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The Use of the History of Mathematics in the Teaching Pre-service Mathematics Teachers

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Abstract

Many scholars have written about using the history of mathematics in the teaching of pre-service mathematics teachers. For this study, pre-service mathematics teachers developed an electronic journal of reflections based on presentations in the history of mathematics in a secondary mathematics education course. The main purpose of the Mathematics History Journal was to help measure the mathematics content knowledge and pedagogical content knowledge of the pre-service mathematics teachers for accreditation purposes. Results of the study indicated that by allowing pre-service teachers to investigate and present topics in the history of mathematics, pre-service teachers believed they strengthened their mathematics content knowledge and were introduced to a new avenue for teaching secondary students about mathematics.

Keywords: History, pre-service teachers, secondary mathematics, teacher knowledge



El Uso de la Historia de las Matemáticas en la Formación de Futuros Maestros/as de Matemáticas

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Resumen

Varios investigadores/as han escrito sobre la historia de las matemáticas en la formación de los futuros/as maestros/as de matemáticas. Para este estudio, futuros/as maestros/as de matemáticas han desarrollado un diario de reflexiones electrónico, basado en las presentaciones de historia de las matemáticas realizadas en un curso de matemáticas de secundaria. El propósito principal del Diario de Historia Matemática era ayudar a medir el contenido matemático y el contenido pedagógico de los/as futuros/as maestros/as con fines de acreditación. Los resultados del estudio indican que permitiendo a los/as futuros/as maestros/as investigar y presentar temas de la historia de las matemáticas, hace que crean que refuerzan su conocimiento matemático a la vez que aprenden nuevos recursos para enseñar matemáticas a los estudiantes de secundaria.

Palabras clave: Historia, futuros/as maestros/as, matemáticas de secundaria, conocimiento profesional de los/as maestros/as



Many would agree that there is much to gain by incorporating the history of mathematics into the education of pre-service mathematics teachers. Numerous studies (i.e. Arcavi and Isoda, 2007; Charalambous, Panaoura, Philippou, 2008; Clark, 2012; Furinghetti, 2007) have investigated the role and benefits of including the history of mathematics in teacher preparation courses. In 1991, the international journal *For the Learning of Mathematics* dedicated an entire issue to the history of mathematics. In 2007, an entire special issue of *Educational Studies in Mathematics* was also devoted to the history of mathematics.

The National Council of Teachers of Mathematics (NCTM, 2003) expects programs that educate pre-service mathematics teachers to include instruction in the historical development of mathematics and the contributions of diverse cultures. Programs seeking national recognition through the NCTM must show that pre-service teacher candidates in their programs have been prepared to develop student proficiency in the history of mathematics in seven content areas: (1) number and operation, (2) algebra, (3) geometry (4) statistics and probability, (5) calculus, (6) discrete mathematics, and (7) measurement. As an example, the indicator for algebra states that all secondary mathematics teachers should be prepared to develop student proficiency by demonstrating “knowledge of the historical development of algebra including contributions from diverse cultures” (NCTM, 2003, p.5). The National Council for Accreditation of Teacher Education (NCATE) process for the accreditation of mathematics teacher preparation programs requires a review of individual institutional programs by NCTM, the specialized professional association (SPA).

In this study, the reflective (electronic) journals written by pre-service mathematics teachers after viewing presentations based on topics in the history of mathematics were analyzed for new knowledge of mathematics content and new knowledge of pedagogical strategies. The study sought to answer the question; can the history of mathematics be used to strengthen pre-service teacher’s mathematics content knowledge and pedagogical content knowledge? The following research questions were asked:

1. Was there evidence that using the history of mathematics for instruction can strengthen the mathematics content knowledge of pre-service mathematics teachers?

2. Was there evidence that using the history of mathematics for instruction can strengthen the pedagogical content knowledge of pre-service mathematics teachers?

Review of Literature

Many studies (i.e. Clark, 2012; Fauvel, 2007; Furinghetti, 2007) that proposed using the history of mathematics in the preparation of new mathematics teachers did so because this practice helped candidates build their content knowledge and pedagogical content knowledge. In a quest to outline the categories of a knowledge base of teacher understanding needed for effective teaching, Shulman (1987) included content knowledge, general content knowledge, and pedagogical content knowledge. The last, pedagogical content knowledge, he described as “the blending of content and pedagogy, into an understanding of how particular topics, problems, or issues are organized, represented, adapted to the diverse interests and abilities of learners, and presented for instruction.” (Shulman, 1987, p. 8) Shulman described the act of teaching as an exchange of ideas that starts with the teacher first probing and comprehending the essence of a topic, and then relating this through careful practice to his or her students.

The history of mathematics may provide new teachers with a new setting for the design of mathematics instruction that might include new teaching strategies, problem solving examples, and topics for discussions. A study by Furinghetti (2007) proposed that providing teachers with a new context to view topics in the mathematics curriculum may allow them to teach in a manner different than how they were taught. He suggested using the history of mathematics to provide this context. He summarized the ideas that participating prospective teachers took away from the study as follows:

History provides meaningful examples of algorithms and methods that allow exploitation of the operational nature of mathematical objects.

History suggests the development of the concepts in a visual/perceptual environment such as that provided by geometry. (Furinghetti, 2007, p.137)

The means to what Furinghetti described as an aware style of teaching, was to use the history of mathematics to “look at old mathematical problems not only as steps in the development of the mathematical culture

but rather as promoters of powerful insights into the roots of mathematical knowledge.” (Furinghetti, 2007, p. 142)

Research by Clark (2012) sought to connect pre-service mathematics teachers’ mathematical and pedagogical knowledge through the use of the history of mathematics. By analyzing participants’ reflective (electronic) journals, Clark used the term *illumination* to describe the revelation and new understanding of a mathematics concept and an “increased awareness of their conceptual or relational understanding of a mathematical idea.” (Clark, 2012, p. 68) By including the history of mathematics in the preparation of prospective mathematics teachers, she proposed “new mathematics teachers may experience significant shifts in their attitudes, beliefs, and mathematical knowledge for teaching.” (Clark, 2012, p. 81)

Many studies (i.e. Battista, 1994; Prawat, 1992; Thompson, 1992) have shown that the attitudes and beliefs teachers hold towards mathematics have a strong influence on their performance and preparation in the classroom. Philippou and Christou (1998) set out to show that adding content based on the history of mathematics to both content and methods courses in a mathematics education program could change pre-service teachers’ attitudes towards mathematics. Their results were positive with gains in the improvement of attitudes towards mathematics and its usefulness. In 2008, Charalambous, Panaoura, and Philippou set out to use the history of mathematics in a program for pre-service mathematics teachers to induce changes in both their held beliefs and attitudes towards mathematics. Results of this study showed positive changes in beliefs and attitudes for some variables. However, some changes not expected in a negative direction included a negative attitude towards mathematics and a belief of less competence to teach mathematics.

Teaching future teachers about the history of mathematics to add to their mathematics content knowledge and increase their pedagogical content knowledge may prove to be a worthwhile task. The assignment is to bring the knowledge of the past into the future mathematics classrooms of prospective teachers. Fauvel (1991) provided a list of 15 reasons why the history of mathematics should be an important player in the mathematics curriculum. Based on Fauvel’s list, Liu (2003) asked the question, “Why should the history of mathematics have a place in school mathematics?” He proposed five reasons for including the history of mathematics in the contemporary mathematics classroom:

History can help increase motivation and help develop a positive attitude towards learning.

Past obstacles in the development of mathematics can help explain what today's students find difficult.

Historical problems can help develop students' mathematical thinking.

History reveals the humanistic facets of mathematics knowledge.

History gives teachers a guide for teaching. (Liu, 2003, p. 416)

Liu makes the key point that by informing students of the human struggles involved with the development of mathematics throughout history, students can teach themselves to persevere and stick with a problem in spite of past failures.

In three related studies, Jankvist (2009, 2010, and 2011) sought to categorize the “whys” and “hows” of using mathematics history in the teaching of mathematics. He described the difference between using “history as a goal” –meaning to know the actual history of mathematics including people, places, and events involved– and using “history as a tool” to provide interest and motivation and an understanding of the struggle involved with the discovery of new mathematics.

The NCTM's Curriculum and Evaluation Standards for school Mathematics made the following statement about the value of placing the history of mathematics in the school mathematics curriculum:

Students should have numerous and varied experiences related to cultural, historical, and scientific evolution of mathematics so that they can appreciate the role of mathematics in the development of our contemporary society and explore relationships among mathematics and the disciplines it serves: the physical and life sciences, the social sciences, and the humanities. Throughout the history of mathematics, practical problems and theoretical pursuits have stimulated one another to such an extent that it is impossible to disentangle them ... It is the intent of this goal – learning to view mathematics – to focus attention on the need for student awareness of the interaction between mathematics and the historical situations from which it developed and the impact that interaction has on our culture and our lives. (NCTM, 1989, pp. 5–6)

Marshall and Rich (2000) suggested the use of historical games as a means to help students develop new strategies for problem solving in mathematics and to “improve their critical-thinking skills and understand

the interconnectedness of our diverse human history.” (Marshall & Rich, 2000, p. 705)

Data and Methodology

A grounded theory approach was implemented to gather and analyze the data. This methodology includes the constant comparative method where the researcher repeatedly compared data with the objective of uncovering patterns and categories. A multiple case study was conducted across four cases where each case was made up of the journal entries for a particular mathematical topic. The data was taken from journal entries for the history of algebra, the history of geometry, the history of measurement, and the history of probability.

The participants in the study included nine students who submitted History of Mathematics (electronic) journals. The class included three female and six male students. The students were all enrolled in the second of two secondary mathematics methods class as part of a program leading to a bachelor’s degree in mathematics with secondary (grades 6–12) teacher licensure. For the history of mathematics presentations, a student along with a partner selected, researched, and presented a topic in a particular content area for 30 minutes. One student worked by himself. For example, for the subject algebra, one pair of students selected the topic of logarithms to research and present. For the subject geometry, the discovery of Pi was selected as the topic. Presenters were also required to develop mathematics problems related to their selected topic and lead the class through a problem solving session during that time.

All students were required to submit a one-page, single-spaced reflection electronically within one week after participating in the presentation and problem-solving session topic led by a pair of fellow students. The students were given the following directions: Each student in the class will write a one-page, single-spaced reflection based on the activity, its appropriateness for the high school classroom, and the important mathematics presented. The reflection is to be an analysis of the presentation and not a summary of what you saw.

The reflections of those students not presenting a topic were analyzed to find indications of their acknowledgment of learning of new mathematics content. The same strategy was used to uncover examples of pedagogical content knowledge.

Analysis

The reflections from the history of mathematics journals were analyzed and what became apparent were indications that students had learned new mathematics content from participating in the presentations. An analysis of the reflections was done by examining the content for phrases and words that indicated new math content was learned. For the four cases (algebra, geometry, measurement, and probability) it was evident that a majority of the students learned new mathematics content in each subject area as shown in Table 1.

Table 1

Journal excerpts: Percentage of students indicating new knowledge gained

Subject	Indication that new mathematics content was learned	Indication that new pedagogical was content learned
Algebra	86%	71%
Geometry	71%	86%
Measurement	71%	43%
Probability	100%	43%

1. Was there evidence that using the history of mathematics for instruction can strengthen the mathematics content knowledge of pre-service mathematics teachers? Below I give some representative excerpts from journal entries indicating new content was learned:

RC 2012: I learned that measurement has quite a rich and extensive history. The development of measurement acted as a sort of springboard for the development of mathematics.

TC 2012: It amazes me how accurate they were doing tedious calculations by hand.

AL 2012: I learned that Pi is actually taken from the Greek word for perimeter. I learned how Archimedes and others developed each of their respective values of Pi.

JP 2012: I was shocked to find out that the constant Pi has been traced all the way back to 1900 BCE by the Babylonians.

DS2012: It was also interesting to learn that today probability is involved in insurance (actuarial science), gambling (still), science

(genetics), art (color contrast ratio), and music (octaves and scales) just to name a few.

KA 2012: I also learned a few new terms with logarithms. I was blatantly ignorant as to the nature of these expressions.

MI 2012: I did not know that log base 2 was used in music.

TC 2012: It surprised me that I did not know this.

KA 2012: Overall, I did not realize how much probability affects the life around us. It was very interesting to learn about how it was developed and that it was developed because a mathematician was trying to support himself by gambling with the rolls of certain determined amount of dice.

2. Was there evidence that using the history of mathematics for instruction can strengthen the pedagogical content knowledge of pre-service mathematics teachers? Below I give some representative excerpts from journal entries indicating new pedagogical content was learned:

MI 2012: This would be wonderful to present to students to capture a different technique to reach different students (such as, some are musical learners, some are writers, and all the other differentiated learning techniques).

WG 2012: As educators, we must utilize key algebraic properties to show students that though they have reached the correct answer, there are more efficient strategies that they could use to reach the answer.

JP2012: I learned that there is a difference from knowing material and actually being able to speak and talk about the same material correctly.

WG2012: Students could benefit from their methodology of discovering a closer approximation of Pi because these mathematicians had to couple critical analysis with effective problem solving skills in order to find a more efficient means of demonstrating Pi.

KA 2012: I learned that Pi is the abbreviation of the Greek word for perimeter. This would be something that would be nice to introduce my future students to as they may better understand why we use Pi in a math class. I think that future students might be able to understand the concept better after understanding what Pi means.

Discussion

The reflective journals for the history of mathematics started out as a means to track student assessment for accreditation purposes. Using reflective journals to capture students' knowledge in the history of mathematics resulted in benefits beyond this original purpose.

Although caution is warranted because of a small size sample, based on the results it appeared that using the history of mathematics in teaching pre-service mathematics teachers is beneficial when considering content knowledge and pedagogical content knowledge. Qualitative data indicated that in many instances participants increased their content knowledge in mathematics. The data also indicated that the participants believed that learning about the history of mathematics provided them with new ideas for preparing instruction and instructional resources. The importance of using alternative mathematics pedagogical strategies when teaching mathematics content was one important result learned from the journal assignments.

Other observations that emerged from the reflective journals included students' observations of the connections within the branches of mathematics and connections to other disciplines like music, science and business. Understanding the development of new ideas in mathematics can amaze and astonish students and motivate them to stay interested. Students were impressed by the tenacity of the ancient mathematicians in their quest to calculate without the use of any technology and their creativity of methods when tackling problem-solving challenges. They were also impressed that the development of mathematics crossed so many borders and involved so many different countries and cultures. The NCTM stated, "Mathematics is one of the greatest cultural and intellectual achievements of humankind, and citizens should develop an appreciation and understanding of that achievement." (NCTM, 2000, p.4)

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