

2015

# Fully Online Methods Courses? Reconceptualizing STEM Teacher Preparation Through "Spaces of Learning"

Geeta Verma

*University of Colorado Denver, geeta.verma@ucdenver.edu*

Heather L. Johnson

*University of Colorado Denver, heather.johnson@ucdenver.edu*

Joanna C. Dunlap

*School of Education and Human Development at the University of Colorado Denver, Joni.Dunlap@ucdenver.edu*

Evan McClintock

*University of Colorado Denver, evan.mcclintock@ucdenver.edu*

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## Recommended Citation

Verma, Geeta; Johnson, Heather L.; Dunlap, Joanna C.; and McClintock, Evan, "Fully Online Methods Courses? Reconceptualizing STEM Teacher Preparation Through "Spaces of Learning"" (2015). *STEM Faculty Presentations*. 48.  
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# FULLY ONLINE METHODS COURSES? RECONCEPTUALIZING STEM TEACHER PREPARATION THROUGH “SPACES OF LEARNING”

Geeta Verma, Heather Lynn Johnson,  
Joanna C. Dunlap & Evan McClintock

University of Colorado, Denver (USA)

Geeta.Verma@ucdenver.edu, Heather.Johnson@ucdenver.edu, Joni.Dunlap@ucdenver.edu,  
evan.mcclintock@ucdenver.edu

*Rather than viewing eLearning as being best suited for courses fitting a particular type, we suggest a paradigm shift, involving a reconceiving of the nature of instructional experiences within a course. We share how we have reconceptualized mathematics and science (STEM) teacher preparation at the University of Colorado Denver (CU Denver) through designing and implementing fully online methods courses for our prospective STEM teachers (pSTEMs). Our fully online methods courses incorporate Spaces of Learning (SOL)—multidimensional instructional experiences that provide opportunities for pSTEMs to engage in a variety of activities designed to promote and scaffold their investigation of, reflection on, and response to STEM teaching practices. By reconceptualizing what it means to engage in STEM teacher preparation, we are expanding possibilities for our pSTEMs through their participation in SOL.*

*Although online courses have been available for years, certain types of courses may be seen as challenging or even undesirable to deliver through eLearning. Methods courses in teacher education programs—in which prospective teachers develop knowledge, pedagogy, and strategies for teaching—represent courses of this type. Rather than viewing eLearning as being best suited for courses fitting a particular type, we suggest a paradigm shift, involving a reconceiving of the nature of instructional experiences within a course. We share how we have reconceptualized mathematics and science (STEM<sup>1</sup>) teacher preparation at the University of Colorado Denver (CU Denver) through designing and implementing fully online methods courses for our prospective STEM teachers (pSTEMs).*

*As part of their teacher preparation program at CU Denver, pSTEMs take two methods courses in either mathematics or science education. The methods courses occur in the last two semesters of the program, in conjunction with field experiences at local middle and high schools. Currently, we offer one methods course in science education and one in mathematics education in a fully online format. We have designed the program experience such that pSTEMs can enrol in the two methods courses in any order, rather than requiring that one methods course precede the next. In making these design decisions; we are working to create greater access for pSTEMs in urban, rural, and remote locations.*

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<sup>1</sup> Throughout the paper, we refer to the combination of mathematics and science as “STEM.” We use the acronym STEM—standing for science, technology, engineering, and mathematics—to be more succinct in our writing. We do not mean to suggest we consider STEM to include only mathematics and science.

## **THREE REASONS WHY ONLINE METHODS COURSES ARE APPEALING**

One of the reasons why online versions of teacher preparation courses—including STEM methods courses—are so appealing is the varied background and current life circumstances of the prospective teachers enrolled in the program. Prospective teachers selecting CU Denver have a range of life experiences. Some are undergraduate students, attending CU Denver just after finishing high school. Others are working adults, participating in a graduate teacher preparation program while balancing demands of work, home, and family. STEM methods courses at CU Denver are intended to meet the needs of a range of pSTEMs, whose concurrent field experiences span middle and high school grade bands and encompass a wide variety of STEM content. We see the diversity of our pSTEMs' experience as a strength of our program. By differentiating our STEM methods courses to meet the needs of our diverse pSTEMs, we work to maximize affordances and minimize limitations related to accessibility by making the program—including methods courses—available online.

Another reason why online versions of STEM methods courses are instructionally appealing is the challenge of engagement in face-to-face courses. In our face-to-face courses, we have noticed that there are students who are physically present but not intellectually engaged with the work of the course. One of the advantages of a fully online course is that it allows space and time for all students to engage with and make contributions to all of the course materials and activities.

Finally, we were keen to develop and deliver online versions of our STEM methods courses because of our pSTEMs' busy schedules. pSTEMs at CU Denver have classroom field experiences during the day. If the STEM methods courses are not online, the pSTEMs have to come to campus for classes in the evening after a full day in their field-experience classrooms. Releasing temporal bounds supports our work with our pSTEMs in part by removing challenges of a traffic laden commute to an urban campus and a balancing act between family and school responsibilities. By allowing our pSTEMs to engage with the STEM methods course content when they can be most present, we can support their learning.

Through fully online methods courses—one in both mathematics and science education—we can design powerful experiences that robustly address the needs of our population and prepare pSTEMs for the high-touch, high-interaction endeavour of teaching middle and high school students.

## **PRESENCE+EXPERIENCE**

To guide our<sup>2</sup> design of fully online STEM methods courses, we created the Presence+Experience (P+E) framework (Dunlap, Verma & Johnson, in press), which integrates the Community of Inquiry (CoI) model (Garrison, Anderson & Archer, 2000; Garrison & Arbaugh, 2007) with Kolb's experiential learning cycle (Kolb, 1984; Kolb, Boyatzis & Mainemelis, 2000) (see Figure 1). An established model in the online-education realm, the CoI model serves to explain the relevance and criticality of attending to three key presences in online learning environments: teaching, social, and cognitive presence. Teaching presence refers to the decisions and actions of the instructor in a learning environment, such as the decisions related to the organization and structure of a learning experience, the design

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2 In sections of this article in which course planning and design decisions are described, “our” and “we” refers to the two authors who developed the courses described in this article.

of instructional materials and activities, the facilitation of instructional activities, and the assessment of student learning. Social presence involves the connections students and faculty establish in a learning environment; social presence is influenced by the quality and quantity of student-to-student and student-to-instructor interaction, helping all involved to feel more involved, engaged, and real in an online space. Finally, cognitive presence refers to the interactions students have with course content; supported by teaching and social presence, students' cognitive presence is engaged through relevant cognitive-processing activities and assessments that lead to enhanced conceptual understanding.

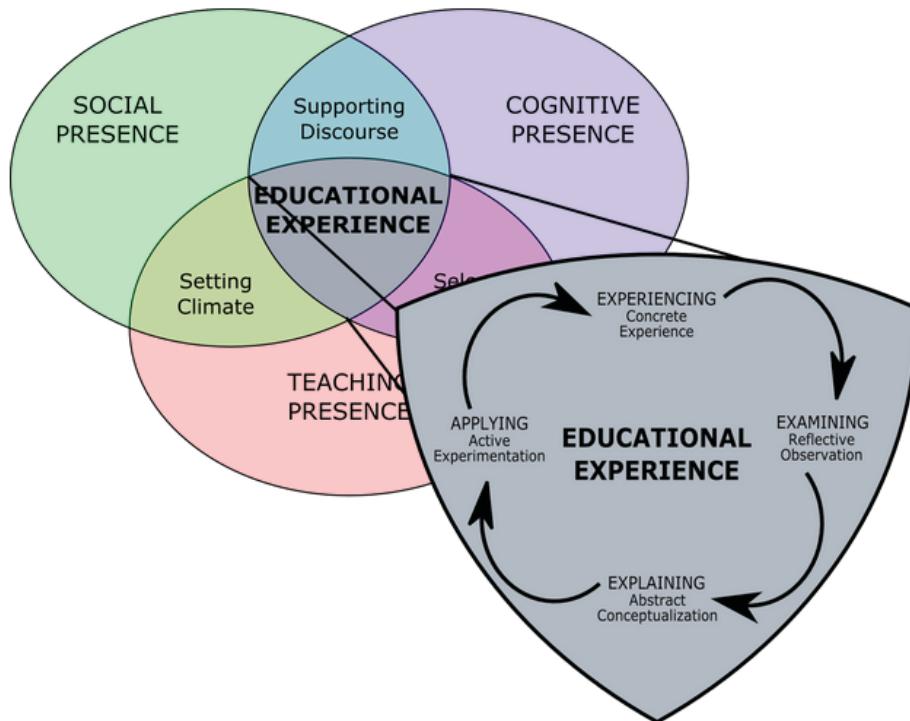


Figure 1: The presence+experience (P+E) framework

Defining learning as the transformation of experience, Kolb's experiential learning cycle involves four key components: Experiencing (Concrete Experience), Examining (Reflective Observation), Explaining (Abstract Conceptualization), and Applying (Active Experimentation) (Kolb, 1984; Kolb, Boyatzis & Mainemelis, 2000). Kolb's cycle recommends starting with a concrete experience, in which students engage in a specific experience. Then, students reflect on the experience, considering various aspects of their observed experience and drawing meaning from the experience. At this point, students are primed to handle the abstract conceptualization of what they have been studying, drawing logical conclusions based on their reflections and in light of theoretical constructs that explain aspects of the experience. Finally, students apply their new learning and understanding through active experimentation (e.g., completing a project, simulation, case study, fieldwork).

Because the CoI model is more descriptive than prescriptive, the P+E framework simply overlays Kolb's cycle on the CoI model to provide specific online-course design and facilitation guidance. Using the P+E framework, online course designers and educators can

leverage Kolb’s experiential learning cycle to systematically address the teaching, social, and cognitive presences of the CoI model.

### **THE PRESENCE+EXPERIENCE (P+E) FRAMEWORK IN ACTION: “SPACES OF LEARNING (SOL)”**

When developing fully online STEM methods courses, we drew on resources (e.g., readings, classroom videos, and interactive web-based tools such as simulations) similar to those we would use in a face-to-face STEM methods course. Using the P+E framework, we designed Spaces of Learning (SOL) (see Figure 2)—multidimensional instructional experiences that provide opportunities for pSTEMs to engage in a variety of activities designed to promote and scaffold their investigation of, reflection on, and response to STEM teaching practices. Figure 2 shows overlap between the investigation, reflection, and response dimensions because the dimensions do not live in isolation. For example, a pSTEM’s reflection may stimulate further investigation, and her subsequent response may stimulate yet more investigation and reflection.

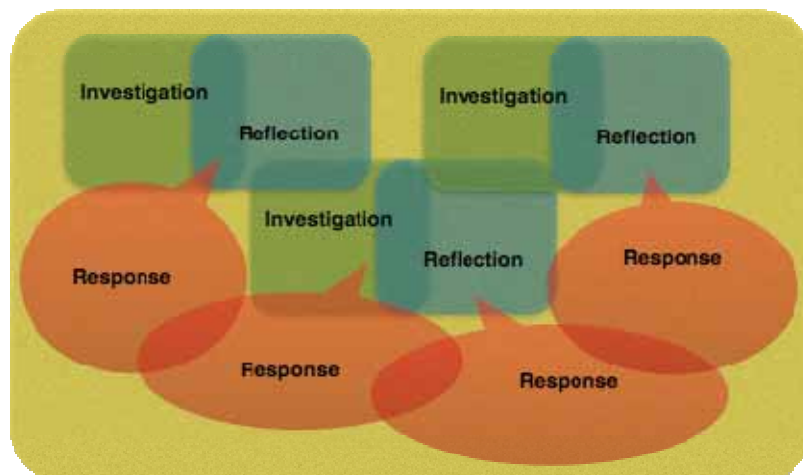


Figure 2: Investigation, reflection, and response dimensions of the spaces of learning (SOL)

In the investigation, reflection, and response dimensions of the SOL, pSTEMs engage in each of the four components of Kolb’s (1984) experiential learning cycle. Furthermore, each dimension addresses the teaching, social, and cognitive presences of the CoI model. In particular, we design and facilitate the SOL (teaching presence) to engage pSTEMs in critical thinking related to the work of teaching (cognitive presence) in ways that support their interaction with other pSTEMs and their instructor (social presence).

A key feature of our SOL involves our strategic use of vetted classroom video to support our pSTEMs’ development of teacher noticing, which refers to teachers’ interpretation of a teaching situation for a particular purpose (e.g., Sherin & Han, 2004; van Es & Sherin, 2002). Through the investigation-reflection-response dimensions of our SOL we provide opportunities for our pSTEMs to engage in teacher noticing to foster their development of high leverage teaching practices (Ball & Forzani, 2009). By high leverage practices, we mean those “tasks and activities that are essential for skilful beginning teachers to understand, take responsibility for, and be prepared to carry out in order to enact their core instructional responsibilities” (p. 504).

**Investigation:** In the investigation dimension, pSTEMs observe videos of STEM teaching practice and explore interactive web-based tools, addressing the Experiencing (Concrete Experience) component of Kolb’s (1984) experiential learning cycle. We drew on reputable web resources with freely available video and interactive web-based tools, including but not limited to the Teaching Channel (<https://www.teachingchannel.org/>), Annenberg Learner (<http://www.learner.org/>), PBS Learning Media (<http://www.pbslearningmedia.org/>), the National Council of Teachers of Mathematics’ (NCTM’s) Illuminations (<http://illuminations.nctm.org/>), and the National Science Teachers Association’s (NSTA’s) Learning Center (<http://learningcenter.nsta.org/>).

For example, in the mathematics education course, pSTEMs could explore an interactive web-based tool that could be used to foster their students’ learning of key STEM content, such as NCTM Illuminations’ “Cost per Minute”: <http://illuminations.nctm.org/Activity.aspx?id=6380>, which dynamically links graphs representing different linear relationships. In a related investigation, pSTEMs could observe a classroom video for the purpose of noticing how a teacher’s STEM teaching practices provide students opportunities to draw on multiple resources to support students’ developing proficiency in graphing linear equations, such as the Teaching Channel’s “Graphing Linear Equations: Full Body Style” Lesson: <https://www.teachingchannel.org/videos/graphing-linear-equations-lesson>. In another investigation, pSTEMs could observe a different classroom video using a different full-body approach to graphing linear equations, such as the Teaching Channel’s “Linear Graphs: Life-Size Coordinate Pairs” lesson: <https://www.teachingchannel.org/videos/linear-graph-lesson-plan>.

In the science methods course, students watch multiple video to investigate how reform guided teaching looks in an actual classroom. As an example, students watched a video called making predictions to investigate ways in which a teacher promotes inquiry in his classroom, how the teacher helps his students make predictions throughout the lesson, and understanding collaborative meaning making.

**Reflection:** In the reflection dimension, pSTEMs determine salient aspects of interactive web-based tools and identify key teaching moves represented in the videos, addressing the Examining (Reflective Observation) component of Kolb’s (1984) experiential learning cycle. As an example, in the mathematics education course, exploring the “Cost per Minute” interactive web-based tool, pSTEMs could develop conjectures about how changes in one graph could result in changes in a linked graph. In related reflections, pSTEMs could identify specific practices in each classroom video that fostered students’ drawing on multiple resources to develop proficiency in graphing linear equations, making explicit connections to the different lessons.

In the science methods course, students reflected on various prompts posed by the instructor that tied the class readings to the investigation activity. See a screen shot of this investigation activity below:

Now view this video:

[Making Predictions](#)

When viewing the video, focus on two aspects:

- 1) 5-E learning cycle: Where would you place this lesson activity on the 5-E template (think various phases of learning cycle - engage, explore, explain, elaborate, and evaluate)
- 2) Inquiry: What kind of inquiry is happening in this lesson (think open inquiry, coupled-inquiry, structured inquiry, and guided inquiry) and why?
- 3) If I were to ask you to capture the essence of inquiry in the science classroom using one image from this video (making predictions) what would it be? In other words, think about a visual image that got your attention from this video.

Screenshot 1: Investigation and reflection dimensions of the spaces of learning (SOL)

**Response:** In the response dimension, pSTEMs demonstrate their developing competency and emerging STEM teaching practice, addressing both the Explaining (Abstract Conceptualization) and Applying (Active Experimentation) components of Kolb's (1984) experiential learning cycle. pSTEMs have the opportunity to respond to instructor prompts designed to focus their attention on salient aspects of STEM teaching practice represented in the videos and to foster their strategic use of web-based tools with which they interacted.

In mathematics education course, pSTEMs could explain how they might facilitate their students' use of the "Cost per Minute" interactive web-based tool to develop conjectures about how changes in one graph could result in changes in a linked graph. In a related response, pSTEMs could use images, videos, and/or text to communicate aspects of the STEM teaching practices they were noticing in one or both of the lessons that they viewed. In another response, pSTEMs could compare and contrast the tasks used in the different lessons, explaining how those tasks might be used to support students' developing proficiency in graphing linear equations. In conjunction, pSTEMs could address how they are working to enact compatible high-leverage STEM teaching practices around the same or related content in their concurrent field experiences.

In science education course, pSTEMs could also use multiple modalities (e.g. images, videos, text) to share their understandings about successful aspects of the investigation activity. In addition, they were able to demonstrate their competencies as they start to enact these practices in their own teaching. The screenshot shared below captures the essence of the response dimension of *Spaces of Learning*:



## Posting to the Discussion Board - No Group Work for this discussion board



**this is a media comment**

1) Based on watching the video (making predictions), [take a screenshot](#) of a [particular instance in the lesson](#) that captures the essence of inquiry for you. [Post it here \(don't attach\)](#) - rather embed the image for everyone to see on the discussion board (do this individually):

- Provide a **short title** for the screenshot (**6 words or less**)
- In **50-100 words**, explain how the instance in the lesson that you captured fits in the inquiry conversations (did you find the lesson to be structured, guided, coupled, or open inquiry). Where do you fitting this prediction activity in the 5-E learning cycle template?

2) Please share your initial ideas about your 5-E unit plan. We will be using [this template](#) to write our unit plans. **Become VERY familiar with this template.** Read the prompts and guidelines I have provide in the explore and engage section of the template. Now, post a response to the following prompts using bullet points (please don't write it out as a paragraph) - **do this individually:**

- **Topic for your unit plan** (At least 1-2 sentences)
- **Initial Engage Ideas** for your unit plan (let's start with one lesson) - At least one paragraph
- **Initial Explore Ideas** for your unit plan (let's start with one lesson) - At least one paragraph
- **Classroom management challenges** you anticipate in implementing this unit plan - identify 2-3 challenges
- **Inquiry Continuum categorization** - As of now, where do you see you engage and explore activities on inquiry continuum (structured, guided, coupled, or open inquiry)? At least one paragraph

*I've included a my picture and caption to get things started.*

### Screenshot 2: Response dimensions of the spaces of learning (SOL)

## CONCLUDING REMARKS

Rather than engendering pSTEMs' progression through a lock-step sequence of instructional experiences, such that particular competencies must be demonstrated prior to moving forward, we leverage Spaces of Learning (SOL) to enculturate pSTEMs into STEM teaching practices. In particular, SOL provide safe spaces in which pSTEMs can engage in teacher noticing and develop high leverage STEM teaching practices through rich, multidimensional experiences.

Multidimensional SOL provide an example of a way in which online course designers can use the Presence+Experience (P+E) framework to design learning experiences for courses that may be seen as challenging or even undesirable to deliver through eLearning. Although we designed SOL for our online STEM methods courses, we believe that SOL could be useful for other types of online methods courses.

Not only is it possible for STEM methods courses be delivered through eLearning, we argue there are a greater range of possibilities available by leveraging the affordances of eLearning. SOL allows us to tap into those affordances. Important, we are not "converting" face-to-face STEM methods courses to fully online methods courses. Rather, we are expanding possibilities for our pSTEMs by reconceptualizing what it means to engage in STEM teacher preparation.

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