Implementation of Immersive Classroom Simulation Activities in a Mathematics Methods Course and a Life and Environmental Science Course

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Abstract

This study investigated the influence of immersive classroom simulation activities on the development of elementary pre-service teachers in two separate mathematics and science education courses that simultaneously focus on pedagogy and content. Participants submitted written personal reflections about their teaching experiences using the immersive classroom simulation activities. These reflections were analyzed for common emergent themes within and across courses. The participants discussed the benefits of the immersive classroom simulation activities in their written personal reflections. They viewed the experience as helpful in developing their skills as a practicing teacher in mathematics and science. Specifically, participants identified three sub-themes including: (a) the immersive classroom simulation activities as being beneficial by providing more authentic real-life teaching experiences than those experienced during peer-group teaching activities; (b) the importance of holding complete and appropriate understandings of content when teaching mathematics and science; and (c) the role of deep content knowledge in the process of developing high quality questions for students. This study has shown immersive classroom simulation activities to be a viable alternative for teacher education programs to engage elementary pre-service teachers in developing skills regarding classroom mathematics and science discourse.

Keywords: *Immersive classroom simulation, Math, Life and Environmental Science*

INTRODUCTION

Ambitious teaching is necessary to ensure learning for all students and pedagogies of elementary teacher education have been re-conceptualized to engage elementary pre-service teachers (EPSTs) in ambitious teaching early in their preparation (Lampert et al., 2013). One vital aspect of ambitious teaching is eliciting and responding to student thinking. However, the majority of classroom interactions reflect a teacher-centered approach with little opportunity for students to share their thinking (Michaels & O'Connor, 2015). The U.S. educational communities have achieved a national consensus that instructional subject areas for K-12 grade levels should promote academic talk as a critical component. The National Research Council, along with the major teacher organizations, report the need to emphasize active discourse with students when discussing investigations to involve thinking about using evidence to support their claims, conjectures, predictions, and explanations (NCTM, NSTA, NRC reports). To prepare teachers to facilitate productive discussion, strategies for eliciting and responding to students' ideas are supported by research (Michaels & O'Connor, 2015; Kovalaninen & Kumpulainen, 2005), emphasized in standards (NGSS, 2013; CCSSO, 2010; NCTM, 2000), and centralized in methods and field experiences (Esmonde, 2009).

Educational research has focused on the tools and structures necessary to successfully engage elementary preservice teachers (EPSTs) in the intricacies of eliciting and responding to student thinking (Lampert, Beasley, Ghousseini, Kazemi, & Franke, 2010; Thompson, Windschitl, & Braaten, 2013; Kazemi, Franke, & Lampert, 2009). Within this work, pedagogies of teacher education have been examined (Lampert & Graziani, 2009; Ghousseni & Herbst, 2016) and structures such as Cycles of Enactment and Investigation (Lampert et al., 2013) have been designed to engage EPSTs in opportunities to deliberately practice specific teaching episodes and enact those episodes in classroom settings. These rehearsals allow for concentrated feedback on teaching to build the skills and conceptual understanding to truly develop ambitious teaching. Just as a chess player will repeatedly practice a series of moves in order to become an expert, novice teachers can benefit from practicing or rehearsing certain teaching episodes to develop their skills and conceptualization of pedagogical elements. However, the human resources needed to employ an iterative, practice-based process within teacher preparation are often unavailable at institutions with large programs.

One innovative technology to facilitate such iterative practice is virtual simulation software, such as that available from Mursion® (developed as TLE TeachLivE™), that allows for the simulation of various classroom scenarios and provides a platform for EPSTs to practice interaction with students. These virtual environments provide immersive, interactive learning through practice-based teacher development (Dieker, et al., 2014). During each immersive classroom simulation activity (ICSA), pre-service teachers can engage with a classroom of five student avatars on a large computer screen. A simulation specialist operates the avatars and uses a simulation scenario to guide the interactions. In this article, we describe the utilization of ICSAs within a mathematics methods course and a science course to develop EPSTs' facilitation of effective classroom discussions. In addition to a delineation of the implementation, we also examined EPSTs' perceptions of the rehearsals to better understand the impact.

RELATED POLICY AND RESEARCH

Mathematics and Science Standards

Ambitious teaching and use of appropriate pedagogy are necessary to ensure all students are making progress towards appropriate learning benchmarks and standards. Recently adopted standards for both math and science education serve as a foundation for instruction and are used to inform how educators and students interact with each other while discussing math and science topics. These standards are aimed at refining how students learn and encourage the fostering of a deeper understanding of underlying principles and the relationship between topics. The Next Generation of Science Standards (Lead States, 2013) emphasizes the need for students to construct their own explanations of scientific phenomena that incorporate current understandings of science. This critical component of discourse should be incorporated into every lesson, allowing students the opportunity to examine essential academic content by discussing alternative ideas and clarifying understanding. To accomplish this task, students need explicit experiences in discourse by creating their own explanations with evidence from investigations that emulate the actual practices of scientists (Sandoval and Morrison, 2003). These classroom experiences need to be structured by experienced classroom teachers skilled in facilitating appropriate discourse opportunities.

The Common Core Mathematics Standards (CCMS) emphasize the context of mathematical concepts, for example, in kindergarten students are expected not only to be able to count up to 100, but they should also understand that each successive number represents the addition of one to the previous number. At each level, the students must engage in discourse surrounding topics in order to engage with the mathematics using the appropriate terms used in the field and to demonstrate their understanding of the concepts involved in the use of mathematical communication. The Standards for Mathematical Practice outline the ways in which students should do mathematics, including constructing arguments and critiquing the reasoning of others (CCSSO, 2010). The content and practice standards require that students express understanding through explanations and justifications and not merely regurgitation of procedures.

Importance of Discourse in Mathematics and Science Instruction

Discourse is at the heart of expressing understanding of mathematics and science.. Mathematics educators have described learning mathematics as a sociocultural process that allows learners to become participants in discourse (Esmonde, 2009). Discourse in mathematics learning has been divided into several categories including conjecturing, supporting claims with evidence, representing mathematical concepts, and using specialized language and symbols accurately (Moschkovich, 2002). In order to present any meaningful conclusion from the solution to a problem or the analysis of data, one must be able to engage with others in a discussion using the appropriate jargon and must be able to communicate both orally and in written form regarding their understanding of the problem. The use of discourse is particularly important in group work situations in order for students to communicate with other students about their work and to ensure all students are building a better understanding. Discourse also helps to identify and correct student misconceptions. A wrong answer to a math problem illustrates misunderstanding, but the use of discourse helps to identify the thinking behind the wrong answer and gives the instructor the opportunity to remediate (Sfard, 2001).

Learning science also requires students to be engaged with others in a social context while constructing meaning and building an understanding of scientific concepts (Duit & Treagust, 1998). In an attempt to advance scientific reasoning and understanding in science classrooms, science education researchers have been investigating how classroom discourse occurs among teachers and students and more importantly, the interactions between students and their peers (Candela, 2005; Chin, 2007; Cornelius & Herrenkohl, 2004; Erdogan & Campbell, 2008; Moje et al., 2001; Roth & Lucas, 1997; Scott et al., 2006; van Zee et al., 2001). A majority of classrooms do not provide students with opportunities for negotiating their own ideas or time to talk with others in order to incorporate new and old ideas into their own conceptual framework (Alexander, 2008; Lyle, 2008). The process of leading discourse requires pedagogical skills and strategies that science teachers need for engaging students in the process of knowledge building (Duschl, 2008). Kovalaninen and Kumpulainen (2005) observed and described elementary classroom discourse as teacher-initiated talks that were information-driven with the teacher delivering information with limited interactions between students discussing evidence about investigations. This common method of classroom discourse typically results in students offering brief comments, which requires limited student reasoning or critical explanations.

Scientific and mathematics knowledge is constructed through engaging in a social process through negotiation and consensus building (Candela, 2005; Michaels & O'Connor, 2015). Understanding how to facilitate these types of discussions with students is a skill that is nationally recognized as essential (Mercer, 2008) and complex. The complexity of leading discourse for teachers involves two important aspects understanding the conceptualization of classroom discourse and negotiating the sequencing of the talk while also managing the engagement of students (Lehesvouri, Viiri, & Rasku-Puttonen, 2011). To help elementary pre-service teachers (EPSTs) learn about the complexity of discourse and build competence facilitating it, they need explicit experiences with planning and implementing effective classroom discourse in both math and science.

Interactive Classroom Simulation Activities-Mursion

This article reports on initial findings from a three-year, National Science Foundation (NSF) funded effort entitled Project INTERSECT. The purpose of Project INTERSECT is to determine whether integration of ICSAs into mathematics and science education pre-service teacher candidate curriculum improves teacher candidate performance with respect to both teacher and student discourse. Project INTERSECT is engaged in: (a) developing a curricular model for math and science pre-service teacher education that expands opportunities to master teacher discourse, (b) measuring the effects of curriculum change and increased discourse engagement on pre-service teachers' use of discourse including anxiety and confidence in the classroom, and (c) disseminating the study results. Project INTERSECT seeks to advance knowledge regarding design for learning, particularly in math and science undergraduate teacher preparation by contributing an innovative, replicable research design that expands the metaphor of the teacher's toolkit to include a series of discourse tools or Teacher Moves (Chapin, O'Connor, & Anderson, 2013) that pre-service teachers can analyze, practice, reflect upon, and improve upon to develop confidence and competence in both using and facilitating effective STEM- oriented discourse.

For decades, teacher educators have recognized the disparity between pre-service teachers' knowledge of content and their ability to apply essential instructional and management skills (Pretti-Fontczak et al., 2005). In order to overcome this disparity, some teacher preparation programs have attempted to restructure coursework with alternative field experiences (Allsopp et al., 2006; Brownellet al., 2005). Educational researchers have documented the impact of field experiences on novice teachers' beliefs about teaching and learning, but there is a limited amount of research on how field experiences affect their instructional practices (Clift & Brady, 2005; Maheady et al., 2014), due to the inability of educators to align conceptual understandings of practice with the range of complexity of actual classrooms (Clift & Brady, 2005). This complexity of classrooms requires pre-service teachers to try and figure out what to concentrate on in their lessons, especially when they are not experienced with numerous instructional strategies and classroom management skills (Girod & Girod, 2006).

Teacher preparation programs have recently begun investigating virtual simulations as a way to represent the complexities of actual classrooms for practicing teaching (Dieker et al., 2008; Dieker, Rodriquez, Lignugaris/Kraft, Hynes, & Hughes, 2014). The theory of situated learning (J.S. Brown et al., 1989) supports that training in a virtual environment should transfer to practice in actual classroom settings. The Murison laboratory can be used as a sophisticated classroom simulation with full immersion teaching experiences representing countless situations and complexities that exist in a real classroom (Dieker et al., 2008; Dieker et al., 2014). Mursion® is an immersive classroom learning experience that provides education candidates with a managed space in which they can practice teaching skills and receive direct feedback from virtual students, peers, and their professor. The concept and technology was developed at the University of Central Florida (UCF) as TLE TeachLive™ but is now commercially marketed as Mursion®. During the interactive classroom simulation, participants interrelate with a classroom of five student avatars on a large computer screen. The avatars are operated by a specifically trained actor, or simulation specialist, who portrays the avatars as typical and/or atypical students within the classroom as determined by the specific simulation scenario. The power of Mursion is having pre-service teachers practice their instructional skills with life-size avatars that engage them with immediate verbal responses (Dieker et al., 2014; Elford, 2013). The benefit of Mursion as an effective teaching platform for educational instructors is the ability to control the complexity of the teaching environment for pre-service teachers to practice management skills and more complex instructional strategies.

CONTEXT OF ICSA IMPLEMENTATION

This study investigated the influence of ICSAs on the development of elementary preservice teachers (EPSTs) in two separate mathematics and science education courses that simultaneously focus on pedagogy and content. Each course will be described to provide context for the implementation of the of ICSAs.

Intermediate Elementary Mathematics Methods Course

Elementary education majors are required to take a course series of two mathematics methods courses; the first focusing on primary grades (K-2) and the second concentrating on intermediate grades (3-6). Each course includes instruction on content and methods for teaching in the specified grade bands and a practicum experience parallels the courses. In the intermediate methods course, the content focus is rational numbers and the pedagogical focus is the implementation of effective discourse. One of the key instructional activities designed to help ESPTs develop in both of these areas is the design and implementation of Number Talks (Chapin, O'Connor & Anderson, 2013).

Number Talk Assignment. The Number Talk Assignment involved each EPST planning and implementing one number talk in which they lead the entire class of their peers. As a part of the planning process, each EPST utilized a graphic organizer to record anticipated strategies and misconceptions, possible questions to guide discussion, and a closure to their number talk. They then lead the class in their number talk on one assigned day throughout the semester which was recorded by the EPST on their personal device. The content of the number talk varied based on the topic of the week. During the number talk, the instructor utilized elements of coaching, by interacting as a student, posing questions, and taking notes. Notes focused on mathematical accuracy, talk moves, and student engagement. Talk moves are pedagogical tools used by teachers to help navigate discourse among students (Michaels & O'Connor, 2015). Notes were used in a debriefing session directly after the number talk in which key talk moves and strategies were highlighted by the instructor.

The complete Number Talk Analysis involves components that deconstruct the mathematics and pedagogy. To account for the mathematics, EPSTs selected two peer strategies and described student thinking, pinpointed mathematical properties underlying the strategy, and created examples and non-examples of effective use of the strategy. To reflect on pedagogy, EPSTs responded to the prompt, "How did the use of Talk Moves influence your number talk?" and "Discuss the experience of teaching a number talk. What did you learn about teaching mathematics?" EPSTs used their recorded number talk to assist in this analysis.

Life and Environmental Science Course

At our university, all elementary education majors are required to choose an eighteen-hour concentration in an academic discipline as part of their undergraduate program. There is a subset of elementary majors that have chosen to concentrate in science. The Elementary Science Concentration (ESC) includes courses that focus on specific science content and methods for teaching K-6 science. Science education professors teach five of the courses within the College of Education. The ESC courses include Life and Environmental Science, Earth Science, Physical Science, Elementary Science Methods, and Informal Science Methods.

For this study, we will discuss the implementation of an assignment called Science Talks within the Life and Environmental Science course. The Life and Environmental Science course is divided into four modules that align with the disciplinary core ideas of life science within the Next Generation of Science Standards (Lead States, 2013). The four life science disciplinary core ideas are: 1) From Molecules to Organisms: Structure and Processes, 2) Ecosystems: Interactions, Energy, and Dynamics, 3) Heredity: Inheritance and Variation of Traits, and 4) Biological Evolution: Unity and Diversity. During the semester, each EPST is required to plan and implement a science talk that focuses on the content within each of the life science disciplinary core ideas.

Science Talk Assignment. Each semester, EPSTs complete an assignment called Science Talks within each of the content courses of the ESC. The Science Talk assignment was initially designed to provide experiences for EPSTs to rehearse their skills at leading discourse in science. In each ESC content course, each EPST plans, conducts, and reflects on one Science Talk. In addition, EPSTs also participated in three talks led by their peers. To prepare their science talk plan, EPSTs use a Page Keeley assessment probe (Keeley et al., 2005). Selected probes are aligned with each disciplinary core idea of the content courses. The probes include a scenario focused on the disciplinary core idea, related student misconceptions, and preconceptions. EPSTs use the "Teacher Notes" provided to learn the background information and suggestions for implementation of the probe.

Each EPST completes a plan for conducting his/her/their Science Talk, which includes research on the content, a discussion map of questions to ask, and designated times to implement talk moves. This initial Science Talk assignment was conducted only with a peer group during one class meeting which was videotaped for the purpose of reflection.

METHODS

Participants

Elementary Mathematics Methods Participants. Thirty-eight EPSTs completed the number talk assignment within the Intermediate Mathematics Methods Course. The undergraduates were in the junior year of coursework and ranged in age from 20-22 years except for one non-traditional student who was 36 years old. All participants were female (thirty-six Caucasian and two Black).

Elementary Science Concentrators. Forty-two EPSTs were in enrolled in two sections of the Life and Environmental Science Course and participated in the science talk assignment. All participants were undergraduate students ranging in age from 18-22. Participates ranged in college status from two freshmen, twenty-two sophomores, twelve juniors, and six seniors. There were forty-two females (forty Caucasian and two Latino).

Implementation of ICSA

Number Talks. The initial Number Talk assignment was redesigned to include the ICSA. The assignment was expanded to include two rehearsals in the ICSA with a third implementation in an elementary classroom. The mathematical content was connected to multi-digit multiplication problems to allow for a specific focus within an iterative cycle. For each of the three implementations, ESPTs planned their assigned problem in groups. For example, for the first implementations, the number strand was 12x6, 12x8, 12x15, or 12x24. As a part of the planning process, EPSTs had to utilize a graphic organizer to record anticipated strategies and misconceptions, possible questions to guide discussion, and a closure to their number talk. Then ESPTs individually led their number talk within the ICSA with three to four peers, building in complexity (i.e., 12x6 first and then 12x8). That is, ESPTs led their number talk and observed others within their group lead their assigned problem.

During the ICSA, the instructor took notes on talk moves, mathematical accuracy in explanations, student engagement, and then also stepped in at key points. After each ICSA, the instructor facilitated a debrief based on notes. In addition to the debrief session, the instructor viewed the recorded session via GoReact (video software) and provided timestamped comments that EPSTs reviewed as a part of their analysis of their teaching. The completed Number Talk Analysis involves components that deconstructed the mathematics and pedagogy. To account for the mathematics, EPSTs selected two student strategies and described student thinking, pinpointed mathematical properties underlying the strategy, and created examples and non-examples of effective use of the strategy. To deconstruct the pedagogy, EPSTs utilized the GoReact interface to indicate their use of the talk moves (Chapin, O'Connor & Anderson, 2013) and the impact on the discussion. If they did not use a certain talk move, they indicated where they could have used the move and how it would have impacted the session. Finally, they responded to the prompt "Discuss the experience of teaching a number talk. What did you learn about teaching mathematics?"

Each EPST completed this planning, implementation, reflection process for two ICSAs before completing the process with a number talk with elementary students in a 3-5 grade classroom as a part of their parallel practicum experience.

Science Talks. The initial Science Talk assignment described above was redesigned to include ICSA experience. The ICSA experience was added to provide EPSTs with additional rehearsal opportunities to discuss life science topics with avatar students in a simulated environment. EPSTs used the Science Talk plan for implementation within the ICSA before implementing with a peer group.

On an assigned day at the end of each life science disciplinary core idea module, six EPSTs conducted their Science Talk within the ICSA. Each EPST implemented their 10-minute Science Talk with the avatar students and five of their peers. The Science Talk discussions centered around life science disciplinary core ideas such as cell growth, microorganisms found in pond water, life cycles of various organisms, flow of energy within a food chain, impacts on an ecosystem, changes in habitats, genetics, and natural selection.

Data Collection

This study focuses on the first ICSA implementation of both Number and Science Talks. Two types of data were collected for analysis: notes from debriefing session that occur after each talk and personal reflections written by ESPTs about their ICSA experiences.

Debrief Sessions. During each Number and Science talk, instructors and EPSTs took notes for the purpose of providing feedback for the debrief session immediately following the talk. The debriefing session provided immediate feedback which is extremely valuable in development of ambitious teaching practices (Straub, Dieker, Hynes, & Hughes, 2016). The debriefing session notes for mathematics and science were read and coded by both mathematics and science instructors. Common themes are reported below.

Personal Reflections. The complete Number Talk Analysis involves components that deconstruct the mathematics and pedagogy. To account for the mathematics, EPSTs selected two peer strategies and described student thinking, pinpointed mathematical properties underlying the strategy, and created examples and non-examples of effective use of the strategy. To reflect on pedagogy, they responded to the prompt, "How did the use of Talk Moves influence your number talk?" and "Discuss the experience of teaching a number talk. What did you learn about teaching mathematics?" EPSTs used their recorded number talk to assist in this analysis. Twenty personal reflections were analyzed from the Intermediate Mathematics Methods Course.

After the implementation of each Science Talk, EPSTs completed a personal reflection. EPSTs were asked the following questions about their Mursion experience: 1) Did you feel the Mursion experience was helpful? Why or why not? And 2) What changes did you make to your original talk based on your experiences with Mursion and why? EPSTs were able to use a video recording of their Mursion experience for reflection. Twenty personal reflections were analyzed from the Life and Environmental Science Course.

Analysis of Debriefing Sessions of Number Talks and Science Talks

The themes that emerged from the debriefing sessions centered on issues including classroom management, timing of activities and the flow of the talk, content knowledge, and the importance of teacher disposition.

Classroom Management. One of the advantages of using the Mursion lab is to have pre-service teachers practice their classroom management skills in a managed environment (Dieker et al., 2008; Dieker et al., 2014). The ICSA allows instructors to select the level of classroom management between low, medium, and high. The lowest level represents a class of students who are well-behaved and easier to work with and the highest level having students exhibiting negative behaviors that create a more challenging environment for pre-service teachers to learn to manage. For the purpose of this initial assignment, the lowest level of classroom management was selected for both Number and Science Talks since the focus on the lesson was for EPSTs to practice their discourse skills in math and science and not classroom management.

Even though classroom management was not the focus on our assignment, it was discussed as an important theme in our debriefing sessions. The managing of students' behaviors was discussed by a majority of EPSTs as important for learning how to lead discourse. For example, EPSTs were unsure of what to do when the avatar students played on their cell phones or fell asleep during discussions. EPSTs were unsure of how to approach correcting such behaviors while continuing the discussion. Some EPSTs were very nervous, which lead them to concentrate on the talk and not on the behaviors that were occurring. During the debrief sessions, the instructors discussed ways to correct such behaviors in a positive manner to reduce conflict and disruptions.

Timing and Flow of Talk. Another theme discussed during the debrief sessions was the importance of timing and the flow of talk. EPSTs discussed how difficult it was to know how much time questions or activities would take. The issue of managing a classroom activity, especially discourse among students, is a common and complex problem for novice teachers (Weinstein et al., 2004). EPSTs commented that it was beneficial to observe how colleagues dealt with time issues while implementing their own talks.

EPSTs discussed how the flow of the talk was promoted when talk moves were implemented appropriately. For example, when an EPST asked students to elaborate or asked students to restate another students' response, the discussion continued. EPSTs also noticed that the flow of the talk was disrupted when EPSTs responded to students' comments using responses such as, "good answer," "good job," or "do you understand it now?" Although, these responses are commonly used by teachers in regard to student comments. EPSTs observed that when they used these responses, the discussion paused or, in some cases, students stopped talking about the topic because students felt the answer to the question had been expressed, therefore there was no need to continue discussing. Also, EPSTs had difficulties elaborating or providing a variety of examples to students after students' responses. This inability to elaborate on students' responses was noticed by EPSTs. They commented that their limited experiences in discussing the topics, as well as their knowledge of the content, was a barrier in their ability to think of ways to elaborate on students' responses. Teachers' knowledge of content was discussed as vital for allowing the flow of talk to continue uninterrupted.

Knowledge of Content. The knowledge of content was discussed as a key component to prompting discussion. For the number talks, the implicit number properties that were used in solution strategies were explicitly discussed. Also, any issues in the representations of student strategies were also noted. For, example if an EPST wrote 12+12=24+12=36 on the board, the inequality of the number string was discussed to promote accurate representation of the number expression. For the science talks, EPSTs were unsure how to address students' questions posed about particular science concepts when they themselves did not know the answer. As an example, some EPSTs would response to students by saying "I'm not sure if that's right or not" or "It's very confusing," when pressed about topics such as genetics, natural selection, or flow of energy in a food chain. These instances of confusion for EPSTs during their talks were "eye opening" for them regarding the importance of conceptual knowledge.

Teacher Disposition. The last theme discussed in the debriefing sessions was the importance of a teacher's disposition. Several EPSTs were complimented on their "teacher voice" by their peers, which was described as having a voice that students felt comfortable with and, in turn, were more engaged in the discussion. Another positive disposition displayed by EPSTs was described as having confidence in their teaching. EPSTs that had more experiences teaching were extremely more confident in their ability to teach and lead a group of students. EPSTs that lacked experiences in teaching were nervous, scared, and at times had to stop their discussions to gain their composure, determine what to do next, or look to their instructors for a cue. For EPSTs with less experience, they commented on how the ICSA experience allowed them to see different styles of teaching, which they felt was helpful in shaping their own disposition.

Analysis of Personal Reflections

Thirty-eight EPSTs in the mathematics methods course and forty-two EPSTs in the life and environmental science course submitted written personal reflections about their teaching experiences in the ICSA. Reflections were blinded and twenty reflections from both courses, equaling a total of forty, were randomly selected and analyzed.

Reflections were initially analyzed for common themes within the individual courses of math and science. The initial coding of real-life benefits, importance of content knowledge, and appreciation of good questions and questioning skills were identified within the individual courses. The second round of coding consisted of combining the reflections from both courses to clarify the themes as being consistent from both groups of EPSTs.

DISCUSSION OF STUDENT PERSPECTIVES

Math and Science EPSTs discussed the benefits of the ICSA experience in their written personal reflections. They viewed the ICSA experience as helpful in developing their skills as a practicing teacher in math and science. When discussing the beneficial impacts of the ICSA experience, three sub-themes emerged from both the math and science EPSTs reflections. Therefore, we have combined their reflection results in our discussion. The first theme EPSTs discussed as being beneficial was the real-life experience that ICSA offered them as practicing teachers. EPSTs noted that the ICSA experience was more like "real life" teaching versus the teaching experience with a peer group. The real-life experience of ICSA using avatar students lead EPSTs to realize the importance of knowing your content when teaching math and science. EPSTs also recognized that knowledge of content helped with developing better questions to ask students during discussions, as well as understanding the timing of those questions. These three sub-themes are discussed below.

Real-life Experiences. Thirty-six out of forty EPSTs' reflections discussed how the ICSA experience was like being in a "real-life" classroom working with real students. The EPSTs were surprised at how real the ICSA experience was to them as teachers. This is evidenced by one EPST's statement, "I do not think that there is a better way to prepare someone for something like this because of how realistic it actually is" (EPST 5). A majority of EPSTs stated that the experience made them nervous, as shown by another EPST's statement that "I was very nervous going into it, but after my first talk I'm more confident in my ability to lead a number talk in my practicum classroom" (EPST 3). This same sentiment about being nervous and anxious about teaching is often revealed by EPSTs when preparing to go into local elementary schools. The reality of the ICSA experience was characterized through the personalities of the avatar students as discussed by the following EPST:

> "So, I really do feel that Mursion was extremely helpful in demonstrating what types of interactions you can have with students based on their personalities. For example, Jayla was a very outspoken student, which definitely made her answers a little more comical and so if differed from the other students and that really helps you see that each student is very different which in return makes their answers very different from their peers' answers." (EPST 2)

One disadvantage of the ICSA environment mentioned by twenty of the math and science EPSTs involved the inability to use hands-on materials within the simulation. The inability to use materials or manipulatives with the avatar students was one aspect that EPSTs mentioned in their reflections as being difficult when adjusting their plans. "I knew that in Mursion I could not have something like a container of marbles for the avatar students to use to show the amount of energy in a food chain so I just drew the name of the organism on the whiteboard and wrote the amount of energy for each one." The use of hands-on materials are an essential part of effective elementary mathematics and science instruction (Muschla & Muschla-Berry, 2015; NRC, 2008). The use of hands-on instruction can be the focus of instruction for a majority of elementary classrooms while at times eliminating the minds-on part of the instruction. Facilitating the discourse of a lesson is part of the minds-on portion of a lesson. Before, during, and after the hands-on instruction, the discussion of content should be implemented, addressing the investigations made with the materials and manipulatives. For EPSTs, the elimination of the hands-on portion of a lesson and turning the focus of the teaching practice to discourse was seen as difficult.

Knowledge of Content. Across content areas, thirty-four EPSTs shared how their experiences provided an awareness of their weaknesses in content knowledge. The majority of these experiences involved student questions that the EPSTs were not cognizant of how to answer or student solution strategies for which they were not familiar. The experience with student avatars guided them to analyze the content from a child's perspective and anticipate questions from the mind of a child. One ESPT shared, "The students provided answers to my questions that I did not think about as well as when answered by my classmates. It helps us think on our feet and understand how a child might look at this content through their eyes and not just how we see it" (EPST 7). ESPTs' reflections captured how their Mursion experience also motivated them to research and revisit the topics within their talks. One reflection stated, "When I started doing it, I thought I knew more than I actually did. They asked a question and I couldn't answer it. I went back and did some more research on my topic" (EPST 10). Another shared, "For my next talk, I need to...become familiar with all the possible strategies and the proper terms for those strategies that can be used to solve the problem" (ESPT 17). Their desire to know their content is driven by their authentic interactions with students that are possible through the ICSA experience.

Examination of the reflections on the number talks revealed an impact on EPTS' beliefs about the nature of mathematics. For some EPSTs, this was their first time witnessing students solve a multiplication problem other than with the standard algorithm. This is evident in the following response:

> I learned that there are a lot of different ways that students can solve problems and before I really never considered the thought process a student might have. Instead I only think on my own way or the general [standard algorithm] way to solve a problem" (EPST 12).

One goal of the mathematics methods course is to shift beliefs about mathematics; one EPST captured this by saying it is “not just based on knowing equations, but learning about the relationships between numbers and truly understanding it” (EPST 13). Another EPST commented, “I learned that math doesn’t have to be limited to paper worksheets. Math can be discussed, moved around, and manipulated in multiple ways” (EPST 15). The ICSA seems to support this shift by echoing the learned coursework through student interactions.

Questioning. One specific element that was discussed in thirty-one reflections was the impact of questioning on the experience. EPSTs shared that they were now aware that the questions they asked were the force behind how students would share their ideas. One EPST stated, "I learned what kind of questions to ask and WHEN! I never realized how important the timing of your questions is and in what sequence” (EPST 7-capitalization added by participant). Another shared, "I definitely felt that the Mursion experience was helpful...It helped me to understand the importance of asking good questions, without constantly prompting students to say what I would like them to say” (EPST 19). This particular quote exemplifies a shared experience in which EPSTs would ask a string of literal questions instead of allowing students to share their thinking through an open-ended prompt. This is also evident, as one EPST reflected:

> I learned that it is important to step back and allow students the time to explain their strategies. I oftentimes like to jump in and give the answer before students truly get the opportunity to share their thinking and I could see that in this number talk” (EPST 14).

In addition to the impact of questioning, several EPSTs attended to the purposes of certain questions or teacher moves. That is, they wrote about using talk moves for particular reasons and therefore showed a more advanced conceptualization of eliciting student thinking. As one EPST wrote, "In the future, I need to question their strategy to understand where they are coming from...I think one of the most important things I learned about teaching mathematics from this number talk is to question students to assess and advance them” (EPST 14), we can see that she is strategically trying to listen to the students’ strategy for the purposes of understanding their thinking to inform instruction. Another example of this was when EPSTs spoke specifically about wanting students to make connections within the discussion. One EPST commented, “Another thing I learned that I didn’t really think about is how to relate certain problems to their thinking, how to aid connections to their thinking, to others, and to other mathematical problems” (EPST 12). Another EPST shared, "It was nice to see the students come up with their own strategies and then I was able to help other students make connections with the strategies that they didn’t understand right away” (EPST 16). This attention to connections is evidence that within this teaching experience, EPSTs are beginning to grapple with not only how to elicit student thinking, but how to respond in ways that bring student thinking to the forefront of the discussion.

CONCLUSION

Teacher preparation programs across the nation struggle with finding opportunities for EPSTs to engage in ambitious teaching throughout their undergraduate studies. These teaching opportunities traditionally take place in local schools surrounding the university or in peer-to-peer role play experiences. This traditional teaching experience in schools still remains one of best ways for teachers to practice their craft, but at times, it becomes impractical due to school schedules, teachers’ limited time in classrooms for EPSTs to practice teaching, and EPSTs’ schedules with their own classes at the university. This study has shown ICSAs to be a viable alternative for teacher education programs to engage EPSTs in ambitious teaching.

In addition to logistically opening doors for teaching experiences, ICSAs also allow for specific feedback on elements of ambitious teaching that are predesigned within the simulation scenarios. Within the number and science talk scenarios, one of the main focuses was on eliciting and responding to student thinking. In the debriefs, the teacher educators were able to hone into the development of the EPSTs' questioning and how they utilized students' ideas. Current research on rehearsals have involved cycles of peer-to-peer practice and then implementation of the same instructional activity in an elementary classroom (Kazemi et al., 2009). This cycle requires extensive resources that are not available to larger teacher preparation programs. Utilizing simulations is an innovative approach to rehearsals. The immersive nature of the simulation and the structure embedded in the scenarios creates an opportunity for coaching and enactment within one phase. The reflections showed that EPSTs valued the realistic interactions with the avatars and that these interactions illuminated areas for improvement. The debriefings allowed instructors to target key elements of ambitious teaching and connect that feedback with examples from the student avatars.

Another promising impact of ICSAs is the shift in beliefs about mathematics and science that was evident in EPSTs' reflections. As we strive for EPSTs to see mathematics and science as tools for problem solving and experiencing the world around them, we are fighting against ingrained experiences that position these subjects as merely a set of rules or definitions to memorize. After their first experiences with the ICSAs, ESPTs were sharing that they were thinking of math and science in new ways. They were noting the importance of students' prior knowledge and the value of different approaches. These experiences not only seemed to shift their thinking, but also motivated EPSTs to dig deeper and expand their content and pedagogical knowledge. Incorporating ICSAs early in teacher preparation programs may support earlier shifts in beliefs that can further strengthen the development of ambitious teaching.

Lastly, EPSTs were mindful that the ICSAs did not allow for lessons that utilize manipulatives or hands-on learning experiences. While EPSTs need explicit coaching on effective use of manipulatives and hands-on activities, the other themes that emerged from the reflections support attention on other aspects of ambitious teaching before bringing use of manipulatives to the forefront. That is, EPSTs grappled with eliciting students' thinking and how to navigate a semi-structured discussion and therefore it seems they need opportunities to practice this fundamental aspect of instruction. In doing so, it seems that they will be more likely to effectively attend to student thinking when integrating more hands-on experiences and transform instruction to minds-on experiences that do not merely involve doing activities without meaning.

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