

## **Board 27: Using an Immersive Classroom Simulated Environment for Math and Science Discourse Development in Pre-service Teachers**

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## **Using an Immersive Classroom Simulated Environment for Math and Science Discourse Development in Pre-service Teachers**

An interdisciplinary team of researchers from East Carolina University (ECU)'s College of Education and College of Engineering and Technology were funded in 2017 by a three-year, \$599,939 grant through the Improving Undergraduate STEM Education (IUSE) program (Grant #1725707). This project focuses on the development of discourse on math and science topics between teacher candidates and students using an immersive classroom simulator to practice math and science methods with student avatars. This project follows cohorts of students through a mathematics methods course or a science methods course, and into their internship in schools. The goal of the project is to determine if the integration of interactive classroom simulation activities (ICSAs) in math and science education courses improves teacher candidates' ability to communicate and to facilitate discussion on math and science topics. Pre-service teacher candidates exposed to the immersive classroom simulator are compared to a control group of pre-service teachers who practice math or science methods through peer roleplaying.

The immersive classroom simulator used in this project features a diverse group of five student avatars who have distinct personalities and aptitudes. Teacher candidates have multiple opportunities in their math methods course or science methods course to lead a short lesson and subsequent discussion with students in the immersive classroom simulator. In addition to leading lessons, students also have multiple opportunities to observe other pre-service teacher's lesson delivery. Each session is recorded allowing students to critique their own interaction with students and to learn from their successes and failures. Each session is immediately debriefed by the student's professor with both positive and negative feedback provided.

The immersive classroom simulator is designed to provide opportunities for rehearsal that will improve teacher-facilitated discussions on various topics fundamental to engineering practice including the engineering design process, experimental design, arithmetic, data analysis, and hypothesis testing. This study is designed to evaluate the effectiveness of immersive classroom simulators in the preparation of STEM educators. This study also addresses issues of diversity in STEM education by examining the types of interaction pre-service teachers have with each of the students in the classroom to determine if the interactions are equitable or if certain students are addressed differently based upon disability status, gender, or race.

Videos of each session have been recorded, transcribed, and coded. Preliminary analysis of data collected during the first year of the project are presented including documentation of teacher moves and evaluation of the level of discourse elicited by pre-service teachers through their lesson delivery.

### **Importance of Discourse in Math and Science**

It is critically important to the development of the future engineering workforce to improve student literacy in both math and science. At the heart of math and science literacy is discourse development and enabling students to be able to converse with professionals from a variety of

disciplines using the appropriate vocabulary and techniques for problem solving in both math and science. The interaction students have with math and science educators plays a crucial role in the development of students' understanding of mathematics and science and attitudes about career choice. It is critically important for teachers to communicate topics in math and science, to encourage participation in math and science from all students, and to showcase how math and science is important in a variety of fields. It is also critical to economic development to have an educated workforce that can contribute to jobs requiring math and science knowledge.

Students in eastern North Carolina (NC) consistently perform below state averages on end of grade standardized tests in science and mathematics. According to recent state report cards regarding school performance, only 37% of fourth grade students in eastern NC school districts achieved proficiency in science. Given unsatisfactory student outcomes, it becomes important to examine teacher preparation to communicate these topics effectively to students.

Teachers often receive low evaluation scores on complex teaching skills such as discourse. Many teachers point to a lack of preparation to engage students in discourse in their teacher education [1]. Given the need to allow each teacher candidate to practice discourse development, time and resource constraints can limit the number of opportunities education majors have to practice discourse development prior to their student teaching practicum. Discourse simulation activities at universities prior to student teaching and internships are often insufficient to prepare teachers for engaging in discourse with students throughout an entire school day.

### Traditional Methods of Discourse Development

Traditionally, discourse development begins with pre-service teachers' own understanding of math and science based upon how they were taught when they were first learning the material. Most education programs require pre-service teachers to take at least one laboratory-based science course and to complete mathematics courses. Once the students have a foundation in math and science, they then take courses in mathematics education and science education where they practice delivery of content to students. Traditionally, this is done with the instructor modeling how to present information to students and then the students crafting short lesson plans and delivering short talks.

At ECU, students preparing to be elementary school teachers take courses in both math and science methods where they practice leading a class discussion on relevant math or science topics called "math talks" and "science talks." Pre-service teachers take turns leading the class or pretending to be students. In Figure 1, the student at the front of the table is leading her peers (who are role playing as elementary-aged children) through a 10-minute discussion on a science topic. Another pre-service teacher can be seen raising her hand to answer one of the questions the discussion leader has posed. In this particular discussion, the pre-service teacher is leading the students through a discussion about how children riding on skateboards on a track could test different materials to determine which material is best for slowing down a skateboard on a track at a skate park. This pre-service teacher guided the students to think about how to design an appropriate experiment to test their hypothesis including the factors that must be considered in setting up the experiment. In this particular talk, students discussed whether the experiment

should be done with real skateboards or if it should be done with a scaled model. This science talk also included discussions about the importance of material properties and how they can be evaluated. When discussing the experimental setup, the students were observed discussing which variables would be independent or dependent and what would be used as a control.

Throughout their science and math talks, the pre-service teachers are encouraged to use “talk moves” to increase participation in the discussion by all students and to ensure that all students feel understood by the teacher and by their peers. A table of appropriate talk moves (Table 1) is posted below the whiteboard behind the students in the picture. The talk moves encourage students to explain their reasoning, put complex science vocabulary into words they understand, and to demonstrate understanding of what they have heard from the instructor or a peer. The pre-service teachers are encouraged to restate to the students what they are hearing them say in order to ensure the students feel like their opinion is understood and to allow the students the opportunity to present their thoughts in ways that are understood by the teacher and the rest of the class. Using wait time in discussion is highly encouraged as many novice teachers often do not provide enough time for students to think before they answer their own questions and to allow all students time to formulate an answer before calling upon the first student to volunteer an answer.

Following each of the science and math talks, the course instructor provides feedback to the student about their talk. They discuss their use of talk moves and engage the other students in the class in a conversation about what they thought their peer did well and what they thought their peer could improve upon.



**Figure 1** A pre-service teacher giving a science talk to her peers with the course instructor observing at the end of the table

**Table 1 A table of talk moves pre-service teachers are encouraged to use to facilitate discussion**

Teacher Talk Moves	
Re-Voicing	So let me see if I've got your thinking right. You're saying _____?
Re-stating	Can you repeat what he just said in your own words?
Asking students to apply their own reasoning	Do you agree or disagree and why?
Prompting for further participation	Would someone like to add on?
Asking students to explicate their reasoning	Why do you think that? What evidence helped you arrive at that answer? Say more about that.
Using wait time	Take your time-we'll wait.

While this approach does give students the opportunity to practice talk moves and to learn how to present content and drive a discussion, there are several drawbacks to this traditional method of discourse development. First, while other college students may be able to role play and put themselves into the shoes of an elementary school child, they have spent more years learning math and science and have the advantage of high school and college-level math and science courses. They may not be able to fully impersonate students who are learning math and science topics presented to them for the first time. In some of the peer-to-peer science talks it was observed that college students engaged in discourse about terms like gravity, friction, mass, volume, control variables, and other terms that may be new or unknown to elementary-aged students.

Second, in peer-to-peer simulation, the students may not be exposed to as diverse of a student population as they are likely to find in the classrooms where they will teach during their career. At ECU, elementary education majors are predominantly female (97%) and Caucasian (95%). There is an underrepresentation of male students in most education majors, especially those intending to teach younger students, making it a challenge to simulate teaching boys when the audience simulating the teaching experience is comprised entirely of women. This approach also does not give students exposure to students from a diversity of cultural backgrounds. As an overwhelming majority of education majors at ECU are Caucasian females, pre-service teachers have limited opportunities to practice discourse development with students from other cultures until they reach their student teaching internship experience.

Thirdly, this method of discourse development involves engaging peers who want to participate in the discussion. Children in real classrooms often have bad days, may talk out of turn, may not respect their peers, and may not be kind to their classmates when they give an answer they disagree with. In the peer-to-peer simulation, it was observed that all of the pre-service teachers were supportive of each other, participated in the discussion without coercion, and volunteered input to the conversation. This may present an unrealistic expectation as teachers enter a real classroom.

Finally, the pre-service teachers simulating the behavior of elementary-aged children often may not present a broad spectrum of intellectual abilities. In a real classroom there are often students who are academically gifted and ahead of their grade level on some topics, students who are on grade level, and students who may require remediation to improve. The peer-to-peer simulation did not allow students many opportunities to correct misunderstandings of students who may have a hard time grasping topics. It also did not present the opportunity for pre-service teachers to interact with students who may have learning differences or emotional and social challenges such as autism, dyslexia, or attention deficit disorder.

### Immersive Classroom Simulator

The Mursion interactive classroom simulator was developed at the University of Central Florida under the name TeachLivE. This system has avatars representing students who can interact with teachers, answer questions, and participate in discussions. The virtual student avatars are able to raise their hands, speak, and express various emotions. Each avatar is also able to mimic reading a worksheet, taking notes, and simulates carrying on conversations with other students in the class. A voice actor who has a background in theatre and has also been trained on various cultural competencies voices all of the avatars and controls their movement. ECU has a license to use the Mursion system and contracts with an interactor for each Mursion session. The Mursion classroom at ECU is decorated to look like a regular classroom, but has a large flat panel television so education majors can see and interact with the student avatars. There are microphones and cameras in the Mursion classroom so the interactor can see the lessons being presented including seeing what is being written on a whiteboard. Chairs in the Mursion classroom allow observers to view the interaction between a presenter and the student avatars.

Figure 2 depicts the upper elementary virtual classroom used in this study. This virtual environment is designed to look like a modern classroom including a smartboard, bookshelves, and tables. While there are only 5 students in the virtual classroom, they represent a diverse set of students including an Asian-American girl (Mina), a Caucasian boy (Will), an African-American girl (Jayla), a Caucasian girl (Emily), and a Hispanic boy (Carlos). Each of these fifth grade students have their own personal stories that pre-service teachers can learn as they interact with them. Mina, for instance is president of the student council and her family recently adopted a dog. Carlos enjoys playing video games and building things with his erector set. Some of the students are more outgoing and enjoy being part of the conversation (Carlos and Jayla) and others are shy (Emily and Will). Carlos has a strong sense of humor and likes to make jokes. Certain avatars also have other capabilities to help pre-service teachers learn classroom management, Will, for instance can become bored and fall asleep in class. The Mursion classroom can be customized to have five students as shown in Figure 2 or only three students. Additionally, the Mursion system has a middle school classroom environment with older avatars. The middle school virtual classroom also can swap in different avatars including a student with autism, a student who is learning English as a second language, and a student with a language-based learning disability.





**Figure 2 Upper Elementary Mursion Classroom**

The Mursion system allows two videos to be simultaneously captured and synchronized, one showing what the preservice teacher is doing throughout the simulation and the virtual classroom. In Figure 3, a screen capture from one of the collected videos can be seen. In this picture, a pre-service teacher is delivering a lecture on genetics and drawing a punnett square on the board to illustrate the contributions from both mother and father to the genetic makeup of children. The video on the left shows what the interactor is able to see in the Mursion classroom through the camera and the video on the right shows what the interactive classroom simulator looks like from the perspective of the pre-service teacher.



**Figure 3 A pre-service teacher delivers a science talk on genetics to the Mursion class**

## ICSAs in Math Methods Course

In the math methods course, pre-service teachers have primarily engaged in teaching students to multiply. The simulation activities are done in small groups (6 students per group) with each student taking a 10-minute turn interacting with the simulator. The first student introduces multiplication of a one digit number with a two digit number ( $6 \times 12$ ). The second student to work through the simulation then advances the students to multiplying two two-digit numbers ( $12 \times 15$ ). The third student uses bigger two-digit numbers to practice multiplying ( $12 \times 24$ ). The students in the virtual classroom were told to solve each problem in their head without writing anything down on paper. While one pre-service teacher is leading the number talk, the other 5 are observing the interaction. After the progression of instructions in multiplying progressively more challenging problems is done with the third number talk, the talks reset and the last 3 pre-service teachers go through the same problems as the first 3 teachers.

In each simulation, the pre-service teachers practice presenting the problem to the students and asking what answers they got to the problem. In one video, most of the students respond with correct answers to the problem, but the interactor is sure to have students answer incorrectly every so often to ensure the pre-service teachers get a chance to correct improper procedures. In the case of  $6 \times 12$ , all but one student responds that they got 72 as the solution. The pre-service teacher then asks the students to discuss their methods and helps the student who answered incorrectly to discover the mistake in his methods. This offers the pre-service teacher the opportunity to present various strategies based upon the techniques the students in the classroom are using.

The Mursion simulation environment is able to expose students to a common occurrence in a traditional classroom, when one student has a hard time understanding a concept and becomes progressively more frustrated by not understanding. In Figure 4 it can be seen that one of the students (Will) is still thinking about how to solve a problem while the other four students are raising their hands to present a solution. In Figure 5, Will becomes progressively more frustrated and visibly exhibits his frustration by crossing his arms and holding his sides, he also begins rocking back and forth. As the problems become progressively more difficult, he makes comments about how he will not be able to solve a harder problem because he didn't figure out how to solve a previous easier problem. This simulation gives pre-service teachers the opportunity to engage in remediation of students who may not be tracking a lesson with their peers.





**Figure 4 All but one of the students in the Mursion classroom have an answer to a math problem**



**Figure 5 A student becomes visibly frustrated because he does not understand how to solve a problem**

### ICSAs in Science Methods Course

In the science methods course, each student has the chance to lead the course through three talks. In the first talk, they discuss planning and carrying out investigations in which they walk their peers or the Mursion students through a probe prompting them to think about how they would design an experiment to test a hypothesis. In the second talk, they will walk the class through interpreting and analyzing data from an experiment. In the third talk, they will lead the class through conducting the experiment.

Each of the science talks began with the pre-service teacher presenting a probe. In the case of the traditional classroom, the teacher read the probe aloud to the students, in the Mursion classroom the teacher instructed the students to “read” through a probe that was provided for them in writing. The probes covered a diverse set of topics ranging from genetics and how physical traits are expressed based upon the composition of our genes contributed from each parent to cellular structure to the lifecycle of butterflies. In the Mursion classroom some pre-service teachers chose to use the whiteboard to draw diagrams such as drawings of single-cell organisms and the different components of plant and animal cells to aid in their presentation and others elected to conduct the entire talk orally.

One probe prompted students to think about what would happen on an island if all of the plants died off. The students were asked to discuss whether the animals that eat only plants would die, if the predators who eat other animals would live, if omnivores who eat both plants and animals would live, or if eventually all animals would die off. In this talk the students were introduced to vocabulary terms such as producer, consumer, secondary consumer, food chain, and food web. They discussed the terms predator and prey.







A set of probes regarding the design of an investigation was developed by the science education faculty member Co-PI and distributed to preservice teachers to use in their science talks. There were eight probes and the pre-service teachers were asked to present them in small groups. Six students attended class at a time and practiced discussing the probe for ten minutes each followed by feedback from the instructor. Probes were designed to introduce students to various science topics while using scenarios familiar to children. Topics in the experimental design probes ranged from designing experiments to find out whether a light ball or heavier ball would travel further when thrown from the bleachers, if a soccer ball would roll further on grass or bare dirt, and whether cars rolling down a steep slide or a less steep slide would go further or faster.

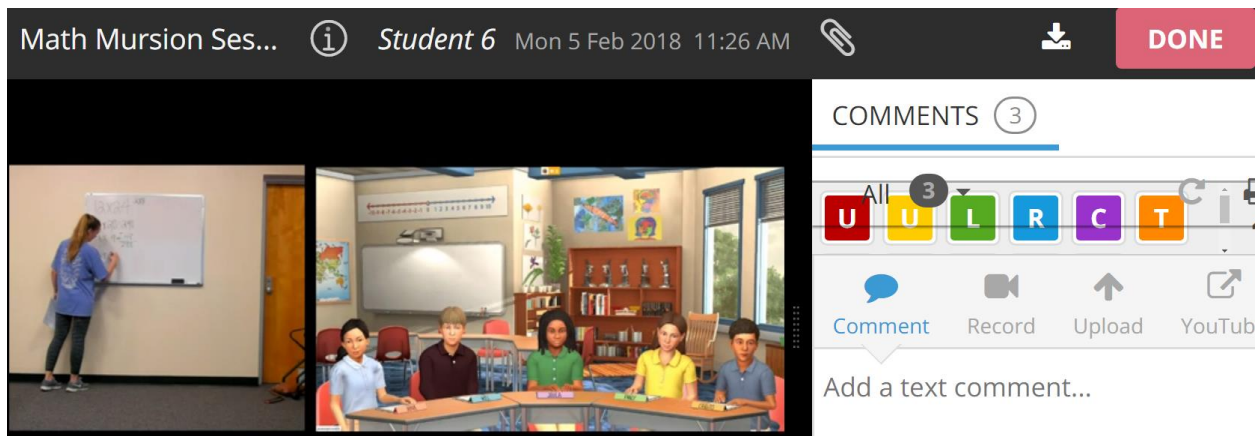
In the second science talk, students will have the chance to present data and lead the class through discussions on how to interpret that data. Talks could include plotting the data, finding trends in data, drawing conclusions from data, and using proper statistics techniques to analyze the data. The third number talk will allow the teachers to lead their peers or the Mursion students through conducting an experiment or observing a demonstration and collecting and analyzing the data from their experiment.

### Data Transcription Methodology

The videos from each number talk and science talk in both the traditional classroom format and the Mursion classroom have been uploaded to GoReact to allow coding of each “teacher move.” The videos are in process of being coded through systematic observation [2] using the Analyzing Teaching Moves Guide (ATM) as a-priori codes. The ATM is a tool for examining how a teacher orchestrates discussions in the classroom by categorizing each question or comment a teacher makes [3]. Furthermore, each question or comment from the teacher is considered in the context in which it is used. This means that when coding a teacher’s question or comment, the coder must consider what was said before and after to determine the categorization of the code. Beyond a categorization of moves, the ATM is a targeted method for studying the interactions within a classroom in their context [4],[5]. Each teacher utterance or question, termed teacher moves, are broadly categorized as initiating moves (e.g., launch, literal), which are moves a teacher uses to start a discussion, and rejoinder moves (uptake, connection), which are moves that show a teacher is hearing what a student has said [3] and can use responses students have given to get the class to think more deeply about the problem. The moves being considered are delineated in Table 2. GoReact allows the coder to watch the videos and mark at particular timestamps when each of these talk moves occurs. Figure 6 is a screen capture from the GoReact interface. The colored tiles to the right of the videos on GoReact allow instructors to code the videos with the teacher moves observed at a particular timestamp.

**Table 2 Teacher moves used to begin, continue, and end conversation**

Teacher Move	Definition	Example
<i>Initiating Moves</i>		
Launch 	Open-ended question or prompt at the start of a lesson to get students thinking about the topic at hand.	“As we begin today, please think about a time when you had to share something with others. How did you determine how much each person should get?”
Literal	A question looking for a very specific factual answer	“How many trials were performed in this experiment?”
<i>Rejoinder Moves</i>		
Repeat 	The teacher echoes back the answer heard from a student.	Student: I got 45 Teacher: Jason got 45 as the answer to the problem
Uptake  	The teacher begins with a student response and expands on what was said to extend or deepen the conversation. In GoReact the U was used for both a regular uptake (red) indicating an extension of the discussion based upon one student’s answer and an uptake-literal (yellow) where one student’s answer is used to drive a student to solve a similar problem with a literal answer.	<i>Uptake</i> Student: I saw something like this before when I was at camp. Teacher: Tell me more about what you did at camp.  <i>Uptake Literal</i> Student: The area inside the rectangle is 36. Teacher: Using the same technique you used to get 36, what would be the area if each side was twice as long as it was in the previous rectangle?
Connection 	The teacher tries to make an explicit connection between concepts or methods.	How can we use what we learned about multiplying in the previous problem to solve this harder problem?
<i>Terminal Moves</i>		
Terminal 	A move by a teacher to either end the discussion or to move the conversation in a different direction.	Let’s consider a different problem... That’s all for today...



**Figure 6** Screen capture from GoReact system showing video of the Mursion classroom and the interface for adding comments and coding teacher moves.

The videos have been entered with anonymous student identifiers (“Student 6”) and the date and time of the session. When an instructor clicks on a tile, it is added as an overlay to the video at the time in which that move occurred. The instructor can also add comments to recognize good use of teacher moves or to suggest alternative approaches. The students can see their own videos in GoReact and are instructed to code and critique their talk.

### Interactions with Diverse Students

As was previously mentioned, the elementary education major at ECU does not present many opportunities to practice interaction with male students or students of color. The avatars in the Mursion classroom are purposefully designed to be diverse in order to allow students to interact with a diverse group of students. In preliminary observations, it was discovered that many of the students called on Emily (Caucasian female avatar) first in class discussions. In addition to coding the videos based upon the number of talk moves used, the PI team has plans to code the videos of the Mursion sessions to determine how often the pre-service teachers interacted with each of the avatars and in what ways. The goal of this coding is to determine if pre-service teachers, whether consciously or subconsciously, interact differently with boys and girls or with students of color and other students in the class.

### Data Analysis

Once the videos are all coded, the talk move data will be presented in an infographic as shown in Figure 7. The infographic in Figure 7 divides a math talk into turns where each time a teacher and a student have an interaction a new turn begins. During each turn, the number and type of teacher moves are tabulated. All the moves within a turn are represented by the different colored boxes within each column and they are marked with the sequence order (e.g., 1, 2). For example, within teacher turn #8, the teacher initiated the turn by repeating what a student previously said, then she provided information, and she ended the turn by asking a literal question.



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