PRESERVICE MATHEMATICS TEACHERS' TPACK DEVELOPMENT IN STATISTICS TEACHING: A MICROTEACHING LESSON STUDY

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This study examined the development of technological pedagogical content knowledge (TPACK) of preservice mathematics teachers in statistics teaching that involves virtual manipulatives, in the context of a microteaching lesson study (MLS). Theoretical framework was based on the TPACK framework (Koehler & Mishra, 2009). MLS group which consists of 5 participants studied on a research lesson and implemented it. How TPACK of preservice elementary mathematics teachers was supported regarding the teaching statistics through virtual manipulatives (VM) and how their knowledge domains were affected by MLS are the research questions of this study. The findings showed that preservice mathematics teachers' TPACK changed and developed through MLS. They were observed to have significant developments regarding some TPACK knowledge domains.

INTRODUCTION

This study investigated the development of TPACK of preservice mathematics teachers (PMT) in statistics teaching with VM in the context of a lesson study. VM are web-based online resources which usually include Java-applets or Flash-based demonstrations and they present students dynamic environments to understand mathematical concepts interactively. They could also be described as dynamic versions of physical manipulatives (Moyer, Bolyard & Spikell, 2002). Through the perspective of teaching, integrating technology is an issue since it should not only deal with content and instructional purposes but also consider the how and why technology is used (Earle, 2002). Teachers also lose their enthusiasm to technology integration without necessary knowledge of related curriculum materials. In fact, strategies for effective integration have not evolved as rapid as digital technologies (Kastberg & Leathom, 2005, as cited in Niess, 2008). Additionally, designing case studies is a useful research strategy that helps to examine and evaluate how PMT learn how to teach statistics (Niess, 2008). Thus, there are two main research questions here: First one is "how was TPACK of PMT supported to teaching statistics via VM?", and the second one is "how do PMT's knowledge change regarding TPACK framework during a lesson study group?"

THEORETICAL FRAMEWORK

The approach suggested by Koehler & Mishra (2009) for teaching with technology integration in which teaching is assumed as "an interaction between what teachers know and how they apply what they know" in different contexts lies as a fundamental idea behind this study (p. 62). In order to define what TPACK is, they assume that technology, pedagogy and content should lie at the heart of good teaching and it was claimed that these three core knowledge bases form TPACK framework (Koehler & Mishra, 2009). TPACK framework includes seven different knowledge dimensions: pedagogical knowledge (PK), content knowledge (CK), technology knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), pedagogical content knowledge (PCK) and technological pedagogical content knowledge (TPCK) (Koehler & Mishra, 2009). In order to relate TPACK with statistics teaching, rather than describing via different types of knowledge domains and their overlap domains as it was done for TPACK; Lee and Hollebrands (2011) presents technological pedagogical statistical knowledge (TPSK) framework as nested circles (which in fact shows a similar structure in TPACK): Outer circle is statistical knowledge (SK) which is knowledge needed for a teacher to engage in statistical thinking. Their claim is that a teacher should firstly be able to capable of statistical knowledge and thinking abilities before dealing with pedagogy and technology in teaching statistics. Then, innermost circle is the TPSK and "founded on and developed with teachers' knowledge in the outer two sets of technological statistical knowledge (TSK) and statistical knowledge (SK)" (Lee & Hollebrands, 2011, p. 361). Thus, TPSK framework constitutes the theoretical framework of this study, forms also structure and organization of findings.

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METHODOLOGY

Research design is based on the case study approach and each lesson study group could be considered as the unit of analysis. Lesson study, or lesson research, is a research method which originates from a Japanese process of instructional improvement, which research lesson (lesson plan) is its core piece (Lewis, 2000). "Research lessons are real classroom lessons with students and show five specific characteristics: Research lessons are observed by other teachers; they are planned for a long time, usually collaboratively; they are designed to bring to life in a lesson a particular goal or vision of education; they are recorded and lastly discussed by the observing teachers together" (Lewis, 2000, p. 4-6). Such artifacts can help PMT in order to develop an understanding of how statistical ideas can be taught. Although traditional lesson study is mainly dealt with in-service teacher education, it could be applicable to preservice teacher education contexts (Murata & Pothen, 2011; Leavy, 2014) which is defined as microteaching lesson study (MLS) (Fernández, 2005).

This study is a part of a larger study including two MLS groups. One of them was included and discussed here. Volunteered participants were all in their fourth year of undergraduate education in the program. They had attended two consecutive statistics courses in second year. Before MLS began, they attended a 4-weeks workshop which was designed by the research team including the teaching statistical concepts through VM. In the last week of workshop, MLS group started to study on a research lesson integrating a virtual manipulative for teaching a statistical concept such as data displays, measures of central tendency or measures of spread. Through MLS, participants discussed their lesson plan with researcher two times whether it needs a revision. Then, they implemented them to classmates (microteaching) and each group came together once more in order to analyze implementation process. Thus, these three group discussions formed the main data. At the end, participants were asked to reflect upon their overall lesson study experiences. This concluded data collection period. All group discussions were transcribed verbatim and coded using TPACK codebook (Hughes, 2013). Besides, lesson plans were assessed using 'technology integration assessment rubric' (Harris, Grandgenett & Hofer, 2010).

FINDINGS AND DISCUSSION

Since coding was applied according to TPACK framework, findings were outlined according to knowledge domains included in TPACK framework. The specific ones were discussed here because of the page limitation.

In their research lesson, MLS group tried to teach histogram as a main learning objective for eighth grade level. In their first draft of lesson plan, they wanted to begin with bar graph concept while using a data set including the 16 achievement scores (taken from a course), which they claimed these data as both categorical and quantitative. Then, they wanted to transfer it to a stem-and-leaf display. Their final aim was to make a transition from stem-and-leaf display to histogram on the same set of data. Below, there is a part of conversation which shows their lack of CK:

Gizem: I'm confused when the stem and leaf display is turned clockwise. It doesn't create a bar graph?
Researcher: No, it doesn't.
Gizem: I mean, I wouldn't expect to create this when I turn this. There's space between them.

This finding showed their lack of CK in terms of variable type used in data displays. While trying to present data set with a bar graph, they were actually drawing a dot-plot via virtual manipulative they chose. That means, they were not aware of what a dot-plot is, as can be seen in the below conservation:

Gizem: Yes, indeed. I couldn't remember its name. I even told you that this graph wasn't a bar graph, it was something else.
Esen: I directly assumed it was a bar graph.
Gizem: I didn't but I couldn't remember the name.
Researcher: Remember I even told you about...
Ezgi: We call it a dotplot because we accumulated?
Gizem: I couldn't remember it. No, I even told you about it while discussing but you said it was a bar graph. You said it was drawn dot by dot. And then I assumed it was something else.
Banu: I don't remember saying something like that.

Later, in the second draft of lesson plan, they omitted the bar graph part and focused only on transition from stem-and-leaf display to a histogram but they had also some misconceptions about classes (stems) and the terminology of histogram. Although MLS group used transitions between data displays in order to emphasize structural relationships between data displays as suggested (Bright & Friel, 1996; 1998), they were incapable of selection the right data display for the current data set which Jacobbe and Horton (2010) also founded similarly regarding the construction of data displays as well. However, MLS group overcame their misconceptions regarding the above issues. Then it could be claimed that MLS efforts developed CK of participants and they had improved their graph sense which Friel, Curcio & Bright (2001) were expressed.

Regarding PK, it could be claimed that MLS group developed their questioning skills at most. Leavy (2014) found in her study that questioning strategy was the most visited one as a pedagogical approach by the preservice mathematics teachers although its implementation could be a limitation in a microteaching period. While revising their lesson plan, they dealt more with the construction and wording of open-ended questions. MLS group also aimed to foster inferential reasoning via questioning (Leavy, 2014). On the whole, they demonstrated an increased performance for PK especially for the selected pedagogical approach and its implementation.

One of the most improved knowledge base for MLS group was PCK since their discussions gradually focused on the implementation of selected pedagogical approaches to teach the desired statistical concept. For example, placing transitions from stem-and-leaf display to histogram as the heart of lesson and constructing a discussion using questioning strategy while emphasizing to prevent students' misconceptions not only improved their CK but also developed their PCK. Below conversation shows their discussion regarding a possible misconception of students:

Gizem: I mean, after that, when a comparison is given, we also draw some attention to those spaces between and the use of a different data while comparing them at the 4th step. So, I believe it will be a misconception for the children to create something in here. In order to call it a histogram, he definitely needs to create a different graph.

Researcher: Then.

Gizem: I think, if he creates something similar to what you showed, (referring to the researcher's example for dotplot), it'll be wrong.

Pfannkuch (2008) outlined what teachers should experience in order to enhance their statistical thinking and PCK. Pfannkuch and Wild (2004) summarized in their 4-dimensional statistical thinking framework that teachers should first learn the game of statistics and build the statistical concepts as a secondary dimension, as it was the case of PMTs in the MLS group here. Moreover, Pfannkuch's (2008) arguments about how teacher learning should take place seem parallel with lesson study requirements which he described it with 'simulated classroom settings' (p. 251).

With an increase on the awareness of VM through MLS period, it could be claimed that their TCK developed with an increased control over technology used. They were first faced with VM during the workshop with a few examples only. However, they began to search for others in order to select the most appropriate one. They had an emphasis on possible misconceptions which students might experience because of its user interface, data input options and the ability to show the transition between data displays in the most effective way.

Besides, it could be concluded that their use of virtual manipulative served both as an amplifier and a reorganizer regarding technology integration into lesson (Pea, 1987; Ben-Zvi, 2000) since their use of VM changed their understanding of histogram and helped to understand that a dot-plot is a special histogram whose class-width is 1 as they also learned through MLS. Overall, it could be derived that they certainly started to relate content and technology reciprocally with each other.

Lastly, MLS group performed also an increase in their TPK since they discussed the time management, technical failures, classroom infrastructure, knowing the affordances of selected virtual manipulative, students' possible technical mistakes with an awareness of technology-pedagogy integration which Zhao (2003) described and these also serves as a basis for TPK comprehension of MLS group.

On the whole, it could be claimed that MLS group improved their TPACK regarding the above knowledge dimensions. Their improvement on CK, TCK and PCK were observed more than the one on PK and TPK regarding statistics teaching via integrating VM. Based on the discussion, it could be claimed that there is an interconnected way of relation among these knowledge bases. As Groth (2007) suggested before that PMT do not need more statistics courses but different kinds of statistics courses which foster enhancement to differentiate mathematical and nonmathematical knowledge while offering an implementation of them as any lesson study does.

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