Journal of Mathematical Behavior 43 (2016) 148–164

Contents lists available at ScienceDirect

The Journal of Mathematical Behavior

journal homepage: www.elsevier.com/locate/jmathb

Characterizing questions and their focus when pre-service teachers implement dynamic geometry tasks

Karen F. Hollebrands*, Hollylynne S. Lee

Department of Science, Technology, Engineering and Mathematics Education, North Carolina State University, Raleigh, NC 27695, USA

ARTICLE INFO

Article history:
Received 11 March 2016
Received in revised form 11 July 2016
Accepted 17 July 2016
Available online 25 July 2016

Keywords:
Dynamic geometry
Technology
Pre-service teachers
Questioning

ABSTRACT

When technology is used in classrooms new interactions among students, the teacher, and technology are enabled. The purpose of this study was to examine the ways pre-service mathematics teachers implemented technology-based tasks with individual advanced middle-school students. Pre-service teachers posed questions that focused students on features of technology and geometry in different classifiable ways. In particular, there were instances when teachers focused only on mathematics or technology. There were also instances when the teacher suggested students use the technology for the purpose of noticing mathematics and other times when the teacher would pose a mathematics question or statement with the assumption that students would use technology in response. Analysis of six pre-service teachers' is provided along with a classification system.

1. Introduction

Dick (2011) states, "the value of technology to the teacher lies not so much to the answers it provides, but rather to the questions it affords" (p. 2). For over two decades, the National Council of Teachers of Mathematics (NCTM, 1991) has emphasized the importance of teachers selecting and implementing worthwhile mathematical tasks and asking quality questions that engage all students. Researchers have shown that worthwhile tasks and good questions are critical components of effective mathematics classrooms (e.g., Stein, Smith, Henningsen, & Silver, 2000). Technology has also been identified as a critical component of mathematics classrooms (e.g., NCTM, 2000) with dynamic geometry programs considered an important aspect of geometry instruction (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010).

Some studies have examined how teachers design tasks that utilize technology (e.g., Laborde, 2002) or implement technology-based tasks with students (Hollebrands & Heid, 2005; Lee, 2005). Research has also focused on the implementation of non-technology based tasks in mathematics classrooms (e.g., Stein, Grover, & Henningsen, 1996). However, few studies have considered how pre-service teachers pose questions to students while implementing geometry tasks that employ technology. When teachers are using technology, they need knowledge of mathematics, and technology and the ways technology represents mathematics to pose questions that will focus students on important ideas, relationships, and invariances related to the mathematical goal they want students to learn. The effectiveness of instruction and use of technology depends on the ways tasks are implemented with students. Thus, it is important to know more about how teachers implement technology-based tasks with students. Knowledge about ways teachers can support students learning when

* Corresponding author.
E-mail addresses: karen_hollebrands@ncsu.edu (K.F. Hollebrands), hollylynne@ncsu.edu (H.S. Lee).

http://dx.doi.org/10.1016/j.jmathb.2016.07.004
0732-3123/

using technology can inform the design of mathematical tasks for students and implementation guides for teachers. In the current study, we examined questions and statements posed by pre-service teachers and their interactions with students during the implementation of geometric tasks that incorporated technology. In this paper we address the following research question: How do pre-service teachers focus students' attention on mathematics and technology when engaging with dynamic geometry software tasks?

2. Literature review

2.1. Questioning

Questioning has long been identified as an important practice of teaching (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956; Hargie, 1978) and an important factor in students' mathematical learning (e.g., Martino & Maher, 1999; Sloan & Pate, 1966). Many beginning teachers are familiar with different taxonomies (e.g., Bloom's Taxonomy) and frameworks for analyzing and creating mathematical questions and tasks (e.g., Mathematical Task Framework), but they lack experience working with students. As teachers gain experience with students, they are better able to anticipate how a student will respond to a posed question and are able to formulate an appropriate follow-up question or response.

2.2. Teachers' uses of technology

Technology adds another layer of complexity to posing tasks and questions. Early work by Farrell (1996), Doerr and Zangor (2000), and Goos, Galbraith, Renshaw, & Geiger (2003) identified various ways technology tools, particularly graphing calculators, were used and the roles they played in the classroom. Such roles were characterized as technology as a partner, and teachers serving as an explainer, facilitator and mediator. In particular, Doerr and Zangor (2000) found that when teachers assumed the role of facilitator they asked questions that shifted students' attention from a focus on computational results to considering how to interpret and explain results returned by the calculator. However, other studies have suggested that teachers' questions can narrowly focus students and result in students following a specified set of directions and procedures, rather than considering conceptual aspects of the task teachers have created (e.g., Heid, Blume, Zbiek, & Edwards, 1998; Wood, 1998). More recent research utilizing Rabardel's instrumental approach (Verillon & Rabardel, 1995) has focused on teachers' instrumental orchestrations (Drijvers, Doorman, Boon, Reed, & Gravemeijer, 2010; Trouche, 2004). Leung (2011) proposed three epistemic modes to support students' acquisition of new mathematical knowledge abstracted from interactions with dynamic geometry environments (DGEs) and a corresponding techno-pedagogic task design model. These modes take into consideration the instrumentalization process specific to DGEs.

While all of these studies have added significantly to an understanding of teachers' practices and interactions with students and technological tools, we do not know much about how novice and pre-service teachers learn to interact with students while using a technology tool to solve a task. Bowers and Doerr (2001) and Lee (2005) investigated pre-service teachers' interactions with students while using a technology tool. Both found that pre-service teachers were able to use representations available within the technology environments to focus students' attention on important ideas in a task or to pose additional questions for them to consider. In addition, Lee (2005) also found that the three pre-service teachers in her study each made decisions in their interactions with students to step into a role of explainer (Farrell, 1996). However, in both of these prior studies, the pre-service teachers did not design the tasks that were being implemented. Bussi and Mariotti (2008) analyzed how teachers use artifacts or tools (e.g., abacus, Cabri) as a semiotic mediator of mathematical signs. A recurrent sequence of actions performed by teachers was identified: revisit the task, focus on specific aspects of the use of the tool, request synthesis, and then synthesize. The researchers indicate that this "didactical cycle" was carefully orchestrated by the teacher in response to her analysis of students' uses of the tools and mathematical meanings they were developing. Unlike the studies conducted by Bowers and Doerr (2001) and Lee (2005), teachers in this study had the opportunity to formulate questions, tasks, and new activities in response to their interpretations of students' geometric and technological work.

2.3. Teachers' uses of dynamic geometry software

The use of dynamic geometry programs presents unique opportunities and challenges to students and teachers. Although many different dynamic geometry programs are available, they all share basic features: primitive objects (e.g., points, lines, circles), basic construction tools (e.g., parallel, perpendicular), transformations, measuring and dragging capabilities. Dragging allows one to interact directly with geometric objects and modify them in ways that maintain the properties that were used in their construction (Goldenberg & Cuoco, 1998). Because these programs use properties to respond to the actions of students, students have opportunities to observe and abstract geometrical relationships and theorems from those experiences (Laborde, 1993). In addition, because technology provides fairly accurate measures and representations, students may not feel the need to verify the truth of conjectures, but may seek to know why a particular invariance always occurs (Arzarello, Olivero, Paola, & Robutti, 2002; Christou, Mousoulides, Pittalis, & Pitta-Pantazi, 2004; Jones, 2000; Leung, 2011).

Teachers need knowledge not only of technical aspects of a tool, but the cognitive and pedagogical issues and opportunities that may arise. In a three-year study of teachers learning to design tasks to incorporate dynamic geometry technology,