PRESERVICE TEACHERS ANALYSIS OF THE USE OF HISTORY IN MATHEMATICS LESSONS

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A group of preservice mathematics teachers participated in a course on history and technology in mathematics which includes a study of the historical development of mathematical concepts. This study examined the effect of the course on their critique of teaching materials using history. Results show that the participants developed more insightful critiques of teaching materials that integrated history poorly into the development of mathematical concepts.

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Introduction

Using the history of mathematics as a way of learning mathematics itself is a well-established part of many mathematics curricula and teacher preparation programs. There are many arguments supporting the place of history of mathematics from enhancing learners' cultural sophistication to helping learner's understanding of concepts. The purpose of this study is to examine changes in pre-service teachers' analysis of mathematics lessons purporting to integrate history into teaching mathematics after they engage in a semester-long course focussed on deploying history as a driver of development of mathematical concepts.

Literature review and relationship to research

The use of history as a lever for teaching mathematics in middle and high school is often relegated to the realm of footnotes and passing mentions of historical facts in textbooks adding historical context to some content (Smestad. Jankvist & Clark, 2014) or use of biography, sometimes in the form of student projects on individual figures, to add historical and/or cultural context to the study of mathematics (see e.g. Tzanakis et al., 2002). Jankvist (2009) referred to this kind of approach as using history as "a motivating factor for students in their learning and study of mathematics" (p. 237) but argued that history can also be used to "support the actual learning of mathematics" (p. 238). Indeed, Siu and Tzanakis (2004) argued for thinking in terms of "integrating history of mathematics" rather than "using history of mathematics."

In the realm of teacher preparation programs Furinghetti's (2007) analysis of the literature identified the following approaches to history of mathematics in teacher preparation programs: (i) "delivering a course in the history of mathematics with the aim of giving a historical background to teachers' mathematics knowledge" (p. 132); (ii) "packages of historical materials focused on mathematical concepts difficult to teach were used to deepen teachers' pedagogical reflection on these concepts" (p. 132); and (iii) attention to the link between history and mathematics teachers' beliefs and attitudes about mathematics. The first of these aligns closely with the use of history noted by Smestad et al. (2014) and Tzanakis et al. (2002). Furinghetti herself adopts a different approach in her program: to use the history of mathematics "as a mediator of knowledge for teaching. The aim was to make the participants reflect on the meaning of mathematical objects through experiencing historical moments of their construction." (p. 133)

The goal of the course in which this study takes place, aligning with Furinghetti, was to provide students with examples of the historical necessity for the development of select concepts on mathematics so that participants would gain a deeper understanding of those topics. The goal of this

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study is to examine the effect of participating in that course on pre-service mathematics teachers' critique of teaching materials deploying the history of mathematics.

Methods and Methodologies

Setting and Participants

Participants (n = 20) in the study were prospective middle school teachers in a course on history and technology in mathematics which includes a study of the historical development of mathematical concepts. The central assignment for the course was for students to produce a classroom-ready lesson that infuses mathematics history and technology into instruction.

Data Collections Methods

In order to assess the trajectory of the participants' growth in infusing history into lessons in a meaningful way, they were asked to analyze/critique sample teaching materials that were designed to be poor examples of using history of mathematics for concept development.

The first lesson (Open University, 1988) involved students exploring the Fibonacci sequence. They are told at the end that "the sequence discovered by Leonardo of Pisa in 1202 in connection with the breeding of rabbits!" This was intended as a poor example of infusing history into mathematics lessons in a meaningful way in that there are simply a few historical notes added to the lesson and the history is not integral to the development of the concept.

In the second lesson (Penn Museum, n.d.) students are shown pictures of several famous domes and given the vocabulary apex, oculus, diameter, radius, circumference, and area. Students are then given the formulae for calculating diameter, radius, circumference, and area and, given one or two of those values asked to find the others. This was also intended as a poor example of infusing history into mathematics lessons in a meaningful way in the sense of there being a very low cognitive demand with students simply required to plug numbers into formulae with no emphasis on how concepts were developed historically.

Students were asked to respond to the following prompt: "Comment on the quality of these teaching materials in terms of their capacity to engage middle grades students in the history of mathematics. Identify several strengths and several weaknesses of each resource." In addition, participants submitted a brief biography of their experiences with the use of history in teaching mathematics from their own school and college classes.

During the semester participants worked through a series of activities in which the historical necessity of a mathematics concept is demonstrated i.e. exemplar lessons in which history is integrated into mathematics content. These included John Graunt's development of data analysis and the introduction of Rene Descartes coordinate system. In addition, the students worked on developing their own teaching materials that integrate history in mathematics teaching.

At the end of the semester the participants were asked to reread their original critique/analysis of the "bad" lesson plans and respond to the following prompt: "Describe your reaction to your earlier writing. Specifically: How has that reaction been informed by your experiences of the course? Be specific about how the experiences in the course have either reinforced your opinions about the sample lessons or changed your opinion about the sample lessons."

Data Analysis

The participants' original critiques were analysed using the constant comparative method (Glaser & Strauss, 1967) to establish trends in the data and to develop a code book. The code book was then applied to the critiques at the end of the semester with a focus on any changes asserted and the reasons for those changes. In addition, data analysis focused on whether students spoke about a motivation approach or a concept development approach to using history.

Results

Initial analyses/critiques

Of the 20 participants 19 said they would use the domes worksheet (with three saying they would need to add to the worksheet). In contrast, 13 out of 20 said they would use the Fibonacci worksheet with 7 of the 13 saying they would need to add to/modify the worksheet.

The codes associated with the positive aspects noted by the participants were: Integrating history & mathematics (INT), relating to "Real Life" (RL), engaging visual learners (VIS), and crossing disciplines beyond history & mathematics (CD)

Domes worksheet The historical context of the Domes was assessed positively by 13 of the 20 participants for relating the mathematics to "Real Life" (RL). For example, Participant 5 (P5) said "My favorite part of the math domes worksheet is its link to the past through real life examples." P7's view was that the lesson was positive "making the historical knowledge relevant to the student by describing Domes that exist with these measurements all across the world."

The Domes lesson was assessed by 7 participants as being a positive example of integrating mathematics and history (INT) e.g. "I feel like I am walking in a mathematics museum, each page helps me have the connection between the mathematics history" (P6) and "I thought it succeeded in giving a balanced math-history knowledge to the student" (P7).

Other notable positives in the participants critiques were the use of visuals (VIS), mentioned by 6 participants and crossing disciplines (CD) beyond history and mathematics mentioned by 3 participants. It is noteworthy that the positive aspects reported by the participants were always consonant with Jankvist's (2009) category of using history as motivation.

Fibonacci worksheet The Fibonacci worksheet was assessed less positively by the participants. Only one participant assessed the Fibonacci lesson positively for relating to "real life." (RL): "Also, the lesson outline offered great background on Fibonacci, allowing the students to see a real-life relationship and reason for creating such an idea" (P10).

There was an interesting dichotomy in responses coded with INT+/- (Integrating history & mathematics). Several students remarked that the history portion of this lesson was a little "tacked on." For example, "There was only a small short paragraph on the mathematician who created the "Golden Sequence" . . . which in my opinion added no value to the material." (P14) and "The worksheet focused a lot on the mathematics part and less on the history." (P15). However, several participants viewed the lesson positively on the INT code. For example, "It also makes a good connection between the history of the math and the math itself" (P20) and "It allows students to understand how the history relates to the topic that they are learning." (P11)

Use of history to develop mathematical concepts The critiques were also coded, owing to the focus of the activities in the course, for attention to using history to develop mathematical concepts, either providing evidence from the lessons or noting its absence (DEV+/-).

In coding the participants' initial critiques the code DEV was used 6 times. 5 of those were positive assessments of the Fibonacci lesson as using history as a tool for developing concepts. Examples of the positive assessments were "It gave relevance to why the Fibonacci sequence was created by mentioning it was done in connection to rabbits" (P10) and "Understanding . . . where a math equation or concept comes from can be great for student learning. History gives a better understanding when students wonder how a concept was discovered." (P15)

In summary, the participants were positively disposed towards the "bad" lessons. They mostly said they would use the lessons albeit with some modifications. In addition, they tended to note connections to real life as the main positive factor for using history in teaching mathematics.

End of semester analyses/critiques

At the end of the semester the participants were asked to read their critiques of the lesson plans from the beginning of the semester and to react to what they wrote at that time. Analysis of the responses focussed on whether they had changed their mind about the quality of the lessons and what values the participants espoused regarding the use of history in mathematics teaching.

Overall, the participants were better able to recognise the deficiencies of the sample lessons after the course although they mostly continued to say that they would use the materials in their own classrooms. Changes to the participants' thinking were mostly centred on the idea that the use of history, particularly in the Fibonacci lesson, was an add-on and did not contribute to the development of mathematical concepts (DEV). In contrast to the initial critiques where 5 of the 6 uses of the DEV code were positive attributions to the Fibonacci lesson, all 8 uses of the DEV code in the final critiques were negative. For example, one participant noted "the history of the Fibonacci Sequence . . .was added on at the very end . . . This is more of a short "fact," rather than integrated math." (P8) and another noted that "it adds very little to the lesson and would be easy for a teacher to skip over." (P4).

The participants continued to consider relating to "real life" (RL) as an important aspect of mathematics lessons involving the history of mathematics. For example, Participant 5 argued that "students should be able to find domes in their community and complete the new math concept with things in the world around them." Thinking about the class in general as well as the sample lessons one participant remarked "This class helped show me how important it is for math to have real world applications and connect with history." (P2)

One final theme that emerged in the post analysis was the idea of history "humanising" mathematics i.e. making the idea that actual people were involved in the making of mathematics clear. Participant 4 noted that "teaching math history also helps students to see that normal people like them can make big discoveries that change the world" (P4) and Participant 8 noted that "I learned so much about mathematicians. I think this is important to have in our class because students can learn where the math they are learning comes from." (P8). The participants' interest in this was presented more in the sense of motivation for learning rather than for the development of mathematical concepts.

In summary, the participants, while continuing to see positive aspects of the lessons were much more sensitive to the deficiencies of the lessons in terms of the use of history for the development of mathematical concepts.

Conclusion

The use of history in teaching mathematics is commonplace in the preservice teacher mathematics programs. Preservice teachers' prior experiences, and often their experiences in programs, with history tend towards a focus on biography and the use of history as a provider of context and motivation. This study shows the potential for preservice mathematics teachers to begin to view the use of history as a lever in the development of mathematical concepts. This is an important idea for use of history in pre-service mathematics preparation programs. Through participation in a course with exemplars of such mathematical development, the preservice teachers made more insightful critiques of teaching materials that were deficient in this aspect. They continued to consider connections to real life and to mathematicians as an important positive aspect of mathematics lessons using history for its potential to motivate students.

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