

## THE IMPACT OF TECHNOLOGY ON A GRADUATE MATHEMATICS EDUCATION COURSE CONTRIBUTED RESEARCH REPORT

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*Given the rise in distance delivered graduate programs, educators continue to seek ways to improve teaching and learning in online environments. In particular, the need for high quality K-12 teachers requires superior teacher education programs that model good instructional practice, especially in mathematics. This paper explores the challenges and opportunities presented to the instructor of an online mathematics education course designed for inservice mathematics teachers. The mixed-methods study utilized data from class observations and survey data from participants to capture perceptions of the course. Results of these data are presented and used with the instructor's reflections to make specific recommendations for improving the course and to offer insight to others using distance learning technology to teach graduate mathematics education courses.*

*Key words:* online professional development, mathematics teacher education, teaching geometry

The advances in online technology continue to transform how university faculty can provide teacher professional development (Hramiak, 2010). Advocates of online teacher education maintain that it “holds the possibility of developing not only vibrant explorations of knowledge and practice in the content area, but also communities of learners and practice, and lifelong learning perspectives and skills” (King, 2002, p. 224). Concurrently, problems in the design and implementation of online courses may hinder learners in these environments. Given the demand for high-quality teachers, online courses appear to be an increasingly popular way to provide teacher professional development (Signer, 2008). However, there is a clear need for continuing research in online teacher professional development to ensure that it is meeting the professional needs of teachers (Dede, Ketelhut, Whitehouse, Breit, & McCloskey, 2009).

The purpose of this paper is to present results of an investigation into the design and implementation of an online mathematics teacher education course for secondary inservice teachers as part of the Mathematics Teacher Leadership Center (Math TLC). The Math TLC is a collaboration among the University of Northern Colorado, the University of Wyoming, and partner school districts in Colorado and Wyoming in the United States and is funded by a

National Science Foundation Mathematics and Science Partnership<sup>1</sup>. One goal is to help develop culturally competent master teachers to work locally, regionally, and

nationally to improve teacher practice and student achievement. Designers of the course relied on recommendations from the literature including purposeful attention to instructor roles and community. With this goal in mind, researchers aimed to determine the attitudes students had on technology within an online teaching geometry course. Specific questions investigated were, what insights can be gleaned from learners' perspectives in order to improve future online courses, how are these perspectives related to the instructor roles, and how can instructor reflections on the course offer additional information to overcome challenges in online instruction?

### **Literature Review**

The framework for the design and implementation of an online course for inservice

mathematics teacher for this study is *community of practice*. Wenger (2001) defines a community of practice as "a group of people who share an interest in a domain of human endeavor and engage in a process of collective learning that creates bonds between them" (p. 2). According to Wenger (1998), in addition to learning, there are four processes that need to be in place for a successful community of practice. These four processes are (1) a practice to be learned, (2) a community within which to learn it, (3) meaning developed as part of learning the practice with a group of individuals, and (4) an identity formed as part of membership in that community. To foster these processes, designers of the course relied on an examination of instructor roles from the literature.

Maor (2003) and Johnson and Green (2007) categorize the instructor roles of distance education teachers as pedagogical, managerial, social, and technical. The *pedagogical role* entails all of the abilities involved in delivery of content, included the ability to make instructional decisions, develop appropriate learning tasks, facilitate learning, and assess for understanding. The *managerial role* comprises the abilities to administer the course, including the skills to plan the scope and sequence of the online course, monitor the teaching and learning processes, and manage the constraints of the course, including the timeline. The *social role* includes the ability to provide one-on-one, emotional support and advising to learners. The *technical role* encompasses the abilities involved in the decision-making process of selecting technology, the aptitude to use technology, and the ability to trouble-shoot problems with the technology quickly so that participants may remain focused on learning the material. Designers

of the course maintained that these roles are key elements in developing a community of practice. Specifically, the managerial role helps administer the practice to be learned; the technological role helps create a virtual community within which to learn that practice; the pedagogical role helps develop meaning as part of the learning of a practice with a group of individuals; and the social role helps form an identity as part of membership in that learning group.

### **Research Methods**

The teaching geometry course consisted of 22 inservice secondary (grades 7-12) mathematics teachers working towards a master's degree in the Math TLC program. Ten (45%) were men and 12 (55%) were women, all Caucasian and from predominantly middle-class backgrounds. Because of the relatively sparsely populated nature of northern Colorado and Wyoming, the participants were spread out geographically over the two states, though all learners were within 250 miles of one other. The participants met in person during a six-week session the previous summer, about seven months prior to the start of the

course.

The teaching geometry course took place during a 15-week semester in the spring of

2010 and focused on current research and practices of teaching, learning, and assessing geometry in secondary schools. The instructor facilitated the course completely online with both asynchronous and synchronous components. Participants used the course management system Blackboard to access course materials and submit assignments as well as to post occasionally on assigned discussion board topics. The participants of the course used the online collaboration system Elluminate to meet virtually every Monday night in a webinar, where they used live audio and video conferencing to conduct real-time class discussions, small group work, and lecture. The instructor held virtual office hours using Elluminate and communicated with learners regularly by email.

The study was a mixed-methods design involving survey and observations. Near the end of the course, the grant research team administered a 55-item survey. The electronic survey contained quantitative questions to obtain feedback from teacher-participants about their attitudes about the role of the instructor and the impact of technology on their learning. Thirteen of the 22 participants (59%) completed the survey: nine (69%) were women, and three (23%) were men (one did not respond to this item). Additionally, throughout the semester a graduate assistant acted as both teaching assistant and research observer who took field notes capturing synchronous classroom activity. The instructor and graduate assistant also met regularly during the semester and a few times after the course to consult on the effectiveness of the course, examining instructor roles to identify areas of strength and areas in need of improvement. Information shared during these meeting became part of the instructor's reflection on the course.

## Results

Overall findings from the survey and observational data indicated participants had successful educational and learning experiences with the class (Table 1). Most participants

Table 1. Overall participant experiences ( $N = 13$ )

| Survey Item                                                          | Responses |            |              |                |           |
|----------------------------------------------------------------------|-----------|------------|--------------|----------------|-----------|
|                                                                      | poor      | fair       | satisfactory | good           | excellent |
| My overall educational experience in taking this course, so far, is: | 0         | 0          | 3            | 6              | 4         |
| My learning experiences to date with this course have been:          |           | successful | 13           | not successful | 0         |
|                                                                      |           |            |              |                |           |
|                                                                      |           |            |              |                |           |
|                                                                      |           |            |              |                |           |
|                                                                      |           |            |              |                |           |

indicated they were satisfied with aspects of technology associated with all four instructor roles; specifically participants rated survey items highest on those related to technological and pedagogical roles, with social and managerial roles receiving positive but more widely distributed responses. Results organized by the four instructor roles are summarized below, including relevant survey questions, observational notes, and instructor reflections.

#### *Technical Role*

One of the most important tasks the instructor performed in his technical role was selecting an appropriate online collaboration system for the synchronous portion of the course. Prior to the semester, the instructor considered two options. After experimenting with each platform and considering the educational objectives of the course, the instructor chose to use Elluminate. One of the deciding factors was that Elluminate allowed for up to six participants to simultaneously share audio and video during synchronous sessions, promoting increased in-class dialogue and providing for greater community interaction. Also, the online collaboration system allowed for breakout rooms to facilitate small group work.

Overall results of the study indicate that Elluminate was technologically successful in facilitating the course. While specific learning and evaluation tasks the program allowed are detailed in the pedagogical section below, the technology had relatively few problems in facilitating the synchronous classroom session according to survey responders and the instructor. As indicated in Table 2, most students had sufficient familiarity with using computers and had experience using online course systems. Observations of the course revealed that although one participant had consistent troubles with technology when speaking and displaying video, most students had little trouble with the technology and indicated they were satisfied with the selection of Elluminate as an online collaboration system.

Table 2. Student self-evaluation of ability to use technology.

| Survey Item                                                                             | Responses      |                    |                |           |
|-----------------------------------------------------------------------------------------|----------------|--------------------|----------------|-----------|
| I would rate my level of computer expertise as:                                         | novice         | intermediate       | expert         |           |
|                                                                                         | 1              | 9                  | 3              |           |
| Using technology to participate in this course seems to be:                             | about the same |                    |                |           |
|                                                                                         | getting easier | as day 1           | getting harder |           |
| Before taking this class I already had experience using online course delivery methods: | 11             | 2                  | 0              |           |
|                                                                                         | yes            | no                 |                |           |
|                                                                                         | 9              | 3                  |                |           |
|                                                                                         |                |                    |                |           |
| For me to use computer technology to participate in this course is:                     | some what easy | somewhat difficult | difficult      |           |
|                                                                                         | easy           | easy               | difficult      | difficult |
|                                                                                         | 8              | 4                  | 1              | 0         |

The technical role of the instructor also encompassed the instructor's aptitude and trouble-shooting abilities. A substantial portion of the survey questions focused on these duties of the instructor. Course participants generally thought the technology was reliable, clear, and easy to use (see Table 3). Additionally, a majority of participants indicated that technology concerns did not often interfere with their understanding of classroom material. According to the instructor, the few major problems, such as a delay in the start of a session, and the relatively minor problems, such as failing to set a timer during breakout sessions, subsided as his skills using the Elluminate grew as the course progressed. Increase familiarity with technology also made him a better technical advisor. When issues would come up, on both his computer or on the students' computers, he dealt with them quickly and fittingly to continue educational instruction.

Table 3. Student responses to quality of technology.

| Survey                                                               | Ne | Someti | Of | Alwa | No basis for an |
|----------------------------------------------------------------------|----|--------|----|------|-----------------|
| The video image from other sites is clear.                           | 0  | 0      | 3  | 1    | 0               |
| What others are saying at distant sites                              | 0  | 4      | 9  | 0    | 0               |
| The technology is reliable.                                          | 0  | 4      | 8  | 1    | 0               |
| I can see enough of the speaker's body                               | 0  | 2      | 4  | 7    | 0               |
| The online communication software (e.g., Elluminate) is easy to use. | 0  | 1      | 5  | 7    | 0               |

Observations indicated that student attitudes toward technology were positive, validating the survey findings and instructor reflections. While occasional issues would arise, both students and instructor seemed satisfied in the technological role he played. One student's response to an open-ended survey question asking overall comments about technology emulated this view: "The design of the course, with the integration of the technology as a medium is outstanding - provided the technology is functioning."

#### *Managerial Role*

Balancing the administration roles of the course required planning and monitoring various aspects of the course. Before the semester began, the instructor outlined the scope and sequence of the course, including goals, main projects, and a week-by-week thematic schedule. Reflecting on the role, the instructor was generally satisfied with the pace and structure of the course. He believed the constraints of the course (i.e., limited time and contact with students) were handled appropriately by incorporating Elluminate, Blackboard, and email to overcome these challenges. Student opinions on the pace of the course seemed generally positive; when asked if technology was "being used to support instruction at an appropriate pace", five students responded "always", four "often", three "sometimes", zero "never", with one student indicating he or she had no basis for an opinion. One student chose to elaborate on this view in an open-ended question by stating, "The course involved too much time for a 2-hour class. I was overwhelmed as never before."

The instructor used technological features to monitor the teacher and learning process within the course. Elluminate allowed a participants list to be printed, ensuring the instructor was aware of who was present at each synchronous meeting. The Elluminate display also allowed the instructor to see which participants spoke within the break-out groups, helping to determine which groups were active in their discussions. The asynchronous discussion board on

who had submitted assignments on time. All of these tools were used to monitor the course. Student perceptions of the processes were mixed; students seemed satisfied with the synchronous portion of the course (Table 4). Although no survey items directly inquired about the asynchronous portion of the course for confirmability, comments from observations both in and out of class indicated students' dissatisfaction with the use of Blackboard for asynchronous discussion. The instructor reflected that the discussion board was used infrequently because the majority of discussion was taking place during the weekly meetings; while Blackboard provided the tools to monitor learning, the instructor did not glean much information from this feature.

Table 4. Student perceptions of the synchronous teaching and learning

| process                                                  |       |           |       |        | No<br>basis for<br>an<br>opinion |
|----------------------------------------------------------|-------|-----------|-------|--------|----------------------------------|
| Survey Item                                              | Never | Sometimes | Often | Always |                                  |
| I am comfortable with the way I can be present in class: |       |           |       |        |                                  |

|                                    |   |   |   |   |   |
|------------------------------------|---|---|---|---|---|
| a. through audio                   | 0 | 2 | 4 | 7 | 0 |
| b. through video                   | 0 | 2 | 2 | 8 | 1 |
| c. in breakout or group activities | 0 | 1 | 3 | 9 | 0 |

### *Pedagogical Role*

The pedagogical role of the instructor included his ability to deliver course content, develop appropriate learning tasks, and assess students for understanding. Regarding the delivery of the course, the instructor integrated a few novel approaches to facilitate instruction. The typical class consisted of an interactive lecture using the whiteboard feature, where a PowerPoint presentation displayed content material and breakout discussion and whole-group questions. At least one breakout room was implemented each class to facilitate small group discussion. The instructor on occasion had group reporters write on the whiteboard to provide responses from the breakout sessions for discussion. Dialogue between the instructor and students was frequent partially due to the online protocols the instructor established early in the course. The instructor emphasized the importance of students raising their virtual hand to indicate they had a question or a comment to contribute, and to use the video camera when speaking so the entire group could clearly identify the speaker.

As previously reported (see Table 1) students seemed generally satisfied with their learning experience. Table 5 provides specific perceptions of students on the use of technology to facilitate learning in the teaching geometry class. Respondents generally felt that technology concerns did not interfere with their understanding of the material and that the instructor used technology in clear ways that supported understanding. They were mixed in their responses to the items, “The technology used does not interfere with my understanding of the content” and “My classroom experience in this course is as valuable as my experience in face-to-face only instruction.”

The pedagogical role of the instructor also included his ability to assess students’ understanding. The instructor designed assessments involving thoughtful application of material covered in the course. For instance, designing a lesson involving geometry concepts that applied to the 21<sup>st</sup> century was a major course project. Observational data indicated that the instructor at least partially achieved his goal of assigning tasks that the teacher-participants found useful in their classrooms. Most teachers implemented, or tried to incorporate, parts of several course assignments in their classrooms. One participant commented on the survey about the assessments by saying, “I was able to use and apply most of the material I created for the course assignments in my own classroom.”

Table 5. Student perceptions of the use of technology to facilitate learning.

|             |       |           |       |        |
|-------------|-------|-----------|-------|--------|
| Survey Item | Never | Sometimes | Often | Always |
|-------------|-------|-----------|-------|--------|

| No basis for an opinion                                         |    |   |   |    |   |
|-----------------------------------------------------------------|----|---|---|----|---|
| Technology concerns interfere with understanding.               | 5  | 8 | 0 | 0  | 0 |
| I have to strain to understand the speaker's message.           | 6  | 7 | 0 | 0  | 0 |
| The graphical material and presentations are clear.             | 0  | 0 | 3 | 10 | 0 |
| The transition between video of speakers and visual displays is | 0  | 0 | 6 | 7  | 0 |
| The technology used does not                                    | 3  | 2 | 3 | 5  | 0 |
| With my understanding of the                                    | 0  | 1 | 5 | 7  | 0 |
| The use of technology is appropriate for the course content.    | 3  | 3 | 5 | 2  | 0 |
| My classroom experience in this course is as valuable as my     | 11 | 1 | 0 | 0  | 1 |
| in face-to-face only instruction.                               |    |   |   |    |   |
| I feel I am not being heard in class.                           |    |   |   |    |   |

Some of the major projects in the class required students to work in sustained groups, called Professional Learning Communities (PLCs), for several weeks. The PLCs consisted of three to five students working together. Observations indicated that the PLCs functioned appropriately and reflections by the instructor indicated that his satisfaction with how most of the final projects turned out. However, on one survey item, "The arrangement for communicating with my PLC is as effective as traditional classroom communication," responses were mixed: three (23%) responded never, three (23%) responded sometimes, two (15%) responded often, two (15%) responded always, and three (23%) said they had no basis for an opinion. Open-ended responses that related to PLCs ranged from "I am not sure what PLC is referring to in the context of this course" to a respondent who said the aspect of the course that most contributed to the successful evaluation was "working in groups and discussing projects with the instructor in small groups."

#### *Social Role*

The social role of the instructor included having the ability to provide one-on-one advising and emotional support to participants, as well as assisting in the development and maintenance of feelings of community within the course. Participants favorably viewed the instructor's social role. Observations of the social role included the use email and virtual office hours that provided individual communication with the instructor and the use of breakout sessions that seemed to foster a sense of community with their peers. While one survey question revealed some students felt it was harder to ask questions in the online environment in comparison to a face-to-face classroom, most responses regarding the instructor-student communication were positive (see Table 6). One student commented in an open-ended question on his or her dissatisfaction with online office hours: "The professor needs to be available more than 10 minutes once a week to meet „face to face“ on Elluminate."



Table 6. Student perceptions of the instructor-student contact.

| Survey Item                                                                            | Never | Sometimes | Often | Always | No basis for an opinion |
|----------------------------------------------------------------------------------------|-------|-----------|-------|--------|-------------------------|
| I am satisfied with the type of contact I have with the instructor during:             |       |           |       |        |                         |
| a. class sessions                                                                      | 0     | 0         | 4     | 9      | 0                       |
| b. online office hours                                                                 | 0     | 4         | 2     | 5      | 2                       |
| It is harder to ask a question than it is in a traditional (face-to-face only) class.  | 3     | 8         | 2     | 0      | 0                       |
| I am satisfied with the amount of contact I have with the instructor/TA through email. | 0     | 1         | 4     | 8      | 0                       |
| The use of the whiteboard to communicate is working well.                              | 0     | 1         | 6     | 5      | 1                       |

Participants viewed a sense of community to be quite strong. As the first cohort in the Math TLC master's program all participants worked with one another for the previous two semesters, including three hybrid learning classes (i.e., a combination of face-to-face and site-to-site instruction) and one online class, before enrolling in the teaching geometry course. Survey data validated these findings; respondents indicated a strong sense of community through high amounts communication among participants, feelings of rapport with each other, and low feelings of isolation (see Table 7). The respondent who indicated that he or she often felt feelings isolation also indicated in the corresponding open response item that, "I only felt isolated when my audio would stop working and I could see people talking but could not let them know that I was having computer problems." Another student attributed the sense of community to the group work: "I really like to see break out groups throughout the online session. This really helps take the online class and make it feel like we are in one classroom."

Table 7. Feelings of Community

| Survey Items                                                                | Never | Sometimes | Often | Always |   |
|-----------------------------------------------------------------------------|-------|-----------|-------|--------|---|
| I am comfortable with the way I can be present in class:                    |       |           |       |        |   |
| a. through chatting                                                         | 0     | 1         | 4     | 7      | 1 |
| b. through talking to those                                                 | 0     | 1         | 1     | 5      | 6 |
| I feel a rapport with other class members who are in the distant classroom. | 1     | 2         | 5     | 4      | 1 |
| I feel isolated from the rest of the class.                                 | 8     | 4         | 1     | 0      | 0 |

### No basis for an opinion

Reflecting upon his social role, the instructor thought he did an effective job in maintaining a sense of community through structured group work and the creation of a positive classroom atmosphere. He recognizes the benefit of teaching participants who came into the course already feeling a sense of community; that is, having a sense of community already developed eased his job greatly, especially given the research indicating online instructors must work harder than face-to-face instructors to establish rapport and open lines of communication with learners (Rovai 2001, 2002a, 2002b; Shea et al., 2006).

### Suggested Improvements

From the learners' perspective, two survey items inquired about what improvements they saw fit for the online course they had taken, and for future mathematics and mathematics education courses (Figure 1). Additionally, when asked to reflect on ways the instructor would improve the course, two themes emerged. First, the instructor felt the workload for the course was greater than the two credits not only for the learners but also for him. Thus, one improvement he considered afterwards was to reduce the workload of both the students and instructor to a more manageable rate, given the number of credit hours associated with the course. This recommendation appeared to be shared by participants. For example, one survey respondent wrote, "Remember that we are all full time educators. A heads up about assignments would be really helpful. Assigning readings and work on a Friday afternoon to be completed by Monday evening before class was difficult." Second, based on feedback from participants (e.g., "Post assignments ahead of time so that questions can be asked when the class meets online"),

Figure 1. Responses of ways to improve the course

I have the following suggestions for improving the course:

- Help us with doing websites so we can upload the project to the internet
- I feel like everything is ok for now. More experience is key.

Given that some future Math TLC mathematics education courses will be offered completely online, what kind of supports would you like to see (e.g., ideas for course format, instruction, curriculum, technology, etc.) to promote your success in these online mathematics education courses?

- I have felt successful in all the online math education courses. My suggestion for improvement would be to remember that we are all full-time teachers during the school year in addition to taking these courses.

- Technology that never fails. Perhaps a technology department that can check computer, appropriate software (for the course), peripherals to ensure they are functioning properly.

- Links to assignments at the end of each lecture.

Given that some future Math TLC mathematics courses will be offered completely online, what kind of supports would you like to see (e.g., ideas for course format, instruction, curriculum, technology, etc.) to promote your success in these online mathematics courses?

- I have only taken one math course online previously and I would not do it again. I am thankful that I will have met my MATH requirements without having to take an online

math course – I signed up for the program at UNC with the understanding that the math courses would all be face-to-face and I do not think this was a good change to the this program at UNC.

- Better technology for quickly writing equations
- I have not attempted a pure math class, so I do not know what to suggest

the instructor recommended that assignments be prepared at least a week in advance.

According

to the instructor, “in an online class a teacher cannot simply go into the classroom and improvise instruction, rather instruction must be purposeful and well prepared ahead of time.” Ideally, the course would be complete prepared and available from the onset, but may be difficult to accomplish in most circumstances.

From the data gathered over the duration of the semester, the instructor compiled recommendations for future instructors of online mathematics education courses in this program. First, both instructor and participants thought the use of break-out sessions and polling in the course was important not only as tools for learning but also for community building. Second, participants considered a sense of community an important factor in their learning, a finding supported by literature (Rovai 2001, 2002a). Third, the study results indicated most learners were satisfied with the amount of community they felt, though a few were only slightly satisfied. Now aware of both the importance and the challenge of building community in online courses, the instructor suggests that this aspect of the course be a focus in the future.

Overall, the instructor and the participants thought that the course was educationally successful. In the future, the instructor plans to continue incorporating technology that fosters knowledge and community building. Evaluating his own teaching using the four instructor roles was helpful in identifying strengths and areas for improvement in the online course, and he recommended this approach for other educators.

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