Pre-service Teachers' Fieldtrip to the Battleship: Teaching and Learning Mathematics through an Informal Learning Experience

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Abstract

Teacher education programs are designed to provide candidates opportunities to explore effective ways to teach K-12 students mathematics. Although many of these experiences engage candidates in investigations of pedagogies using technology, manipulatives, media, etc., they often only involve and emphasize more formal experiences such as demonstrated in micro-teaching, K-12 school classroom internships, and mathematics content courses. This article describes teacher candidates' capabilities of learning how to teach mathematics through an informal learning experience. Candidates visited the North Carolina Battleship and wrote lesson plans on integrating the Battleship culture into high school mathematics objectives. The article concludes with a discussion of candidates' reaction to and attitudes about the informal learning experience and their perceptions of the advantages and disadvantages of learning teaching strategies in this fashion.

Introduction

Informal learning is defined as any learning that takes place outside the formal structure of the classroom (Sullenger, 2006). While field trips are the most traditional implementation of informal learning, other types of informal learning may take place through clubs and organizations, virtual visits and traveling programs that bring objects and educators to schools (Melber, 2000). The literature provides numerous benefits offered to students who learn in an informal learning environment. Many believe that such environments present opportunities for students to visualize concepts introduced in class laying the foundation for a deeper understanding of the material (Falk & Dierking, 1997). Falk and Dierking (1997) found that students who experience field trip opportunities in school remember unique artifacts and displays well into adulthood. Overall the consensus is that informal learning environments can be extremely useful in teaching a variety of topics however it is believed that such an event must be well executed and properly aligned with the curriculum in order to be effective. In fact, when a proper connection between the field trip and curriculum is not made, students tend to not view the trip as a unique learning experience but rather as a treat which often leads to an unproductive experience (Noel, 2007).

In disciplines such as science and history there are many existing locations that teachers can turn to for assistance in providing an informal learning experience. Historical landmarks and museums come to mind as possible informal learning settings for a history course while science teachers may choose to take their class to visit a zoo, aquarium or nature center. However, when

we shift our focus to mathematics, possible locations for informal learning environments are not as apparent. The lack of structured opportunities for mathematics means that teachers may be left to their own devices and experiences in planning these events.

In recent years many studies have focused on strategies to help teachers conduct more productive field trips. One area of particular interest is the need for teachers to prepare information before accompanying students to the location. Having teachers visit the location prior to the event and possibly speaking with site personnel to set expectations is said to be a key factor in a successful field trip (Melber, 2000; Anderson and Lucas, 1997). In addition, in an effort to help students focus on the intended purpose of the visit, teachers are encouraged to inform students about the trips agenda, what concepts will be targeted and how the field trip is related to the curriculum (McLoughlin, 2004). In fact, Orion and Hofstein (1994) found that that having students complete a lesson related to the field trip prior to going actually increased their learning during the trip itself.

Along with implementing a pre-activity prior to the field trip, the literature also suggests that teachers should conduct an additional activity after the field trip is completed (Kisiel, 2006; McLoughlin, 2004; Falk and Dierking 2000). The post-activity should be conducted relatively close to the field trip itself but the type of activity that may be implemented can vary. Having students create a newsletter about their trip or requiring students to make a presentation on what they learned both constitute post-activity follow-up. However, Kisiel (2006) notes that if the field trip was designed with the curriculum in mind then the post-activity is "simply the next lesson or project that builds on the experiences introduced" during the field trip. Regardless of the type of post-activity used it is believed that such an event allows students to review and synthesize the information they learned during the trip while simultaneously reinforcing the purpose of the trip itself.

Since there appears to be a need for possible approaches for creating informal learning settings in mathematics we were positive that we would find studies that focused on this issue. Overall however there is a limited body of work on how mathematics teachers create and use informal learning environments. In one study pre-service teachers enrolled in a mathematics content course were required to develop a field trip experience that they could replicate with their future students (Munakata, 2005). The entire project was completed by the students outside of class in groups. Although the project required students to submit a report and lesson plan, it did not emphasize the specific components that researchers suggest are necessary in implementing a successful field trip. These students offered a variety of locations for possible mathematics field trips however a wonderful idea may be insignificant if it is not executed effectively. Clearly, more evidence is needed about the effects these experiences have on student learning as well as the various ways and means teachers implement them.

In our project, secondary mathematics pre-service teachers enrolled in a methods course at a mid-size university visited the USS North Carolina Battleship on the North Carolina Cape Fear Coast with two other discipline cohorts (science and social studies). This project aimed to introduce candidates to the pedagogy of informal learning experiences to : (1) emphasize the connectedness of mathematics to interdisciplinary concepts, and (2) promote its effective use in the prospective teachers' own classrooms.

The Project

All of the secondary pre-service teachers enrolled in a methods course were charged with developing an informal learning experience to use with their prospective students. The

experience was purposed with providing high school students a more interdisciplinary perspective of how their subject-area can be used in the real world. Specifically, secondary mathematics education students were to consider the relationship between what they discovered about the Battleship and high school mathematics content (Algebra, Geometry, etc), investigate ways in which to incorporate technology to assist in modeling occurrences on the ship, and link connections between the two to content and technology related standards.

Because research suggests that field trips are effective when teachers pre-visit the site (Melber, 2000), introduce the purpose and agenda of the field trip to their students, and create meaningful post-visit activities that are connected to the curriculum (McLoughlin, 2004), the pre-service math teachers in this project were asked to do the same. They were required to: (a) visit the Battleship with their peers, (b) create a Powerpoint presentation that would serve as an overview and introduction to their own classroom students, and (3) create a lesson plan that addressed a topic in the curriculum and taught through the perspective of the Battleship trip.

The Battleship Experience

The field trip began with secondary pre-service teachers of all subject areas watching a brief film on the history of the Battleship. They were then grouped by their intended licensure area to discuss possible content-based themes (i.e. problem or inquiry based learning, or authentic learning environments, etc) that could be explored while touring the ship. Interdisciplinary teams were formed and challenged to create a learning experience appropriate for high school students that would meet National Council of Teachers of Mathematics (NCTM) and North Carolina Standard Course of Study (NCSCOS) objectives. All teams represented one of eight departments of the Battleship. The eight teams and key questions for each team to consider were:

1. Navigation: How would sailors plot your location and navigate the Battleship NC and other ships during WWII?
2. Gunnery: What was the gunnery purpose of USS NC during WWII? What was the data sailors on the Battleship NC needed to : 1) bomb an island, 2) destroy and aircraft, and 3) attack another vessel?
3. Hull: How does the Battleship NC float and how did the sailors keep its watertight integrity? How did various types of ships and hulls influence WWII? Why didn't the Battleship NC sink when torpedoed?
4. Medical: What types of contagious diseases were treated on the Battleship NC and during WWII? How were the sailors' diseases prevented and isolated?
5. Communications: How did the sailors on the Battleship NC communicate during battle situation without electricity? How did ships safely communicate during WWII?
6. Engineering: How did sailors safely propel a 44,800 ton ship at 28 knots? Why and how did they build such a vessel in the 1930s?
7. Supply: What did the sailors during WWII and on the Battleship NC consume as food? How did the department feed 2,341 people in a confined area?
8. Executive: How is the ship organized? Why?

It was important for the pre-service teachers to simulate the entire process of planning and implementing a curriculum-based field trip as teachers often underestimate the time and effort it takes to develop a meaningful field-trip for students (Mcloughlin, 2004). This importance was

emphasized by requiring the prospective teachers to also include all components of an actual informal-learning opportunity.

Each prospective teacher created a letter to principals and parents requesting permission for students to attend. They also visited the Battleship and discussed teaching opportunities with their interdisciplinary groups; an activity likened to actual same-grade or same-subject teachers working collaboratively to plan a field trip for their students. Afterwards, candidates created a PowerPoint presentation to be used as a pre-activity and create a frame of reference and focus for their own secondary students.

Sample Lesson Plans

The following three lesson excerpts demonstrate the pre-service teachers' understanding of the importance of providing students with real-world, authentic experiences when learning mathematics. The first lesson is connected to the Navigation function of the Battleship and is designed to give students a perspective of the mathematics it took to plot a course of direction. The second lesson focuses on the Engineering functions of the ship which dealt with the speed needed to move a large ship through water from one destination to another. The last lesson provides a connection to the Gunnery functions of the Battleship and how weapons were used to protect the ship.

Student 1 – Navigation:

One student, a former marine, created an activity that integrated algebra, geometry, and navigation science. The pre-activity consisted of a PowerPoint presentation which provided students with background information of the USS North Carolina and a description of the tools used to navigate the ship. The pre-service teachers' post-activity lesson was designed to teach his students how sailors used mathematics to navigate the ship. The students explored finding the magnitude of a vector using right triangles. The lesson used authentic vocabulary that would connect information that students were exposed to during the field trip. This student was also able to lend his own personal experience to the student's interaction with the content (curriculum) and informal learning opportunity which would make the experience more meaning for both student and teacher. An excerpt from the student's post-activity lesson is given below.

A. DETERMINE THE DISTANCE/MAGNITUDE OF A VECTOR PLOT.

The distance or magnitude of a vector plot is simply the length of the vector. To determine the magnitude of a vector, first transform the vector into a right triangle.

a) DETERMINE THE MAGNITUDE OF VECTOR PLOT #1 (Figure 1)

1) DETERMINE THE LENGTH OF SIDE a_1. Since side a is the vertical side of the right triangle, the length of side a is determined by the formula $y_2 - y_1$. Thus, the length of side $a_1 = 20 - 5 = 15$.
2) DETERMINE THE LENGTH OF SIDE b_1. Since side b_1 is horizontal side of the right triangle, the length of side b_1 is determined by the formula $x_2 - x_1$. Thus, the length of side $b_1 = 40 - 5 = 35$.

3) DETERMINE THE LENGTH OF THE VECTOR. Using the Pythagorean Theorem, $c_1^2 = a_1^2 + b_1^2$, where c_1 is the length of the vector, the length of vector V_1 is:

$$c_1^2 = a_1^2 + b_1^2$$
$$c_1^2 = 15^2 + 35^2$$
$$c_1^2 = 1450$$
$$c_1 = 38.08$$

Thus, the length of vector V_1 is 38.08.

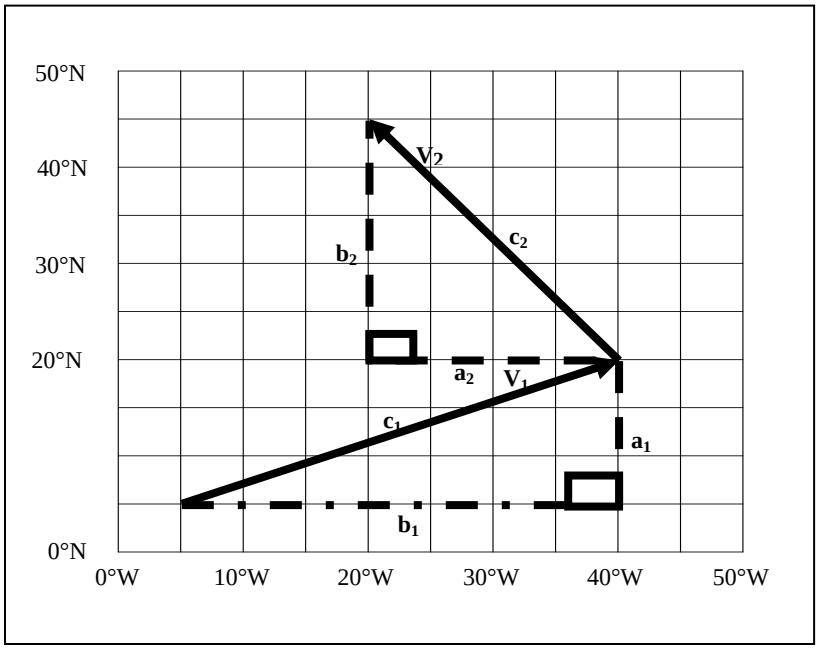

Figure 1: Illustration of Vector Plot #1

Student 2 – Engineering:

The pre-activity consisted of a PowerPoint presentation on the Battleship that included the streamed video, "Nova: Lost at Sea—The search for longitude" from PBS which gave background information on how sailors measured the speed of a ship in the 17th century (http://www.pbs.org/wgbh/nova/transcripts/2511longitude.html). As a post-activity the pre-service teacher created an algebra lesson on the engineering functions of the ship. The objectives of the activity were for students to be able to find a linear relation to model real-life problems and manipulate various units of measurements while using technology to display data. In one exercise students were asked to find the distance a ship has traveled given the time and speed (knots) that it is traveling (Figure 2). Students were expected to use the relationship Distance = rate * time, where the rate is always 28 nautical miles per hour or knots. Then, students were instructed to plot D(t) and make conclusions based on their observations. This activity was extended by requiring students to illustrate these relationships using a spreadsheet program and generate a graph to display the data (Figure 3). This early algebra activity exposed students to linear relationships and data analysis, concepts heavily emphasized in the North Carolina Standard Course of Study algebra objectives.

Exercise 1
The USS North Carolina is a member of a class of battleships that can reach 28 knots.
a) Complete the following table assuming that the USS North Carolina is cruising at her maximum speed.

Time, in hours	12	24	48	72	120	240	360
Distance, in nautical miles							

b) Plot distance in function of time. What do you notice? What is the equation of the function corresponding to this graph?

Figure 2: Sample exercise to find ship distance given time and speed (knots)

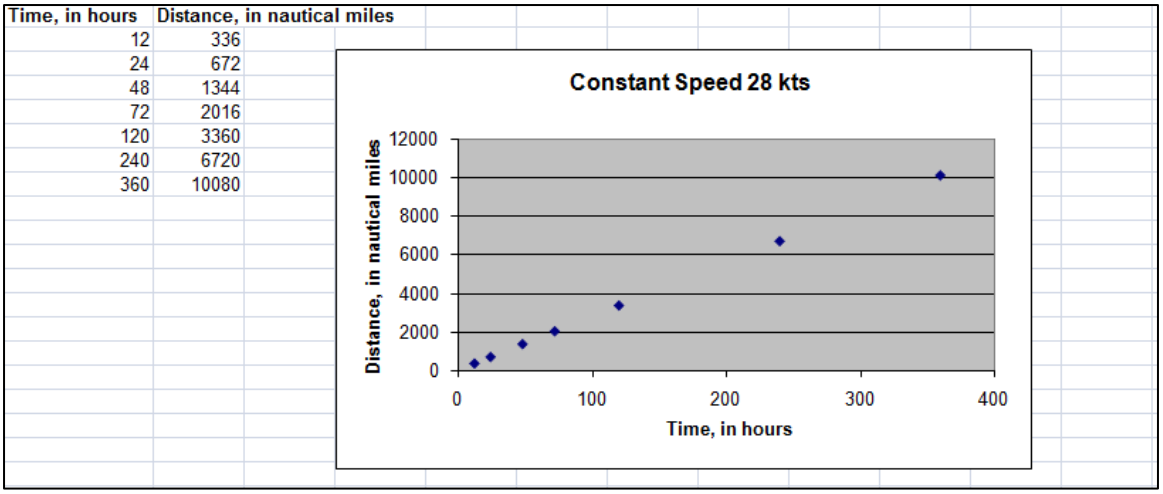

Figure 3: Sample spreadsheet program to illustrate relationship between ship distance, and travel time.

Pre-service Teachers' Attitudes, Beliefs, and Experiences with Informal Learning Settings and Interdisciplinary Collaboration

Methods faculty attempted to determine the pre-service teacher's attitudes and beliefs about the benefits of informal learning settings and working collaboratively with other disciplines. All pre-service students (math and non-math) who visited the Battleship were given a survey that consisted of 13 fixed choice questions and nine open response questions. The survey aimed to ascertain students' attitudes about and experiences with informal learning settings. All of the mathematics education students viewed the Battleship field trip as a positive experience and indicated that they planned to use an experience such as this with their own students when they become full-time teachers. Student responses indicated that they felt as if it was important to learn about informal learning settings and interdisciplinary education in their courses at the university. When asked "What did you learn from interdisciplinary collaboration and informal learning settings?" one student responded that "We all have different approaches in terms of

needs for structure and synthesis of information. Almost any topic can make use of an interdisciplinary model – from engineering to medical care". Others commented that this type of collaboration was "more challenging", but that the "results were well worth it" and that informal learning settings "can be just as educational…and sometimes more beneficial because it was hands-on".

Advantages of Informal Learning Settings

The participating group viewed the advantages of working outside of the traditional classroom setting as being related to one of the following themes: "Fun", "Break from routine/Get out of classroom", "Real life application", "Hands-on learning opportunities, and "Reach diverse learner(s)/student engagement". Specifically, over 32% of the students' described an advantage of informal learning setting as a way to get out of the classroom and break from the daily routine. Students said that these learning environments "add interest" and "breaks up the dull, daily routine of school".

Sixteen percent of the pre-service teachers' indicated that an advantage of this informal learning approach was that it could allow for more hands-on learning experiences for students. Students commented that learning events of this nature can provide "clarity to lessons through hands-on or experiential learning". Students also noted that informal learning settings promote discovery in classrooms no matter the discipline area. Student responses also reflected ideas that these experiences could also offer students a "fun and creative outlook for learning" and it "shows kids learning don't have to be formal and strict and boring".

According to student feedback, activities situated in informal learning settings make it possible for students to become engaged in real life applications. In these environments, students were believed to be able to "relate to the real world". Similarly, an informal environment would help teachers reach diverse learners by varying instruction.

Disadvantages of informal learning settings

Students (29.7%) reported that teaching students in an informal learning setting could create distractions for students making it difficult for them to stay on task. Their comments suggest that a variety of visual and physical stimuli may challenge classroom students ability to stay focused. Similarly, students reflected on the difficulty to organize and structure an activity outside of a conventional classroom as well as handle behavior management issues. This is a valid concern since teachers have sometimes sited behavioral issues as one of the detractors of incorporating informal learning environments into their classes (Kisiel, 2006) The pre-service teachers also noted that in informal environments, classroom students may be confused about the purpose and objective of the mathematical tasks as they may differ from how they are presented in a traditional setting. A little over 10% of the comments provided by the participants focused on the costs of planning and implementing an event that required students to travel or pay admission.

Conclusion

Pre-service mathematics teachers receive instruction in many areas before they ever become a teacher; they work on writing lesson plans, ways to address behavioral issues and mathematical content. Little or no training however is usually given to pre-service teachers on how to incorporate informal learning environments into the curriculum. Judging from the fact that experience teachers often have difficulty with the nuances involved in organizing a field trip

(Melber, 2000), there appears to be a need to educate pre-service teachers on conducting informal learning experiences. In addition, empowering pre-service teachers with the knowledge of how to effectively execute a field trip will only help ease the possible anxiety these teachers may face when planning a field trip themselves. Furthermore, pre-service teachers possess the unique ability to view an informal learning environment from both the student and the teacher's perspective. Having pre-service mathematics teachers enrolled in a methods course experience such events forces them to think about what constitutes a productive field trip before they ever enter a classroom as well as consider components of the curriculum that would benefit from an environment-influenced education. Lastly, exposing pre-service teachers to such experiences may influence them to take advantage of informal learning environments with their own students in the future which could potentially have great benefits on the learning of future generations (Munakata, 2005).

Overall, students viewed the trip to the USS North Carolina Battleship as a positive experience that opened their eyes to resources available to them and ways in which to work with others in different areas. Of course, implementing a project of this sort is not easy as you must always take the pre-service teachers past experiences with informal learning settings and interdisciplinary collaboration into account. In addition, undergraduate mathematics students may not have the same opportunities as students in other disciplines to investigate their subject area outside of the classroom, especially with a group of "non-math" peers. This project did, however, give students an opportunity to truly see the relationship between content, technology, and process standards as they drew connections with math and the real world. In this model, our prospective teachers were able to first experience the activity as a high school student would, then develop post-visit activities as a teacher that would enhance students' learning of mathematics through applications.

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