 3D shape). PSTs sought out resources to help support their learning and lesson planning. For instance, some reached out to teachers and others did library or internet research. The Mathematics team spoke to a high school teacher about the relationship between area and surface area to break it down in the lesson plan.

Another challenge was trying to avoid getting overwhelmed with the process of designing a STEM learning segment. For instance, the Social Studies team felt anxious about the number of steps they had to do to complete the project. They started breaking down their tasks into smaller parts and created several shared documents online and started to work on a general plan together. Then they held a conference call to revise their learning segment and connect the parts of the learning segment.

The Engineering team struggled to connect surface area, area, and volume to the Engineering of pyramids. This struggle came due to the very large dimensions of the Pyramids of Giza, and the team feared that without using these numbers, the content may not make sense. After some careful thinking, they came to the conclusion that their middle school students could still engage in the desired problem solving by considering the shape and structure of the pyramid, and not necessarily the specific area, surface area, and volume. If anything, this is a wonderful

opportunity for PSTs and their future students to brainstorm, hypothesize, and predict how the Egyptians were able to use Engineering on such a large scale!

Considerations for Future PSTs

The PSTs agreed that the STEM project was complex in nature. Designing and planning interdisciplinary lessons requires thoughtful considerations. One important aspect of developing an integrated STEM project using Social Studies is to have an authentic real-world context to be the connective thread for them to tie the pieces of the STEM concepts together. For example, this learning segment was glued together with the story of the Pyramids of Giza.

PSTs who wish to integrate a STEM lesson should consider the knowledge their middle school students bring with them into the classroom. In this way they can build from that knowledge and extend students' understanding of the lesson objectives. By accessing prior knowledge of their students in each subject area, PSTs can plan how to make the subjects come together into a cohesive lesson.

The second thing to consider is to know how to integrate subjects together in a way that makes the connections natural and fluid. What that means is there should not be gaps within the lesson; it should rather flow. The lessons should not be presented in an "introduce, learn, practice, move on" manner. Instead, the subjects should be intertwined together. By presenting the lesson in this way, middle school students will better understand the content, be more engaged, and produce a better outcome. Additionally, in order to create a stellar STEM learning segment, collaboration is key. One person cannot possibly know everything about Science, Technology, Engineering, Art, and Mathematics. With this being true, reaching out to a teacher who specializes in each content area was helpful in creating a cohesive lesson segment that accurately teaches each aspect of STEM.

Following are some examples of questions that can and should be asked to support the development of a STEM learning segment: What is the goal/objective for each lesson? What is the purpose of this segment, and how can it be connected to middle school students' lives? Who should review my lesson before I go through with it? Who can I ask for help on a particular subject? How can I teach this lesson in the best possible way to better serve my students?

Other questions to ask are regarding tying the STEM learning segment with the summative performance task. PSTs should ask themselves: Which subjects can learners approach this content through? What activities will require middle school students to draw on prior knowledge from other lessons and subject areas? How can I assess my students' learning throughout a lesson to ensure they're meeting the lesson objectives? How can I make the rich culminating assessment task something that ties all student learning together so far? How can I embed aspects of this assessment task into the lessons from the integrated subjects? To optimize students' investment and learning of content, a teacher needs to make sure the lessons and standards have connective tissues to other subject areas and life outside the classroom. It's more work but it makes the learning more meaningful.

As with all lesson development, accessibility and differentiation should be carefully considered. Some questions that could guide PSTs' thinking around this are: How can I make this material accessible to all of my middle school students, especially those who struggle with Mathematics and Science? How can I make these lessons tiered for all students? How can I differentiate instruction to provide support for students who may need it?

Conclusion

Training PSTs in STEM lesson planning is enriched and enabled by using a Social Studies component. The STEM assignment's semi-guided design and the instructional methods used in the project helped PSTs achieve all of the assignment's objectives. In methods courses, PSTs often learn how to design an age-appropriate, paced lesson plan that achieves the Common Core standards. This paper demonstrated that creating STEM lesson plans equipped PSTs to think beyond ordinary lesson planning activities. The design of the assignment created a mystery for the PSTs to engage them in this thought process. Because the PSTs were engaged with the interdisciplinary Essential Question of how the Pyramids of Giza have survived, they were inspired to create interdisciplinary lessons for their middle school students. The Social Studies component gave relevance to the lesson, situated it in a real-world context, and acted as the glue that bound all the other subjects to form one cohesive lesson.

Through the enactment of this pilot module, we saw PSTs eagerly meet the challenge of a complex project. They learned new pedagogical approaches and ways to refine their lesson planning. For instance, they engaged in meaningful problem solving by thinking critically about their STEM lessons and how to connect different content areas. When they came up with a solution that was unsatisfactory, they worked to come up with an alternative solution. They found themselves thinking about their capabilities as teachers and what they needed to learn as well as thinking about their middle school students and how to make the learning accessible to them. They practiced collaboration, negotiation, design and planning. They realized that thought and effort are rewarded by meaningful and creative outcomes.

We will continue to engage our PSTs in creating STEM learning segments and lessons so that they would take their learning to the schools, and so creating and teaching STEM lessons become common practice. When creating lesson plans, especially in STEM, teaching with passion and creating engaging tasks like the one explained above will allow PSTs to gain interest in the area of STEM and allow them to carry that interest into the classroom for their own students.

References

Drake, S. M., & Burns, R. C. (2004). *Meeting standards through integrated curriculum*. ASCD.

Hartshorne, R., Waring, S. M., & Okraski, H. (2019). Developing well-informed, critically thinking, and active citizens through the connection of modeling & simulation and social studies education. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *92*(1-2), 48-52.

Hemeda, S., & Sonbol, A. (2020). Sustainability problems of the Giza pyramids. *Heritage Science*, *8*(1), 1-28.

Lloyd, J. (2014). How have the Egyptian pyramids lasted so long? Science Focus. Last modified, 2014. https://www.sciencefocus.com/science/how-have-the-egyptian-pyramids-lasted-so-long/

Maguth, B. M. (2012). In defense of the social studies: Social studies programs in STEM Education. *Social Studies Research & Practice (Board of Trustees of the University of Alabama)*, *7*(2).

Manfra, M. M. (2013). Grand challenges: Nanotechnology and the social studies. *Social Education*, *77*(2), 95-98.

Ryu, M., Mentzer, N., & Knobloch, N. (2019). Preservice teachers' experiences of STEM integration: Challenges and implications for integrated STEM teacher preparation. *International Journal of Technology and Design Education*, *29*(3), 493-512.