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The Influence of an Online Elementary Mathematics Pedagogy Course on Teacher Candidates' Performance

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Abstract

The number of candidates seeking and completing online courses and programs in teacher education continues to increase in order to meet the licensing flexibility demands of adults pursuing teacher certification. Using the theoretical constructs of learner-centered instruction and zones of proximal development, this paper provides an overview of the design principles, analysis of qualitative evaluation data, and description of the refinement of an asynchronous online mathematics pedagogy course for graduate students seeking a teaching license in elementary education (children ages 5-12). Inductive qualitative analysis indicated that course revisions led to an increase in the frequency of teacher candidates' high-level tasks and quality lesson plans. Implications for the design and refinement of online teacher education courses are also shared.

Résumé

Le nombre de candidats enseignants cherchant et complétant des cours et programmes en ligne en formation des enseignants continue d'augmenter en vue de répondre à la demande de délivrer des brevets d'enseignement à une grande quantité d'enseignants et d'assurer la flexibilité aux adultes de poursuivre l'obtention du brevet d'enseignement. En utilisant les concepts théoriques de l'enseignement orienté vers l'apprenant et les zones de développement proximal, cet article fournit une vue d'ensemble des principes de conception, une analyse des données d'évaluation qualitative, et une description de l'amélioration d'un cours de pédagogie des mathématiques en ligne asynchrone pour étudiants diplômés cherchant un brevet d'enseignement pour enseigner aux enfants du primaire (5-12 ans). L'analyse qualitative inductive a indiqué que des révisions de cours ont conduit à une augmentation de la fréquence des tâches de haut niveau et des plans de leçon de qualité pour les participants au cours. Les implications pour la conception et l'amélioration des cours de formation des enseignants en ligne sont également partagées.

INTRODUCTION

Online Learning in Higher Education

The demand for online higher education courses and programs has increased dramatically in the past decade (HEFCE, 2011; Ko & Rosen, 2010). Online higher education programs provide opportunities for individuals to pursue degrees with increased flexibility while being able to complete work when it is convenient without having to commute to a college or university (Tallent-Runnels et al., 2006). While online courses in higher education show promise to provide effective learning opportunities, challenges with evaluating the effectiveness and impact of these programs have been cited (Dede, Ketelhut, Whitehouse, Breit, & McCloskey, 2009; Russell, Carey, Klieman, & Venable, 2009). As a result, educational researchers have called for the establishment of research agendas focused on examining effective educational components and the impact of online learning environments (Dede et al., 2009; Dyment, Downing, & Budd, 2013).

Prior research identified some successful characteristics of online courses. Among these are the importance of rigorous and challenging assignments (Levin, Waddoups, Levin, & Buell, 2001), clear evaluation methods communicated by instructors (Hodges & Cowan, 2012; Moallem, 2003), opportunities for learners to reflect on course progress (Downing & Dyment, 2013), and the consistent presence of a course instructor to facilitate and support learning experiences (Dennen, 2007; Dyment et al., 2013; Hodges & Cohen, 2012). Further, researchers found that online courses with intensive interactions between learners, course content, and instructors are more likely to lead to a greater impact on student performance and student satisfaction (Ke & Xie, 2009; Sobel, Sands, & Dunlap, 2009). Lastly, online education researchers observed that instructor support, scaffolding, and feedback are significant factors of student success (Dyment et al., 2013; Green & Land, 2000; Ke & Xie, 2009). Greene and Land (2000) found that scaffolding questions and frequent feedback from instructors led to higher quality work and that students reported a greater understanding of expectations for assignments. Despite the growing body of research on the impact of online courses in higher education, there is still a lack of studies investigating how these courses impact learner experiences (Dede et al., 2009).

Online Learning in Teacher Education

The popularity of online courses and programs in higher education has also migrated into university-based teacher education programs, as universities continue to add licensure and degree programs with online options (Dede et al., 2009; Dyment et al., 2013; Sobel et al., 2009). While some benefits of online courses have been established by researchers (Dede et al., 2009; Tallent-Runnels et al., 2006), online courses in teacher education are different. There are, for example, some specific teacher education coordination activities that must be addressed prior to designing an online course or program (Delfino & Persico, 2007; Hathaway & Norton, 2012; Sobel, et al., 2009). Specifically, because most teacher education courses include a variety of collaborative activities between students and school-based internship activities, designers of online teacher education courses must carefully design course activities that provide synergy between the course and internship work (McCrory, Putman, & Jansen, 2009).

Research has found that successful online teacher education courses and programs provide students the opportunity to engage in intensive activities with the content and to receive a great deal of feedback from the course instructors (Dennen, 2007; McCrory, Putman, & Jansen, 2009; Sobel, et al., 2009). In studies of specific pedagogies, researchers evaluating online learning experiences for practicing teachers found that writing experiences in an online course helped promote more reflective inquiry about the course's content (Spicer, 2002; Downing & Dyment, 2013). In their five-year longitudinal study, Delfino and Persico (2007) found that teachers' written work in online courses contained frequent instances of critical thinking and in-depth reflection. Further, prior research found that the pre-dispositions of teachers to engage in constructive activities were significant indicators of teachers' success in an online graduate course (McCrory, Putman, & Jansen, 2009).

While research regarding online teacher education courses in graduate programs exist, there is very little research on online pedagogy courses for teacher candidates who have limited or no teaching experience. Many studies have embraced the idea of hybrid courses that consist of both online and face-to-face interactions (Dede et al., 2009; Thomas, 2011). Teacher candidates in a face-to-face science pedagogy course reported that their learning was enhanced by the inclusion of online modules with video vignettes and other online activities (Thomas, 2011). In a hybrid mathematics education methods course, Schwartz (2012) posed a task to a group of students in an online asynchronous format and then compared their strategies and reactions to those in a face-to-face format. While the pre-service teachers approached and solved the task in the same way, opportunities for the instructor and pre-service teachers to discuss the pedagogy and in-the-moment spontaneous teacher decision making in the online course were lacking.

O'Connor (2011) found that while pre-service teachers learned technology and formed effective collaborative relationships with their colleagues, videos from their teaching experiences reflected a lack of student-centered pedagogies and transfer of teaching skills to other environments. In other words, the student-centered pedagogies that were emphasized in the course did not extend from the online course into teacher candidates' internship activities. However, in a prior study, teacher candidates demonstrated higher enactments of reform-based pedagogies in their classroom-based work and developed knowledge and skills that were similar to their peers in face-to-face courses (Polly, 2012). Further, teacher candidates in an online mathematics pedagogy course developed more teaching knowledge than their peers in a face-to-face course (Polly, in press).

Due to the iterative nature of course design and development (Hathaway & Norton, 2012; Moallem, 2003), course instructors must continuously refine and modify courses. A large-scale synthesis of research that compared online teacher education programs to face-to-face ones noted that there was no significant difference between teachers' beliefs, knowledge or skills (Russell, Carey, Klieman, & Venable, 2009). Research studies are needed that examine the impact of online teacher education courses on both teacher candidates and their students (Dede, et al., 2009; Dyment et al., 2013; Polly, 2012). This study describes outcomes from a fully online mathematics pedagogy course for teacher education candidates.

Research Questions

In response to the need for more research regarding online teacher education programs, the purpose of this study was to document the outcomes of a mathematics pedagogy course as it transitioned from a face-to-face format to a fully online one. The study targeted key course components including effective lesson planning and mathematical tasks. The specific questions explored in the study were the following:

1. What relationships exist between the mathematical tasks that teacher candidates included in their lesson plans?

2. What modifications of an online mathematics pedagogy course may have influenced the types of mathematical tasks included in teacher candidates' lesson plans?

BACKGROUND & CONTEXT

Institutional and Program Context

The University of North Carolina-Charlotte (UNCC) is North Carolina's urban research institution. Thecampus is located in the piedmont of North Carolina, just two hours by car from the mountains and three hours from the Atlantic Ocean. It is a large public university with 7 professional colleges that provide more than 170 undergraduate and graduate programs to nearly 26,000 students.

The Department of Reading and Elementary Education offers two initial K-6 licensure elementary education programs: a B.A. in Elementary Education for undergraduate students, and a Graduate Certificate Program to those that hold an undergraduate degree in another field. A Minor in Reading Education is offered for students already seeking initial license in another content area who wish to gain expertise in reading methods in the K-12 public school setting.

For previously-licensed teachers who wish to continue their education, there is a 33-hour M.Ed. in Elementary Education program. Designed for experienced teachers, the M.Ed. in Reading Education qualifies graduates for the North Carolina Advanced Standard Professional II teaching license in K-12 reading education. Relevant to all areas of the K-12 curriculum, this program is designed for classroom teachers and aspiring literacy specialists who are interested in improving instructional programs and practices that promote literacy among all learners. With further studies, there is also a Ph.D. in Curriculum and Instruction with concentrations in Reading Education and in Elementary Education.

The Elementary School Mathematics Graduate Certificate Program is an 18-hour program that meets all of the requirements for the North Carolina Elementary School Mathematics Add-On License. The 18 hours can either be taken as a Graduate Certificate, or can be part of a Master's Degree in Elementary Education. The program has been developed in order to: deepen teachers' and teacher-leaders' knowledge of mathematics content related to the topics in the elementary mathematics Common Core Standards, develop teachers' and teacher-leaders' knowledge of standards-based pedagogies to more effectively teach elementary mathematics learners and, equip teachers and teacher-leaders with leadership skills to be effective leaders of elementary mathematics instruction.

Overview of the Course Evaluated for this Study

The course described in this paper is the second of two mathematics pedagogy courses that teacher candidates complete in the Elementary Education Graduate Certificate in Teaching Program at UNCC. The course is only offered during the fall semester. All teacher candidates in the program have a bachelor's degree in a non-education related field and are taking their initial education courses. While some students have volunteered or worked in schools as teacher assistants or tutors, most students have little to no experience in elementary school classrooms.

The course was initially designed in 2006 to be a project-based course in which teacher candidates would attend face-to-face course meetings, and complete several projects related to planning and teaching lessons and assessing students' understanding of mathematics. In Fall 2010 the course was transitioned to a hybrid version where 33% of the course material was offered through an asynchronous online format. During the Fall 2011 and Fall 2012 semesters the course was offered in a 100% asynchronous online format. All course modules were hosted on the Internet in an open-source environment. Students used the university's Learning Management System (LMS), Moodle, to submit assignments, participate in course discussions, and to complete course activities.

Teacher candidates complete this course in the semester before their full-time student teaching internship. To that end, the course includes a heavy focus on designing mathematics lessons, assessing students, and differentiating instruction. Teacher candidates also participate in task-focused experiences (Polly, McGee, & Martin, 2010), where they explore several high-level mathematical tasks to deepen their content knowledge and make connections between content and reform-based pedagogies.

Theoretical Considerations for Course Design

The design and activities in the course are driven by two theoretical constructs: learner-centered instruction influenced by Vygotsky's Zones of Proximal Development (ZPD) (Vygotsky, 1978) and teaching as assisted performance. In this section, an overview of each construct is provided followed by a description of how each construct influenced the design of the course activities.

Zones of Proximal Development for Teaching

This course is grounded in the neo-Vygotskian constructs of ZPD (Tharp & Gallimore, 1998; Vygotsky, 1998). Vygotsky's idea of learner's ZPD provides an empirically-based framework for examining ways to develop and support learners. Tharp and Gallimore (1998) explicated ZPD in the context of teaching and referred to this idea of teaching as assisted performance, where more knowledgeable others (i.e., professors, classroom teachers) can support teacher candidates' development of knowledge and skills related to teaching.

Tharp and Gallimore described four stages of ZPD for learners. During Stage I, within the ZPD, assistance is provided by more capable others through modeling, coaching and other methods of scaffolding performance, while during Stage II learners become increasingly self-supported and are able to carry out the task without assistance from others. Stage III focuses on internalization whereby assistance from more capable others can paradoxically hinder performance. Stage IV involves the recursive process back through the ZPD, during which learners have to frequently modify their actions based on environmental surroundings and context (Tharp & Gallimore, 1998). Research on mathematics teaching indicates that specific activities, such as co-teaching and providing in-class support have a greater impact than less intensive activities, such as attending planning meetings or providing resources (Killion & Harrison, 2006).

Because the course for this study is taken by teacher candidates learning how to teach, it focuses on activities in Stage I of ZPD where a great deal of scaffolding and support occur. During the course, teacher candidates are assessed in the following ways: writing high-level mathematical tasks, designing an assessment for small groups of elementary students, writing five lesson plans for their small group of elementary students, and a post-test All activities support teacher candidate development by providing them with feedback from their internship and course instructors.

Teacher candidates teach their five lesson plans independently as part of the course. In the next semester during their full-time student teaching internship they are primarily in Stage I as they receive feedback from their internship teacher, and Stage II, as they complete many of the responsibilities of a full-time teacher without assistance.

Learner-Centered Instruction

The design of this online mathematics pedagogy course has also been grounded in the theoretical framework of learner-centered instruction for teacher learning (Polly & Hannafin, 2010; National Partnership for Educational Accountability and Teaching [NPEAT], 2000).The American Psychological Associations' ***Learner-Centered Principles*** (APA Work Group, 1997) provide the empirical basis for designing learner-centered environments for both students and adults. The NPEAT adopted these ***Principles*** for teachers' learning. Recently, the ***Learner-Centered Principles*** were synthesized with empirical research on teacher learning to derive a set of learner-centered principles for the design of learning experiences for teachers and teacher candidates (Polly & Hannafin, 2010). Specifically, these experiences should: prepare teachers/teacher candidates to address student learning issues (Heck, Banilower, Weiss, Rosenberg, 2008), allow teachers/teacher candidates to have some control of their learning experiences (Garet et al., 2001), promote collaboration among teachers/teacher candidates (Glazer & Hannafin, 2006), emphasize comprehensive change processes through ongoing support (Fishman, Marx, Best, & Tal, 2003; Orrill, 2001), develop knowledge and proficiency related to specific pedagogies, content and the intersection of content and pedagogy (Heck et al., 2008; Garet, et al., 2001); and support teacher candidates reflection on work samples and artifacts from students and classrooms (Cohen, 2005; Loucks-Horsley et al., 2009).

Course activities were designed and aligned with effective teacher learning environments and are presented in Table 1. The course was revised slightly each semester. Table 2 provides an overview of the course activities that teacher candidates completed as the course transitioned from a face-to-face to fully online format.

Table 1. Alignment Between Characteristics of Effective Teacher Learning Environments and Course Activities (Adapted from Polly, 2012).

Characteristics of Learner-Centered Environments for Teachers	Course Activities
Address student learning issues	Complete the Culminating Diagnostic Project, which involves pre-assessing, teaching and post-assessing students.
Provide teachers with ownership	Select topics for Culminating Diagnostic Project, Curriculum Evaluation and other activities.
Promote collaboration	Collaborate with classmates on blogs and with in-service teachers on all clinical projects.
Provide ongoing support	Turn in the Culminating Diagnostic Project at various times during the semester for feedback and support.
Develop knowledge of content and pedagogy	Complete cognitively-demanding mathematical tasks in each module, analyze curriculum, and examine video-based and text-based vignettes.
Support the reflection process	Write on blogs throughout the semester and reflect on the impact on students during the Culminating Diagnostic Project.

METHODOLOGY

Using a convenience sample of teacher education students, this exploratory study evaluated student learning outcomes as a mathematics pedagogy course transitioned from a face-to-face to fully online format. Data were collected over a three-year period between 2011 and 2013.

Data Sources and Data Analysis

Research Question One: Data sources for the first research question included lesson plans that teacher candidates completed for their Culminating Diagnostic Project. Lesson plans were written to focus on a cognitively demanding mathematical task, with the teachers' role being to support students' mathematical understanding through high-level questions and follow-up tasks. Tasks were analyzed using the cognitively-demanding tasks framework (Stein et al., 1997). Table 3 provides descriptions and examples of the four types of mathematical tasks. Current mathematics education reform in the United States calls for teachers to pose cognitively-demanding, complex mathematical tasks, such as "Doing Mathematics" or, at the least, "Procedures with Mathematical Connections" tasks (Common Core State Standards Initiative, 2011).

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Table 2. Differences Among Course Sections Through A Transition from a Face-to-Face to Online Format

	Fall, 2010 (Face-to-Face)	Fall, 2011 (Hybrid)	Fall, 2012 (Fully Online)
Writing mathematical tasks	Wrote 2 mathematical tasks that were either Procedures with Connections or Doing Mathematics.	Wrote 4 mathematical tasks; 2 that were either Procedures with Connections and 2 Doing Mathematics tasks. Teacher candidates received examples and 1 round of feedback from the instructor.	Same as 2011
Student interviews	Conducted 2 interviews with students about their number sense.	Completed 3 different interviews with 2 students each about their number sense.	Same as 2011
Analyzing video cases from classrooms	Watched 2 video cases then summarized lessons.	Watched 4 video cases then summarized lessons.	Watched 6 video cases then summarized lessons. Analyzed mathematical tasks included in the lessons
Curriculum analysis	Analyzed 2 units from both a reform-based and traditional types of curricula for types of mathematical tasks and instructional resources.	Analyzed 2 units from both a reform-based and traditional types of curricula for types of mathematical tasks and instructional resources.	Analyzed a unit from a reform-based mathematics curriculum for types of mathematical tasks and instructional resources
Instructor provided examples of lesson plans	The instructor provided an example of one lesson plan that was focused on a Doing Mathematics task.	The instructor provided an example of two lesson plans that were focused on a Doing Mathematics task with significant modeling.	The instructor provided an example of two lesson plans that were focused on a Doing Mathematics task with significant modeling.
Writing lesson plans for diagnostic project	Teacher candidates were asked to include at least one Procedure with Connections or Doing Mathematics tasks in each lesson.	Teacher candidates were asked to include at least one Procedure with Connections or Doing Mathematics tasks in each lesson. Feedback was given on one plan per student.	Teacher candidates were asked to include at least two Procedure with Connections or Doing Mathematics tasks in each lesson. Feedback was given on one plan per student.
Whole Class Teaching	No whole class teaching experiences were required.	Teacher candidates taught one lesson to a class of students. They were encouraged to include at least one Procedure with Connections or Doing Mathematics tasks in each lesson.	Same as 2011

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Table 3. Types of Mathematical Tasks

Cognitive Demand	Name of Task Type	Description	Example
High Cognitive Demand	Doing Mathematics	Students explore mathematical tasks that require them to choose an approach, complete the task, and explain their steps and decision-making.	There are 24 yards of fencing for the garden. If you want to make a rectangular garden with side lengths that are whole yards, what are the possible dimensions of the garden? Which garden is the largest?
	Procedures with Mathematical Connections	Students explore tasks that can be solved with an algorithm, but have to generate more than one representation.	There are 9 dozen cookies in the bag. If you eat 6 cookies how many are left? Show your picture using a picture and an equation.
Low Cognitive Demand	Procedures with Mathematical Connections	Students explore tasks that require only an algorithm and only one mathematical representation.	There are 9 dozen cookies in the bag. If you eat 6 cookies how many are left?
	Memorization	Students recall a fact that is expected to be known.	What is the product of 9x6?

This framework has been used in prior research studies (Henningsen & Stein, 1997; Polly & Hannafin, 2011, Polly, 2012) to analyze mathematical tasks that have been enacted in classrooms and written in lesson plans and curricula materials. The author coded every task that was included in the lesson plans for the 3 semesters. Once tasks were coded, they were organized and reanalyzed to make sure that they were properly categorized. Once each task had been coded and checked, frequencies were determined and entered into a spreadsheet.

Data from the spreadsheet were entered into the statistical software package SPSS version 20.0 (IBM Corporation, 2011). Since semester and the types of mathematical tasks were categorical variables, the author used a chi-square test of independence to test whether there was a statistically significant difference on mathematical tasks between years.

Research Question Two: Data sources for the second research question focused on field notes taken by the course instructor throughout the data collection period. Supplementary data sources included instructions for course assignments, rubrics and course syllabi. Data for this question was analyzed using inductive qualitative analysis (Coffey & Atkinson, 1996). All field notes about course revisions were typed into a spreadsheet. In the spreadsheet, segments of data were coded using an open coding process. Data was then organized around central themes found among the codes. These codes were: support, feedback, and clinical (internship) activities. Data sources were then reanalyzed in order to describe each of these themes in greater detail.

FINDINGS

Question One: What relationships exist between the mathematical tasks that teacher candidates included in their lesson plans?

Table 4 lists the frequencies for the mathematical tasks that were included in teacher candidates' lesson plans for each of the three semesters. In SPSS, a chi-square test of independence was performed to examine the relationship between the course section and the types of mathematical tasks posed in lesson plans. The relation between these variables was significant, $\chi2$ (4, N = 1,273) = 41.96, $p < .001$. There was a statistically significant relationship between the course sections and the types of mathematical tasks in lesson plans. The effect size for this finding, Cramer's V, was moderate, 0.13 (Cohen, 1988).

Table 4. Types of Mathematical Tasks in Lesson Plans

Semester	% Online	Number of students	M	P w/out C	P w/ C	DM	Total Number of Tasks
Fall, 2010	33% Online	44 students	0	5 (1.05%)	422 (88.47%)	50 (10.48%)	477
Fall, 2011	100% Online	39 students	0	7 (2.21%)	286 (90.22%)	24 (7.57%)	317
Fall, 2012	100% Online	31 students	0	2 (0.42%)	375 (78.29%)	102 (21.29%)	479

M: Memorization
P w/ out C: Procedures without Connections
P w/ C: Procedures with Connections
DM: Doing Mathematics

Despite the small effect size, the frequencies of the mathematical tasks provide empirical data in support of having teacher candidates pose more "Doing Mathematics" (DM) tasks in their lesson plans. DM tasks are the most cognitively-demanding and allow elementary school students to explore mathematical concepts in a complex, real-life situation that requires them to choose and justify their approach to solving the problem. The frequencies show a shift in the number of tasks included on teacher candidates' lesson plans.

In the Fall 2012 semester 102 (21.29%) of mathematical tasks were those of DM, an increase from Fall 2011 (24, 7.57%) and the Fall 2010 semester (50, 10.48%). To that end, there was also a decrease in the number of lower-cognitive demand tasks for the Fall 2012 semester (2, 0.42%) compared to Fall 2011 (7, 2.21%), and Fall 2010 (5, 1.05%).

Question Two: What course modifications may have influenced the types of mathematical tasks included in teacher candidates' lesson plans?

The statistically significant relationship between the types of mathematical tasks across course sections in teacher candidates' lesson plans required some thought about how these course sections were different.

Table 4 describes the major variations between the three course sections. Based on the large number of DM tasks in the 2011 and 2012 semester, the data indicated that the course activities influenced the quality of mathematical tasks that were designed, planned, and implemented during teacher candidates' internship experiences. Field notes, course syllabi, and directions for assignments were analyzed.

Emerging Themes

Data analysis yielded three primary themes, which will be elaborated on below: support, feedback, and internship (clinical) activities.

Support: The significant change between 2010 and 2011 was the amount of modeling and support that teacher candidates received in two areas — writing mathematical tasks and writing lesson plans that they could use with elementary school students. Mathematical tasks are a focus of the online course during the entire semester. In the asynchronous online environment, the instructor included a mathematical task to solve in every module, and required teacher candidates to make connections between the mathematical tasks explored and how they could be modified for elementary school students. Further, in 2011 there was an emphasis on writing an effective lesson plan focused on mathematical tasks.

Feedback: Feedback was provided on the task writing assignment in each of the three semesters. This is an assignment completed in the first month of the semester, which becomes foundational for teacher candidates' diagnostic project and lesson plan writing, which they complete later in the same semester. In the Fall 2012 semester, teacher candidates received detailed feedback on one lesson plan for their final diagnostic project, with the expectation that they could take that feedback and apply it in the planning of their other four lesson plans. Instructor feedback was Socratic in nature and asked questions such as "how can we increase the cognitive demand of these tasks?" and "what hands-on materials would support students during this activity?" Through this form of feedback, teacher candidates were directed to respond to the questions by revising their lesson plan, thereby placing the onus back on the student to think critically about the task.

Internship (Clinical) Activities: In addition to feedback and support, clinical activities also varied across course sections. There was an increase in the amount of internship activities in the 2011 and 2012 semesters, providing teacher candidates with richer experiences in an authentic classroom setting with elementary school students. These clinical activities included more interviews about students' number sense and an increase in the number of whole group lessons that teacher candidates taught. While the diagnostic project included 5 lesson plans in each semester, teacher candidates were asked to include a higher number of cognitively-demanding tasks in the Fall 2011 and 2012 semesters.

DISCUSSION & IMPLICATIONS

The findings from this study warrant further discussion and bring to light implications for the research and design of online teacher education courses. In this section we focus on modes of support in an online course and the role of an internship in teacher education program.

Modes of Support in an Online Course

The statistically significant difference on teacher candidate performance between the various sections highlights that the change in course activities had an influence on performance. The section with the highest student performance was the 2012 semester, which included the most support. Based on the construct of ZPD as explicated by Tharp and Gallimore (1998), these teacher candidates benefited from multiple forms of modeling, scaffolding, and support. This occurred in the following ways. First teacher candidates received weekly tasks to explore, and then engaged in individual reflection and online dialogue with their colleagues on a discussion board about how these tasks could serve as examples for their own work with elementary school students. Support was also provided by the course instructors with multiple examples of lesson plans, and regular feedback on critical assignments. Based on the increase in teacher candidate performance, these modes of support may have positively influenced the course experience that candidates had.

Prior research (Dennen, 2007; Dyment et al., 2013; Greene & Land, 2000) found that frequent feedback and support from instructors led to higher quality work products and that students report a greater understanding of expectations for assignments. In the present study, during the 2012 semester, feedback was shared with students on a draft and final copy of their first task writing assignment as well as on their first lesson plan. Further, confirming findings from prior studies (Dyment, et al., 2013; Moallem, 2003), the clear evaluation methods provided in rubrics may have helped to improve teacher candidate's performance. Instructors of online teacher education courses should continue to examine ways to provide effective support and scaffolding on assignments, including examples of work, feedback, and clear evaluation methods.

For an online course instructor to provide feedback to each student is very time consuming and an issue that was faced in each course section in this study. While maintaining a strong presence is important for course instructors (Dennen, 2007; Hodges & Cohen, 2012), online course instructors should examine possible structures that would provide support, and feedback in efficient ways.

The Role of an Internship in an Online Teacher Education Course

All teacher education courses in the program have clinical internship experiences, in which teacher candidates spend extensive time in classrooms observing a classroom teacher, working with elementary school students, and teaching small group and whole class lessons. In the present study, the lesson plans that were written and analyzed in the course were all implemented in classrooms with elementary school students.

Based on the constructs of teaching as assisted performance (Tharp and Gallimore, 1998) and situated cognition (Brown, Collins, & DuGuid, 1989), learners benefited from apprenticeship-like activities that provide a bridge from developing skills and knowledge into the real-world context in which those skills can be applied. Future online courses in teacher education should ensure rich clinical internship experiences for teacher candidates to apply the skills and knowledge that they are learning.

Future Directions for Research

The statistically significant differences of teacher candidate performance across course sections provided empirical evidence that the course revisions and changes made a difference. The increase of models, examples, and instructor feedback were all course revisions made in the online asynchronous teacher education course that likely contributed to the findings of this study.

Future studies are required to confirm and extend research about online teacher education programs (Dede et al., 2009; Dyment et al., 2013). First, teacher education courses are meant to impact both teacher candidates and the students to whom they teach. Subsequent research should systematically evaluate the impact of online methods courses on teacher candidate performance as well as the students in schools that they work with. In prior studies (Polly, in press; Polly, 2012), changes in an online mathematics education course led to positive outcomes for teacher education and elementary school students. However, more substantive studies with larger numbers of teacher candidates and students are needed.

Further, this study provided findings from an online mathematics pedagogy course for elementary school teachers grounded in the frameworks of the ***ZPD*** and ***Learner-Centered Instruction***. In the context of online mathematics pedagogy courses, key features of this course seemed to positively impact the students' outcomes. The activities related to solving, creating, and planning to teach cognitively-demanding mathematical tasks were central to course experiences. Further, the teacher candidates' classroom-based work in an elementary school classroom also effectively supported the content that candidates learned from the online modules. Lastly, consistent with earlier work (Dyment et al., 2013; Ke & Xie, 2009), the feedback that the instructor provided to teacher candidates greatly supported their work. Future studies should examine if these structures transfer into online teacher education courses in other subjects, such as literacy, science, or social studies. Future studies should examine the specific influence of each of these structures to see which aspects of this course have the greatest influence on teacher candidates' performance.

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