Prospective Mathematics Teachers' Technology-Based Presentations on Proportional Reasoning

Jack Carter

California State University East Bay

jack.carter@csueastbay.edu

Beverly J. Ferrucci

Keene State College

bferrucc@keene.edu

Abstract: *This study investigated future teachers' use of technology in teaching proportional reasoning lessons in a senior-level college seminar. Seminar participants were preparing to teach mathematics at an elementary, middle, or secondary school, and the technology-based lesson was a capstone experience wherein they were to demonstrate proportional reasoning concepts or principles that were appropriate for students in the grade levels that they were preparing to teach. Presentations were videotaped, graded, and analyzed for mathematical and technological content. Analysis showed presentations differed with respect to topics covered, prior knowledge required by learners, technological activities and extensions, and reported advantages or disadvantages of the technologies as applied within these lessons. Results also illustrated differences in the presentations based on the grade levels that the future teachers planned to teach. However, regardless of grade level, all the pre-service teachers used a common technology as well as a variety of particular technologies in presenting their lessons.*

1. Introduction

Proportional reasoning is a benchmark in students' mathematical development ([3], [7]) and classroom data continue to demonstrate that students often perform less well on proportional reasoning problems than on other performance measures ([9], [20], [14]). Since proportional reasoning is a focus of the school mathematics curriculum, the capabilities of prospective teachers in solving proportional reasoning problems are critical for improvement efforts [13]. Despite many years of national attention in standards documents and other curriculum policy references, the performance of prospective teachers on proportional reasoning items remains problematic ([17], [8]). A number of recent studies have shown that technology-based instructional components can foster higher-order thinking skills and make for more profound learning experiences ([11], [15], [19], [6]). Technology-based instruction on proportional reasoning has also been the focus of recent research reports that have shown an improvement in student performance ([2], [12], [5], [4], [16]). Consequently, the current study was undertaken to enable future teachers to gain experience in using technology to teach proportional reasoning and to explore and describe these future teachers' resultant teaching.

2. Methodology

The theoretical basis for this study was an adaptation of the zone theory of child development that enables one to make sense of different types of teacher knowledge and experiences that previous research has shown to be vital to the effective integration of technology into mathematics teaching and learning [1]. Within a framework based on this theory, zones of proximal development, free movement, and promoted action contain elements of pedagogical technology knowledge, access to teaching technologies, and beginning professional development experiences with technology, respectively. As a result, changes in classroom practices were stipulated by the theory to be associated with pre-service teachers trying new teaching approaches such as the integration of technology into their beginning classroom practices.

This study particularly investigated future teachers' use of technology in teaching proportional reasoning lessons to their peers. Students in the study were mathematics majors enrolled in a senior-level mathematics education seminar that served as a capstone experience prior to becoming student teachers. Students in the seminar were preparing to teach mathematics at an elementary school, a middle school, or a secondary school. Presentation of the technology-based mathematics lesson was a graded requirement of the seminar, and students received a detailed description of this requirement about 30 days before the scheduled presentations. This description specified that the topic of the lesson was proportional reasoning and that students were to select an appropriate technology, coordinate this selection with the seminar leader, and present a 20-minute lesson at the grade level they planned to teach. Students were also given a list of features to include in their presentations. These features included: intended grade level(s), prior knowledge needed, lesson overview, the lesson, activity or activities using technology, extension(s), advantages / disadvantages of using the technologies, and works consulted.

Students were asked to prepare a presentation that uses technology to demonstrate proportional reasoning concepts or principles that are appropriate for students in the grade levels that they were preparing to teach. They were also told that their presentation must be at least 20 minutes in length and include a lesson description, classroom worksheets, and any other pertinent materials. In addition to their written materials, their assessment would also be based on the clarity of their presentation as well as their ability to communicate effectively to the class and their mathematical knowledge pertaining to the chosen topic.

3. Results

Students' presentations were subsequently scheduled, videotaped, graded, and analyzed for mathematical and technological content. Results showed that students used a common technology as well as a variety of technologies in presenting their lessons. The common technology used by students was PowerPoint, and the number of slides in the presentations varied between 7 and 19 with an average of 11 and a median of 10. Figure 1 shows examples of the introductory PowerPoint slides prepared by the students for the presentations.

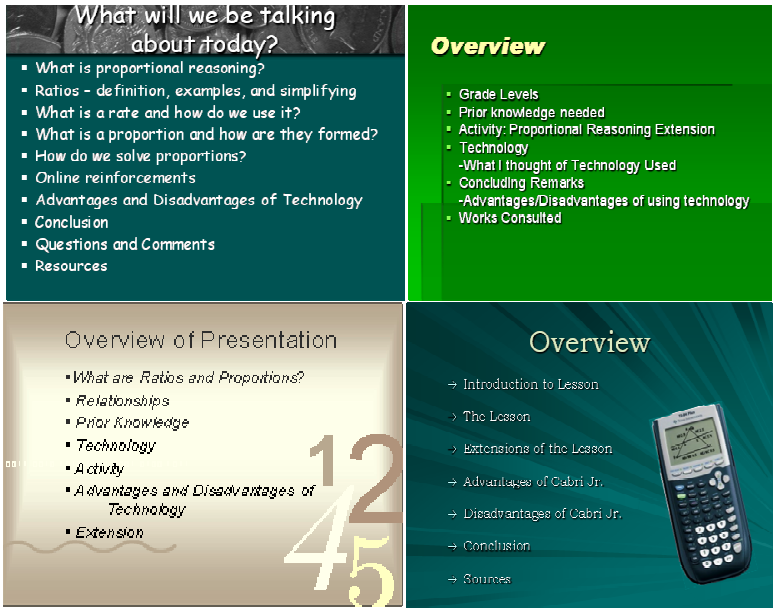

Figure 1: Examples of Students' Introductory PowerPoint Slides

Further reviews of the presentations showed that 9 of the 14 student presenters used web-based activities including software for viewing animations and films on a web browser. Figure 2 shows examples of web-based activities used in the presentations.

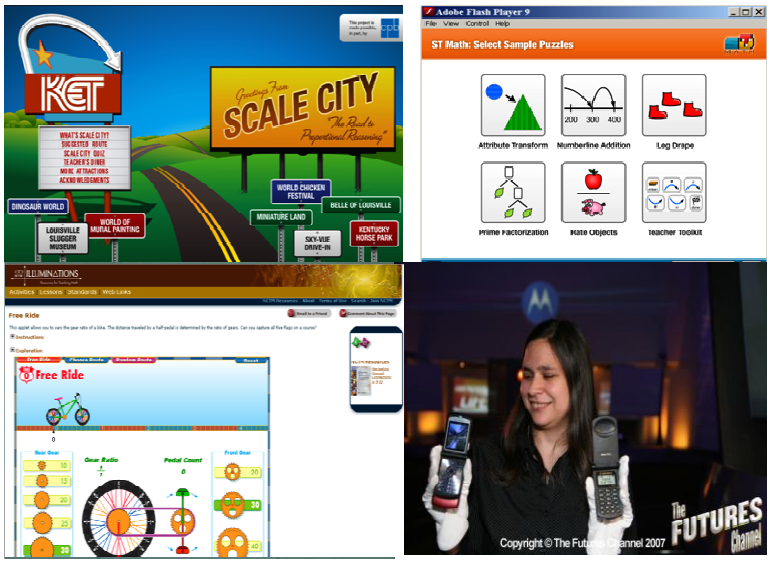

Figure 2: Examples of Web-Based Activities Used in Presentations

Seven students used word processors to prepare and present their lessons. Four students used dynamic geometry (three on a computer and one on a calculator), one student used a spreadsheet and another student used a hand-held graphing calculator. Figure 3 shows illustrations from the presentations that used dynamic geometry or a spreadsheet.

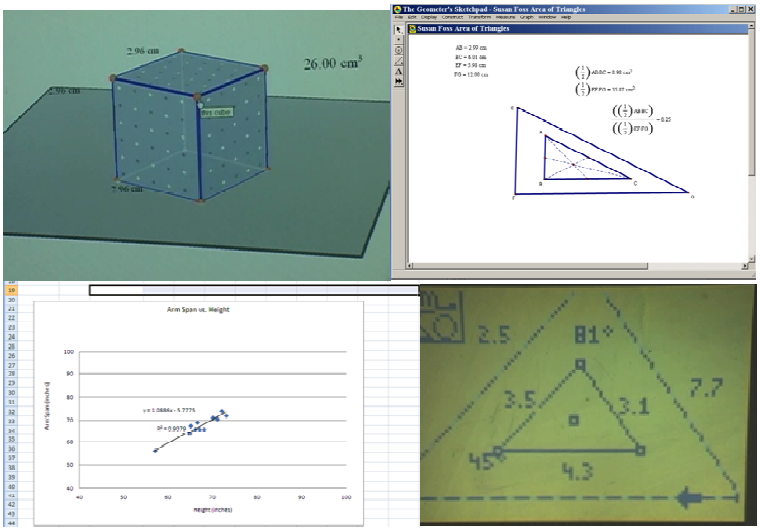

Figure 3: Illustrations from Presentations That Used Dynamic Geometry or a Spreadsheet

Web-based games were another popular device used by the pre-service teachers in their presentations. Figure 4 shows examples of Internet games used in the presentations to introduce concepts or build skills related to proportional reasoning.

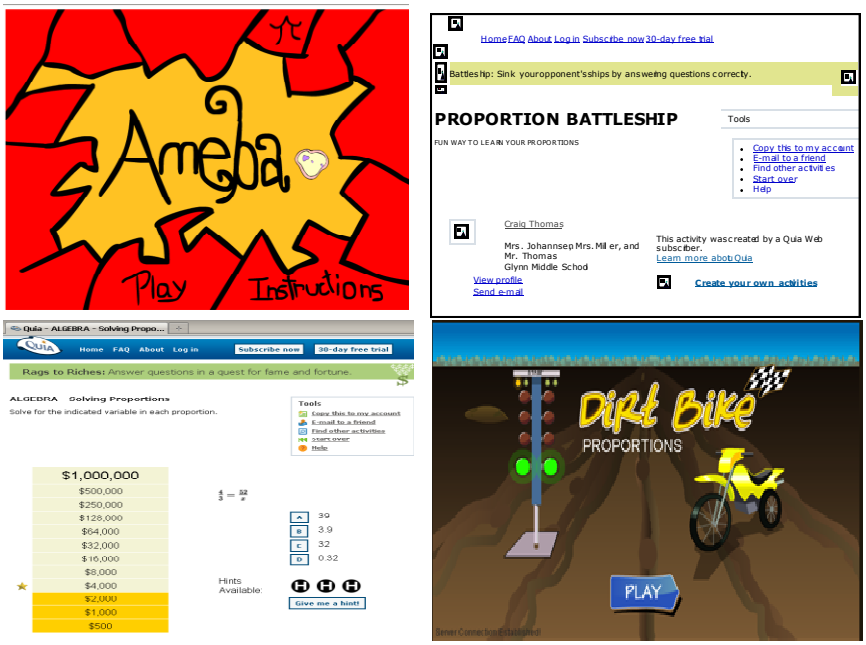

Figure 4: Web-Based Games Used in Pre-Service Teachers' Presentation

On-line Worksheets were another common feature of the prospective teachers' lesson on proportional reasoning. Figure 5 contains examples of worksheets used in the presentations.

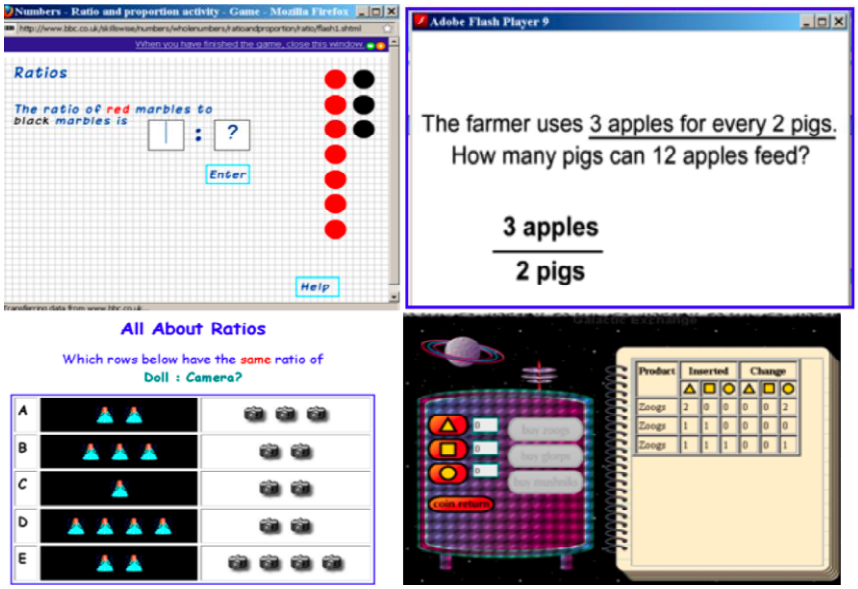

Figure 5: Examples of Worksheets Used in Presentations

Seven of the student presenters used two types of software, six used three types, and one used four types. Five pre-service elementary school teachers were among the seminar presenters. Two of these students used three types of software and three of them used two types of software. Eight of the nine students who used web-based activities, incorporated two of these activities into their lessons while the ninth used three of these activities in the presentation. All five of the future elementary school teachers used two Internet activities in their presentations.

The activities that students used to teach their proportional reasoning lessons covered a variety of topics. For the pre-service elementary school teachers these topics included a battleship game, a bicycle racing game, a comparison of battery performance in different cell phones, properties of similar triangles, use of scale factors in size comparisons, sorting factions by size, finding equivalent factions, comparisons of distances traveled by bicycles with different gear ratios, estimating ratios from visual displays of two quantities, simplifying fractions, and solving missing value, numerical comparison, and qualitative comparison and prediction problems. For the future secondary school teachers, the topics in the proportional reasoning lessons included relations between different bodily measures, solving proportional reasoning word problems, sharing pizzas by splitting them equally, uniform motion applications, Advanced Placement Probability and Statistics applications, statistical applications, hypothesis testing (smoking & heart disease), inferential reasoning from population proportions (attitudes toward mathematics), using concentric figures to construct targets and assign point values to the constructed regions, development of proportional relationships about corresponding sides in similar figures, and development of perimeter, area, and volume properties in proportional figures.

Extensions of the lesson topics were another feature that students were asked to include in their presentations. A review of the presentations showed that exactly half of the presentations

contained extensions of the lesson topics. Three of these extensions were presented by prospective secondary school teachers and the other four were presented by students preparing to teach in elementary schools. The secondary-level extensions were about interpolation and extrapolation, the golden ratio, using calculator-based dynamic geometry to investigate properties of similar triangles, and using dynamic geometry on a computer to investigate proportions and dilation points. Elementary-level extensions dealt with using web-based activities to study proportions of linear objects to their shadows, having students measure distances to form proportions, using a web-based activity to adjust the gear ratios on a bike so as to pedal exactly to a stop at each of several markers, and to estimate the number of cars in different locations and compare rates observed at the locations.

Another of the features students were asked to include in the lesson presentations were the advantages and disadvantages of using technology in the lessons. Twelve of the fourteen presenters included a listing of these features in their presentations. The most common advantage of technology (listed by five presenters) was that it was engaging. This advantage was followed in popularity by four others: interactive, enables visualization, compatible with activities, and enables checks of solutions, all of which were listed by three presenters. The most common disadvantage (listed by six presenters) was concerned with issues of access. Five presenters also listed teacher inexperience as a disadvantage, followed by four presenters who listed technical glitches and expense issues, and three presenters who listed personal/social development concerns as a disadvantage.

4. Conclusions

The lessons presented by the pre-service teachers could be classified into three categories based on the proportional reasoning content. In the first category were lessons that addressed proportional reasoning by beginning with the concepts of ratio and proportion and then introducing proportional reasoning by solving missing value proportion problems. A more elaborated version of the first category was the second category of lessons that introduced additional concepts such as simplified ratios and rate and focused on solving other proportional reasoning problems such as numerical comparison and qualitative comparison and prediction. The third category of lessons contained lessons that focused exclusively on one or a few applications of proportional reasoning usually within a single mathematical area, such as geometry or statistics.

A review of the presented lessons showed that seven lessons were in category three, five lessons were in category two, and two lessons were in category one. Both of the category one lessons and all five of the category two lessons were presented by pre-service elementary school or middle school teachers. All seven of the category three lessons were presented by pre-service middle school or high school teachers.

A notable difference between the presentations was that all the prospective elementary mathematics teachers started their presentations with examples of proportional reasoning by connecting directly to an existing web site, whereby the future secondary teachers explained the basic concepts of proportional reasoning more elaborately in their presentations with their own examples and then listed URLs as resources for further investigation. In the presentations by both these groups of pre-service teachers there was a definite preference for using web sites as part of their lesson materials. This preference supports earlier findings that the area of instructional technology experiencing the most recent growth is the use of web sites [10].

Questions suggested for further investigation from the current study include the following. How might the lessons presented and the technologies used enhance students' understanding of proportional reasoning? How did these lessons show evidence of the teacher-trainees' understanding of proportional reasoning? Which, if any, of the technologies, were especially effective in this regard? The authors believe each of these questions could form a basis for future research on the integration of technology within mathematics education.

In closing, the appropriate use of technology and a strong foundation in mathematical knowledge are fundamental to mathematics education reform. The development of these two critical areas by prospective mathematics teachers at all grade levels will help them to integrate the teaching of mathematics with technology and allow them to make connections between mathematics and other subject areas as well as develop an understanding of how mathematics is used to solve real-life problems.

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