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## Teaching Science Teachers in an Online Context with a Constructivist Approach

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# Teaching Science Teachers in an Online Context with a Constructivist Approach

Frederick W. Freking & Jenny D. Ingber

Over the last few decades there have been several calls to action regarding the necessity for increased numbers and better preparation of American students going into the fields of Science, Technology, Engineering, and Mathematics (STEM) (e.g. National Academy of Sciences, 2006; National Commission on Excellence in Education, 1983). One of the key strategies for answering these calls is better preparation of teachers of STEM disciplines at the kindergarten through twelfth grade (K-12) levels. The need for effective STEM teachers is critical, with the President calling for the recruitment, preparation, and induction support of at least 100,000 middle and high school teachers who have strong majors in STEM fields and strong content-specific pedagogical preparation. However, there are several challenges to the recruitment, preparation, and retention of STEM teachers (President's Council of Advisors on Science and Technology, 2010). The University of Southern California (USC) has begun addressing this need by recruiting and preparing cohorts of STEM majors to become K-12 teachers through a fully online Masters of Arts in Teaching program.

This paper describes the USC program from the perspective of one of its implementers, Fred Freking, who is constantly reflecting on his teaching practice and considering ways to integrate and model learning theory and best practices in the context of a fully online STEM teacher preparation program (STEM TPP). Fred's work is supported by Jenny Ingber, who helps him think through his ideas and serves as a "critical friend." By examining student work from their joint Robert Noyce Scholarship grant, Ingber helps to identify strategies both to maintain a student-centered orientation and improve the quality of student experiences and products. The collaboration between the authors is reflective of the learning theories highlighted in this paper and has articulated how, within the online STEM TPP, learning theory is modeled, addressed, and tied to science teacher practice.

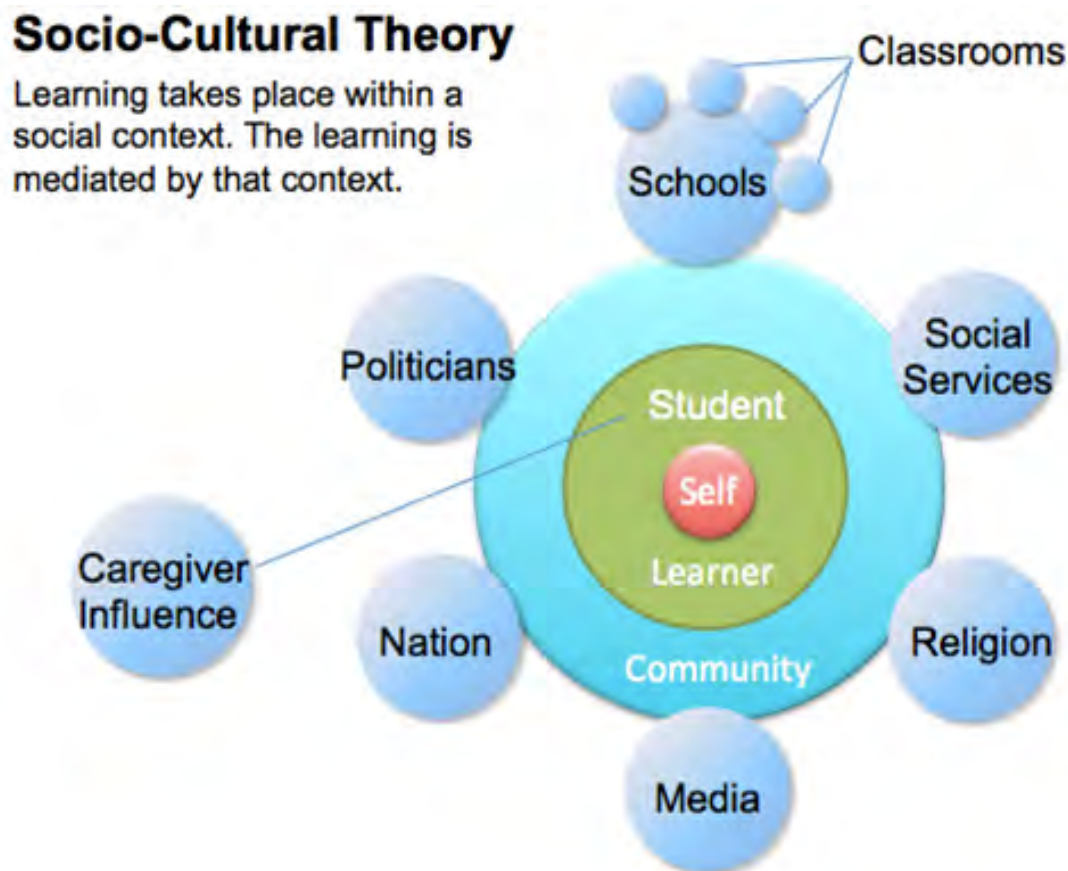
## Learning Theory & Program Development

The development of the online STEM TPP, and each of the courses within the program, required careful consideration of our beliefs about how people learn and the strategies that could support this learning. The theoretical underpinnings of the STEM TPP are based on a framework that draws from sociocultural theory (Vygotsky, 1978; Wertsch, 1991). This framework suggests that an instructor's role is to provide the tasks, assignments, and supportive scaffolding that will allow for increasingly higher order thinking among students. We also want teacher candidates to develop the skills and strategies to create a learning environment that parallels the one we create for them.

We cannot take for granted, however, that such skills will automatically develop in teacher candidates' practice. In the same way that Noddings [1993] calls for teachers to avoid simply "turning students

loose ‘to construct’” (p. 38), we should also avoid turning our teacher candidates loose to think critically or to foster critical thinking in their classrooms without support from us (Anthony, 1996, p. 365). If we want to know, for certain, that our teacher candidates can teach in ways that reflect and foster critical thinking, we must make explicit our commitment to the development and assessment of critical thinking and discourse.

To create the USC online TPP, faculty worked together to develop a curriculum that integrated theory and practice and utilized technology to increase the interactions between faculty and students. The core theoretical underpinning of the program is that learning is a social, societal, and academic endeavor that is enhanced through the inclusion of diverse human and learning characteristics in students’ learning experiences (see Figure 1). This is the essence of sociocultural theory. The sociocultural framework is based upon the seminal work of Lev Vygotsky and is expanded upon in current literature (Gallimore & Tharp, 1990; Ladson-Billings, 2008; Hollins, 2008).



*Figure 1. MAT Program’s View of Sociocultural Theory*

In a classroom built on the ideas of sociocultural theory, students engage in inquiry-oriented, interactive group projects and discussions, co-constructing new understandings through their collaboration and discourse. While class or group ideas may surface through the collaborative work,

each individual learner is also constantly reflecting, making connections, and integrating new ideas with prior knowledge as he or she is confronted with new information and experience, stretching individual knowledge and the knowledge of the group.

Instructors are co-constructors of the knowledge and experiences generated in a course. They shape the learning experiences to push new thinking while being responsive to the developmental needs and interests of the students. Faculty for each of the courses meet monthly to discuss how students are experiencing the program and share ideas across content areas that help students to plan, implement, and assess learning in K-12 contexts; thus, they are learning within a community of their own as they are working with MAT students. Specifically, science educators are mindful to foster classroom discourse and work parallel to that of the scientific community, in addition to the educational one; thus, “enculturating” future teachers into the field.

Not only is the pedagogy of the MAT program grounded in sociocultural learning theory, but features of the program are strategically designed to provide teacher candidates exposure to the theory behind the practice they will use when they enter the classroom. The MAT Program explicitly teaches principles of sociocultural theory in comparison to other theoretical frameworks as it relates to learning context (EDUC 516), learning theory (EDUC 518), language acquisition (EDUC 501), and human difference (EDUC 519). Candidates learn to assign learning principles and theoretical frames to pedagogical decisions (Pedagogy A/B) and instruction (EDUC 568 A/B).



Figure 2. The Course Titles and Sequence for the Online STEM TPP

Sociocultural learning theory is operationalized in our program in the following ways:

- Through strategic facilitation of classroom discourse
- Through instructor responsiveness to teacher candidate needs
- By leveraging teacher candidate expertise and experiences

These elements of the program are built into the ways in which participants, both instructors and teacher candidates, interact within courses and in Guided Practice (similar to what other programs call student teaching or supervised fieldwork). For example, interactions that build community knowledge may take place in small group or whole class face-to-face discussions or in online, asynchronous forums.

## Student Learning Experiences

Students in the STEM TPP have a variety of learning experiences in the online environment. Some are synchronous, which means that everyone in the group is in a shared, online space, at the same time. Other learning experiences are asynchronous, allowing for students to log on and engage in conversation around different ideas, media, questions, at a time convenient for them.

Both synchronous and asynchronous learning experiences were built on the sociocultural framework. The fully online nature of the program provides the ability to bring STEM teachers with varying perspectives from around the world together to co-construct their understandings about best practices in science education. We will show how students experience these strategies and share how the instructor's experience in an online teacher education program informs further development of our science teacher education program.

## Coursework

Students in the MAT program take ten courses intended to help them to build an understanding of K-12 learners and best practices in teaching science (see Figure 2 for course titles). To demonstrate how sociocultural theory is used to create learning experiences in our program, we use the Science Pedagogy courses, in red, as exemplars.

The Science Pedagogy courses are designed to provide science teacher candidates with opportunities to develop innovative, inquiry-based science lessons and unit plans. The courses facilitate the convergence of STEM fields as a foundation for teaching science. Science teacher candidates learn that STEM is a more holistic approach to the teaching and learning of natural phenomena. The philosophical underpinnings of the courses are rooted in sociocultural learning theory and brought to life by challenging students to collaboratively solve real-world problems through constructive activity and modeling processes. All of the interactions, both synchronous and asynchronous, are designed to build an online community of science teacher practice, where faculty and students can discuss how to best teach science to K-12 students.

The two Science Pedagogy courses integrate ideas from the theoretical foundations classes as well as

fieldwork experiences. For example, in the first class, students collaborate to create a science lesson plan using the 5E instructional model (Bybee, 1989), backwards planning (Wiggins & McTighe, 2005), and the relevant state and national standards. Candidates receive feedback from other groups, a mentor from a classroom placement, and the instructor. Based on this experience, teacher candidates design three to five days of instruction, make revisions based on feedback, and then implement, video record, and assess student learning. The process is iterative and non-linear as candidates use new learning and their conversations with each other and mentors to inform the design of their plan.

In the Science Pedagogy courses, students interact with one another and the instructor in a multitude of ways, using both synchronous and asynchronous methods to further their understanding through collaboration and discussion. Course assignments are intended to provide opportunities for sharing, collaborating, and reflecting on experiences both in and out of the classroom. For example, the first assignment in the Science Pedagogy A class is as follows:

*Describe your experiences as a learner of science. Include recollections from elementary, middle, high school, and college experiences. Equally important, describe informal learning experiences that are related to science and mathematics. Submit a 3-5 minute video that addresses these prompts.*

Figure 3 is a screenshot of a few of the videos that candidates posted before the first class. These reflection videos promote development of a community by sharing stories that candidates and the instructor can view before the first class session. In this case, the instructor chooses not to have students respond in writing to the video before the synchronous class. During the first class session, in breakouts and then in whole class discussion, the teacher candidates and instructor connect what was shared in the videos to their ideas about effective science teaching.

All teacher candidates come from unique backgrounds and bring a variety of experiences to the online classroom. Knowing the teacher candidates helps the instructor to establish effective working groups. For example, teacher candidates with research experience can be paired with teacher candidates who come from high needs communities for a group assignment where they will create an inquiry-based lesson plan. The instructor can also encourage teacher candidates to share these experiences during whole class discussions.

Throughout the program, the instructor can remind candidates of their memorable science learning experiences as the class works together to transform their urban science teaching. Candidates who have lab experiences can push the group to develop and implement inquiry-based labs. Candidates with experiences in high-needs communities can share ideas about connecting science content to urban kids. The first author attempted to develop these collaborations during ten years in a face-to-face program, but video assignments provide a more engaging and memorable first look at what teacher candidates bring to a teacher education program.

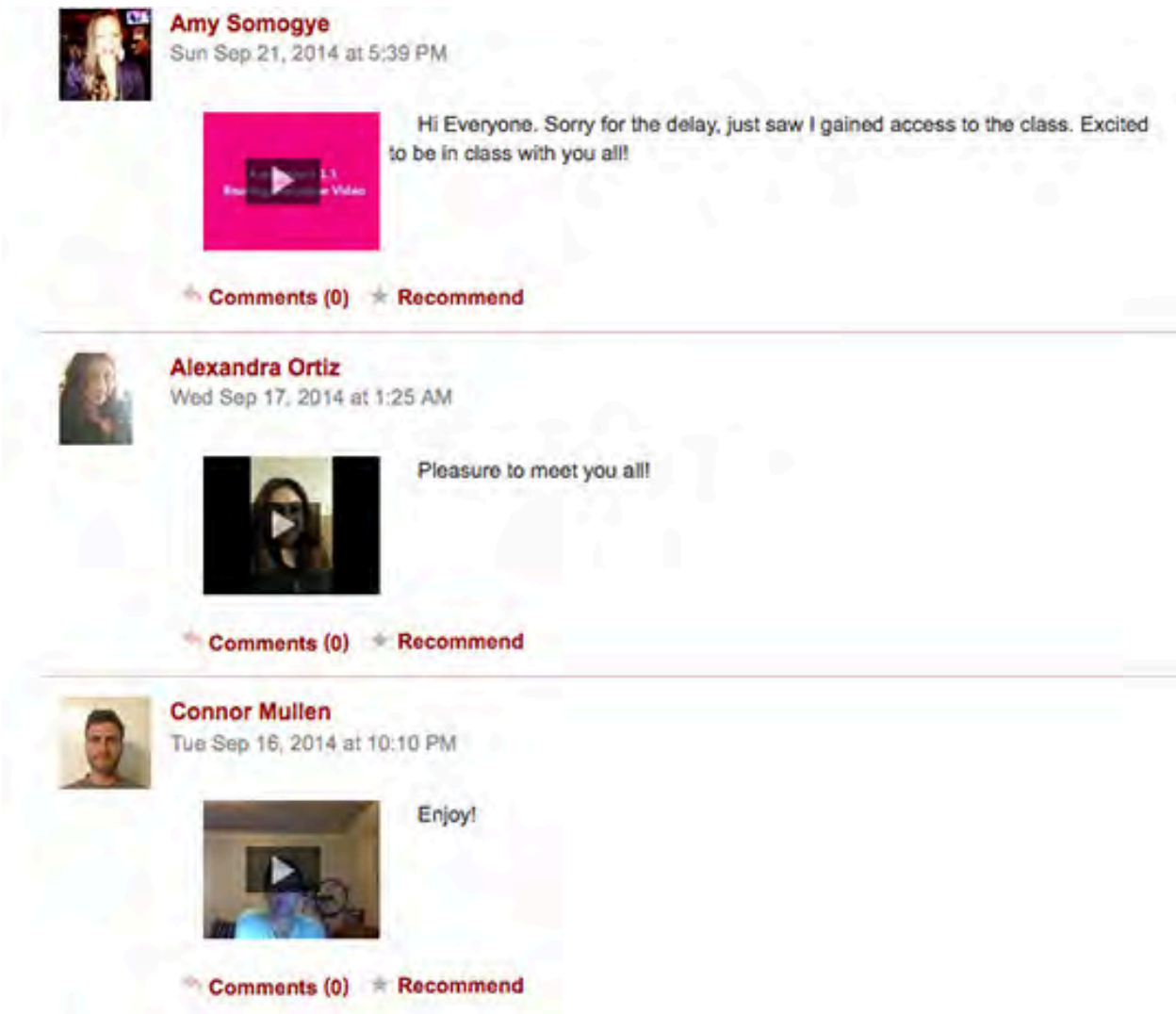


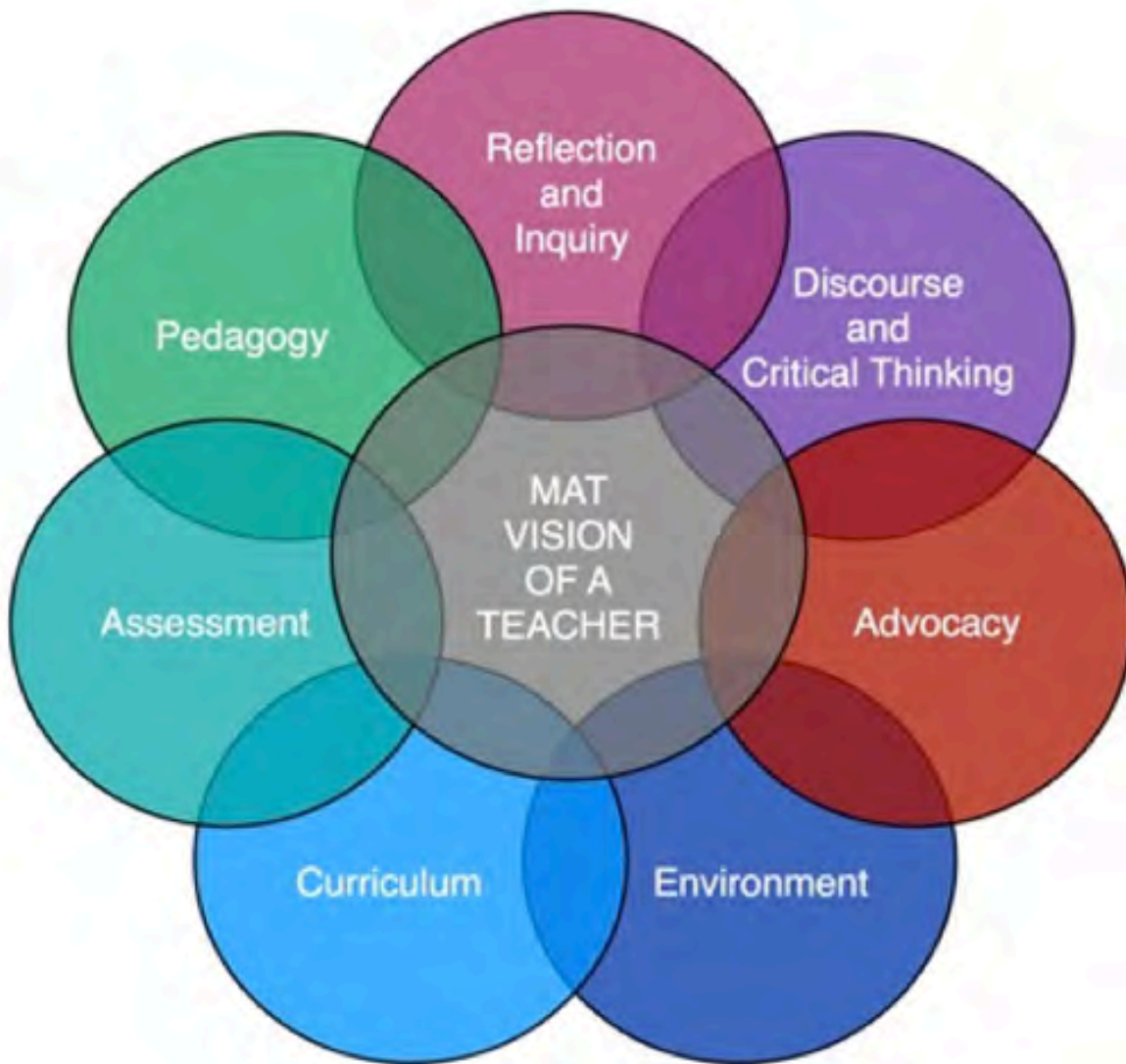
Figure 3. Course Wall in Pedagogy A Class and Screenshot.

In our online STEM TPP, the course videos and teacher candidate-constructed videos foster a burgeoning community of practice that begins with asynchronous experiences and develops in subsequent synchronous class sessions, future assignments, and Guided Practice.

## Guided Practice

Guided Practice is a two-part course that provides science teacher candidates with opportunities to apply theory in practice, to deepen their understanding of the teaching-learning process, and to engage in a continuous cycle of critical reflection. It is similar in many ways to the “student teaching” aspect of face-to-face programs, and it demonstrates the way in which sociocultural learning theory is operationalized within the program.

In Guided Practice candidates realize facets of the MAT program’s professional “Vision of a Teacher,”



*Figure 4. MAT Vision of a Teacher*

which refers to the set of identities and goals that teacher candidates work toward (see Figure 4). We refer to the identities and goals as a “domain,” each of which embodies aspects of both teacher knowledge and classroom practice. During Guided Practice, candidates apply learning theories, content knowledge, and the repertoire of pedagogical approaches acquired in previous courses as they work to stimulate student learning in the K-12 placements. Complementing the Guided Practice course are assignments that require candidates to work together synchronously and asynchronously to explicitly connect theory to classroom practice.



## Specific Learning Interactions

Teacher candidates interact with one another, instructors, and mentor teachers synchronously, asynchronously, and sometimes face-to-face. Each of these interactions contributes to the learning of the individual community member and to the community as a whole. Some assignments and conversations bridge courses and Guided Practice and may occur in both synchronous and asynchronous modes. The idea is that the knowledge and skills needed for science teaching build over time and prior experiences inform future experiences. Although we have separated out the types of interactions, the experience is very fluid.

**Synchronous interactions.** Every participant has live audio and live video and the classroom is completely customizable by the facilitator (see Figure 5 below). All synchronous Adobe® Connect™ sessions are recorded so that teacher candidates can revisit the lessons. Furthermore, teacher candidates can set up their own sessions and invite whomever they choose to participate, including their mentors or local scientists.

During class, the breakout feature seamlessly moves teacher candidates into groups where they can discuss class assignments and fieldwork experience. The facilitator can move between groups, broadcast messages without inhibiting discussion, and bring teacher candidates back to a whole class discussion in seconds. Although the facilitator cannot put his or her hand on the shoulder of a struggling teacher, he or she can read the facial expressions of every teacher candidate as if they were

The screenshot displays the Adobe Connect™ interface during a virtual meeting. On the left, the 'Attendees (17)' panel lists participants categorized into Hosts (Fred Fraking), Presetters (Cristy LeE., DJ Kast), and Participants (Anthony Maddox, Cristy LeE., DJ Kast, Eric Row, Heidi, Jannah Fitch, Jessica Hindu, Julio Ferrufino, Lauren Dandridge, Lillian, Odara Pineda Sanchez, Patrick, Renee, See Choi, shahaine Dhillon, 707xxx8167). The central 'Video' section shows a 3x5 grid of 16 individual video feeds of participants. Below the video grid, the 'Chat (Everyone)' window shows a conversation: DJ Kast: Lets go visit Renee!; Eric Row: WUT; DJ Kast: and Shahaine; Lauren Dandridge: field trip, anyone?; Lillian: I'm game; DJ Kast: Yes!; Jannah Fitch: I just saw Mad Men and I wanted to go to Hawaii watching that and now even more!; Renee: Come on over, field trips are great!; shahaine Dhillon: agreed!; Julio Ferrufino: I took My School to the Science Center. The 'Notes 3' window on the right contains the following text: April Noyce Scholar Meeting; Support Breakouts - Discuss one success and one challenge at this stage in your development as a Science Teacher. Bring one story to discuss as a whole group. Playground; Graduation Event??????????. The bottom status bar shows a timer at 0:11:42 / 1:07:42.

all sitting in the front row. A chat pod, in the middle of the screen, encourages an ongoing dialogue between and among teacher candidates.

In synchronous class sessions, teacher candidates have structured opportunities to construct meaning around aspects of science teacher practice. For example, since science teachers have a difficult time integrating literacy strategies into their K-12 teaching practice, breakout sessions were organized to have each teacher candidate share and discuss one example of how they incorporate a specific literacy strategy into their content area. Each group chooses one strategy to discuss in detail with the whole class. The instructor captures the discussion in a note pod, which is an online whiteboard, and later emails the teacher candidate the responses to co-construct a toolbox of strategies that can be integrated into future science planning and instruction.

One group shared how they planned to incorporate a scientific article on Bee Colony Collapse into an ecology lesson. This led the instructor to challenge all groups to incorporate scientific articles and current events into their science instruction. A future science teacher responded that his students' reading levels were too low to incorporate scientific reading into their lessons. The instructor then prompted the class community to address his concern about student reading abilities. Candidates responded in the chat pod and during ensuing class discussion with ideas and resources to meet this challenge. Suggestions included using Lexile appropriate online science readings or integrating additional strategies, or using "Cornell notes" that worked for participants in similar K-12 contexts. This is exemplary of how a community builds new understanding together, and is reflective of sociocultural theory.

Asynchronous interactions. Although many teacher education programs have adopted learning management systems where teacher candidates can share content and collaborate, in 2009 we developed a flexible and interactive asynchronous space to create assignments designed with a sociocultural approach in mind. The assignments allow for interactions and discourse between and among the teacher candidates and the teacher. These assignments derive heavily from the first author's experience as a science teacher and as a neuroscientist, experiences that have instilled a belief that science should be taught from a sociocultural perspective and with an inquiry approach.

The recently adopted *Next Generation Science Standards* (NGSS Lead States, 2013) and their integration of Scientific and Engineering Practices now serve as the cornerstone for curriculum development for the online STEM TPP. We use the 5E model of instruction (Bybee, 1989) to support an inquiry-based approach to teaching. To be inquiry-oriented and grounded in sociocultural theory, the online STEM TPP leverages a variety of course assignments that allow learners to use multimedia to consider new ideas or observe new situations and capitalize on their dialogues with one another and the instructor to construct new understandings.

**Facilitating discourse videos.** Student teachers often struggle with leading class discussions. Knowing the value of dialogue in fostering more coherent scientific understandings among students, we

## Video: Facilitating Science Discourse

Unit 4: Inquiry Instruction and Diverse Learners

In this video Kristen Metzger, the Natural History Museum School Visits' Coordinator, models facilitation of scientific discourse with students. As you view this video, take notes on the strategies Kristen implements to help the candidates learn science. You will use your observations in your discourse paper and in class this week.



Figure 6. Screenshot from a Video Modeling Scientific Discourse in a Natural History Museum.

created this assignment to enhance this skill. Designed to be completed early in the teacher candidates' Guided Practice, it involves recording a five-minute clip of his or her teaching practice, writing a detailed transcript of the clip, and then analyzing the discourse patterns. The work is done first independently and then in groups. In addition to evaluating their own teaching, teacher candidates also observe, in a video, an informal science educator effectively leading a discussion about the structure-function relationships of a marine mammal (see Figure 6). This assignment has a tremendous impact on teacher candidates, as shown in one response:

*I learned that, while I do include questions to prompt deeper thinking, I don't do this in a very organized way, and it leaves students struggling. I feel that my students communicated to me that they can find given information, but struggle with higher levels of questioning. As such, I need to develop my order of questioning, and think through my points in advance. This will help me scaffold the levels of questioning, so that once I get to the higher levels, students will have familiarity with the initial concepts. (Teacher candidate in Pedagogy B class)*

The classroom discourse assignment is also very important given the new expectations of the Next Generation Science Standards (NGSS). With the implementation of NGSS, STEM teachers will be expected to create learning environments that move from teachers posing questions with only one

## Keeping it Real: Meeting the Needs of All Learners

Unit 4: Inquiry Instruction and Diverse Learners

This unit, the group addresses: What are the ways science teachers can meet the needs of all learners?



Figure 7. Screenshot of STEM Teachers Discussing Their Practice in the Keeping It Real Videos.

right answer to students discussing open-ended questions that focus on the strength of the evidence used to substantiate claims as part of scientific explanations (National Research Council, 2012). And instead of teachers providing information to the whole class, new STEM teachers will be expected to provide opportunities for students to conduct investigations, solve problems, and engage in argumentation with teachers' guidance (Osborne, Erduran, & Simon, 2004). This discourse analysis assignment allows students to develop new scientific understandings as well as participate in the science practices of communicating, explaining, and arguing in science.

It should be noted that this assignment was developed with a colleague who works completely face-to-face with her teacher candidates, so these assignments are not only workable with online programs. Teacher educators have used video recordings to improve practice since the development of video cameras. Learning management systems used by face-to-face programs may also enable teacher candidates to post and comment on different forms of media, such as video, as part of course assignments; however, assignments in an online program such as this rely heavily on these forms of interactions.

The flexibility of asynchronous class environments allows teacher candidates to participate in courses when they have time rather than when a course is scheduled to meet. We note that it is within the *interactions* that new learning is developed in our teachers. How the interactions are encouraged and facilitated, not the venue in which the interactions are occurring, is ultimately what supports the learning.

**Keeping It Real Videos.** One of the major shifts in our online assignments involved updating our asynchronous content to better reflect the classrooms of our teacher candidates. In the early years of the STEM TPP, the asynchronous content focused on an award-winning video series that helped teachers think about inquiry-based teaching. However, the videos were a little outdated and teacher candidates said that the classrooms represented there did not look like their urban classrooms. That led to the development of the Keeping It Real video series (see Figure 7), which attempts to connect inquiry-based teaching to urban classrooms.

For every unit in the Science Pedagogy B class, teacher candidates are expected to view and comment on the perspectives expressed by three science teachers around issues from assessment to teaching diverse learners. The following is one example of a candidate response :

*I really liked how the teacher mentioned the need to incorporate prior knowledge. There is some knowledge that most students will have in common, maybe due to the content being relevant to the school they are at, or something the teacher tried to teach the students in that class. Other things.... For example, trying to relate a roller coaster ride to the feeling you get when you are taking off in an airplane is useless for someone who hasn't been on a plane or a roller coaster.*

*I like how the teachers valued the work the students created and [gave] it meaning beyond it sitting on their desks. Community involvement and helping students create work that will impact their community is an amazing way to have students care about being good human beings and not just scientists. The idea of creating competition and self-motivation to excel is awesome and I think adds entertainment and excitement to the teacher's job as well! (Student in Pedagogy B class)*

After posting their own thoughts about the topic of the week, candidates participate in a synchronous group-inquiry session (see “Blending Asynchronous and Synchronous Interactions”) to build on their understanding of specific skills they will need to develop to become effective science teachers.

**Final Reflection Video.** In the final video assignment for Pedagogy A (see Figure 8), teacher candidates view and comment on each other's thoughts to increase the interactions between teacher candidates and build a community of practice. Examining the dialogue in this online forum and then adding questions and comments helps the instructor better prepare teacher candidates for Pedagogy B and Guided Practice. Knowing teacher candidates' strengths and challenges helps the instructor to provide appropriate feedback to facilitate STEM teachers' growth. The Final Reflection Video comes on the heels of teacher candidates posting their first teaching videos to the course wall (see Figure 9). Candidates' reflection is situated in their recent K-12 science teaching experience and built upon their

## Assignment 5.5: Final Reflection Video

Unit 5: Reflection and Professional Development

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The purpose of this assignment is two-fold. First, this assignment will help you build reflective thinking skills and use oral discourse to explain your thinking to others. Second, since we all build knowledge upon our previous experiences, it is important to identify one's prior science learning experiences as we become science teachers.

### Directions

1. Record a 3-5 minute video in which you address the follow prompt:
  - Describe a few key points you have learned in this course and one topic that you think needs more attention in 502B.
2. Upload your video to your instructor before Class Time this week.
3. Also, upload your video to the Course Wall.
4. Watch at least two of the videos uploaded by your classmates. Were your views similar to or different from those of your peers?
5. Be prepared to discuss your thoughts and questions during Class Time.



Figure 8. Screenshot of Final Reflection Video Assignment

construction of what effective science teaching should look like.

In the science-specific Pedagogy A class, candidates design an inquiry-based lesson with two classmates and then revise according to peer feedback in a forum and then based on instructor feedback. After receiving feedback from three people, the teacher candidates are more prepared to create a science unit plan for their specific context. The interactions during the planning process help to develop a learning community that can critique and support the implementation.

Figure 9 is a screenshot that displays three teacher candidates' first science teaching videos, one of the culminating assignments of Pedagogy A. Below each video, classmates have noted their observations of strengths and challenges.


Here is one of the comments:

*You have a great speaking voice! The kids seem super cooperative and engaged, which is great! It looks like your lesson had a format similar to mine (demo in front of the class, kids make predictions, then*


*kids are given scientific explanation for why prediction was/was not correct). How do you think your lesson went? After my first demo (the one I posted to the wall), I started using think-pair share to make sure all the kids were talking to make predictions. Without it, I realized the same few kids kept answering all my questions! (Teacher candidate in Pedagogy A class)*

The comment reveals the richness of the interactions between teacher candidates in this asynchronous space. The candidate provides much-needed positive feedback to the candidate and identifies a strategy to help facilitate scientific discourse in future lessons. The collaborative and co-constructed nature of the Unit Plan and Implementation assignments are well aligned to the sociocultural approach in the

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**Susana** [redacted]  
Tue Nov 4, 2014 at 5:30 PM




Here I present to you some moments of the Circular Motion class that I conducted on Friday and Monday. To catch you up with it a little, let me tell you that the students designed the experiment procedure in order to answer to the question "What is the relationship between the variables in Circular Motion?". Oh boy! There was so much going on!

[View All Comments \(6\)](#) [★ Recommend](#)

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**Lynne** [redacted]  
Tue Nov 4, 2014 at 1:09 PM



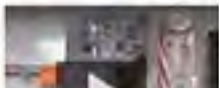
Here is a clip from a demonstration for cellular respiration that I taught F

[View All Comments \(6\)](#) [★ Recommend](#)

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**Laura** [redacted]  
Sat Nov 1, 2014 at 4:17 PM



Here's one of the 3 biology demos I taught on Friday. Like my "Hershey Chase Experiment" costume? :)

Figure 9. Screenshot of Asynchronous Interactions of First Teaching Video

## Assignment 5.2: Group Inquiry - Student-Led Study Session

Unit 5: Inquiry Instruction for English Language Learners

### Purpose

The purpose of this exercise is for candidates to:

- Develop a critical inquiry of science and science teaching and learning;
- Recognize the the importance of creating an using professional networks; and
- Foster quality interaction among peers that will lead to professional growth.



### Inquiry Topic for this Week:

This week's group inquiry will center on this question: What are the literacy and ELL strategies that you learned in term 2 and which of these strategies are working in your GP placement?

### Directions

#### Step 1 - Answering the Question of the Week

1. Remain in the same study group. If you have any concerns, please notify your instructor.
2. Be sure that your Study Group session does not conflict with other classes you are expected to attend.
3. This week, prior to your group meeting, each candidate must post a 5 - 7 minute video that addresses the inquiry question of the week.
4. Upload your video to your instructor.

#### Step 2 - Convening the Student-Led Study Group

1. The group host for this week must open the Study Group 5 minutes prior to the agreed upon meeting

#### *Figure 10. Group Inquiry Assignment Example*

program. Teacher candidates develop greater understandings of what comprises an inquiry-oriented lesson appropriate for the variable K-12 science classes they are teaching through the interactions among them and with the instructor.

Blending asynchronous and synchronous interactions. Teacher candidates are continually revisiting collaborations, work, and ideas from prior courses, building their knowledge and skills in STEM teaching, and learning over the course of the program. One assignment that moves through both courses and Guided Practice is a Group Inquiry assignment. In it, teacher candidates work together to study an aspect of science teaching (see Figure 10).

Before meeting as a study group, teacher candidates record their own ideas about the topic. In this case, they describe their experiences implementing literacy strategies in their Guided Practice placement.



This provides the instructor with a view of each candidate's understanding of the topic before they work with their group. Each teacher candidate can set up his or her own online meeting. During the group meeting, teacher candidates share their experiences around the topic of the week and then bring questions to the whole class session.

This allows for synchronous class time to be spent discussing unresolved issues rather than using valuable time on topics candidates already understand. Here are a few of the questions teacher candidates have come up with around planning inquiry instruction:

- What supports can I provide in an inquiry classroom to meet the needs of all of my students?
- When do I integrate the academic language in a 5E lesson?
- How do I collaborate with my GT to plan inquiry-based instruction?
- How do I manage the time when students are asking so many questions?

During synchronous class time, the emphasis is on building upon participants' knowledge and on solving the remaining questions. The instructor can bring in the perspectives of multiple teacher candidates around a given issue or question how he or she would solve the issue. This leads to teacher candidates co-constructing multiple solutions to the group inquiry questions. For example, "How do I manage the time when students are asking so many questions?" led to a rich discussion of how to foster an inquiry environment while addressing tangential questions.

Teacher candidates share multiple ideas from their varied contexts about how they and their mentors manage the inquiry-learning environment, from using a "Parking Lot" type of bulletin board called "My Scientist Questions" to taking advantage of a "teachable moment." In this context, an instructor is also able to remind teacher candidates about strategies, such as KWL (Know, Want to know, Learn) charts, that they have used in other coursework and may be applicable to this situation. These discussions help beginning teachers understand the complex nature of teaching science, and also provides them with a repertoire of tools they can use in the complicated context of an urban science classroom.

Interactions with guiding teachers. An "Entrance Interview" assignment that science teacher candidates complete before beginning Guided Practice serves as a formal introduction between teacher candidates, guiding teachers, and the Guided Practice instructor, and demonstrates how mentoring can be done within a fully online program. This assignment, and subsequent meetings of the three individuals involved, occurs within structured online meetings. Meetings are held in an Adobe® Connect™ classroom and seek to organize the expectations for Guided Practice. Here is an overview:

*The Entry Interview provides a structured opportunity for you, your Guiding Teacher, and your Guided Practice Instructor to meet together to discuss your understanding of the expectations of this course, your*

*learning goals for the first ten weeks of “student teaching,” the elements that will count as “evidence” of you meeting those goals, and the activities that will constitute your assessment of teaching performances throughout the course/placement.*

As the mediator of the mentor-student teacher relationship, it is critical that the Guided Practice instructor develop an understanding of the placement context. The online meeting begins by discussing our backgrounds to develop a rapport and trust to ensure effective communication over the course of the twenty-week placement. This synchronous meeting allows the instructor to share program expectations from the lesson observation form to the teaching load progression, as well as science-specific pedagogy such as the 5E model (Bybee, 1989).

The importance of guiding teacher feedback and dialogue with the candidate is emphasized and any questions about the MAT program are addressed. A concrete science teaching discussion allows

### **Assignment 3: Pre-Planning Conference Video #1**

Assignments and Grading

The purpose of this page is to provide candidates their first Teaching and Learning Event Pre-Planning Video.

#### **Directions**

1. Meet with your Guiding Teacher to plan your lesson. This pre-planning conference must be videotaped and submitted as part of your Teaching and Learning Event. The recorded session should be approximately 30 minutes. Be sure that your Guiding Teacher has signed the form giving you permission to video-record this planning conference.



2. As you are planning your Teaching and Learning Event, consider the following Guiding Questions:

- What are the expected learning outcomes for this particular learning plan?
- Specifically, what characteristics of the learners have been incorporated into the learning plan (e.g., prior knowledge and experiences, learning preferences, strengths and weaknesses, interests, etc.)?
- What essential prerequisite knowledge and skills do students need to successfully complete the learning plan? How will you provide support for students who have not yet acquired the essential prerequisite skills?
- What role does academic language play in your planning? How will you support students in learning using academic language?
- What sequence of experiences and tools will be used to facilitate learning?
- How does the learning plan maintain continuity and an appropriate developmental sequence in subject matter, concepts, and skills?

Figure 11. Screenshot of Pre-planning Conference Video Assignment

candidates to share their goals and the evidence they will provide to demonstrate achievement. This initial meeting is followed up by weekly correspondence with the guiding teacher and the pre-planning conference video assignment (see Figure 11). The pre-planning conference video provides the instructor with a rich vantage point of the interaction between the guiding teacher and the teacher candidate as they plan inquiry-based science instruction.

Figure 11 shares some of the scaffolding that the online STEM TPP offers for the Guided Practice experience. Guiding teachers have access to previous pre-planning conference videos so they have examples of how to support student teachers. Furthermore, all teacher candidates have the opportunity to learn from all of the guiding teachers in the class by viewing and commenting on these videos. Finally, the Guided Practice instructor can share pieces of these videos to support the development of a key science teaching idea with a voice directly from the K-12 classroom. Access to pre-planning videos provides valuable insight into the dynamics of the field placements and helps the instructor to better support teacher candidates, especially around inquiry-based teaching practices. This technology also strengthens coursework by connecting teacher candidates more authentically to the K-12 context.

## Recent Developments and Next Steps

Although many of the learning activities described here demonstrate a constructivist approach to learning in an online context, courses in the online STEM TPP continue to be refined and developed. Since participation in asynchronous interactions can occur at any time, instructors need to design courses that allow for teacher candidates to balance coursework and fieldwork with their everyday lives. It is critical that we design assignments that are meaningful and will positively impact candidates' science teaching without demanding so much time that they are stressed or burn out.

## Leveraging the Right Amount of Collaboration

Because the amount of asynchronous collaboration is limitless in an online program, we need to design assignments that work with the rigorous schedule of beginning teachers. We are pushing the development of communities of practice that will assist the planning, instruction, assessment, and reflective abilities of our candidates. One assignment that we plan to add, and that is working well in our in-service STEM teacher leader program, is the “professional learning plan.” This assignment requires candidates to participate in local professional STEM teaching and learning communities. It will fill a void in the program when science pedagogy courses have ended and teacher candidates are engaged in Guided Practice B. Connecting our teacher candidates to a local and/or online community of practice will prepare them to participate in a professional support group that they will need after they graduate from the STEM TPP and enter the science teaching profession.

## New Assignments

We are contemplating several other ideas as we continue to refine our program. First, while the Keeping It Real Videos provide context for our discussions, many teacher candidates have requested addi-

tional perspectives. It would be easy to conduct online interviews with our excellent science guiding teachers from urban districts across the nation. Their insights could be categorized around key topics in science teaching and provide a primer for discussions with our pre-service teachers. And it would be possible to connect these resources to the greater science teaching community and the wealth of science teacher knowledge that exists.

While the sociocultural and constructivist nature of our program encourages candidates to learn from each other, not all of the ideas that become part of the group learning are integrated into the coursework. Often times, excellent ideas from teacher candidates shape the program. One teacher candidate created his own Keeping It Real video to share his classroom context. We plan to integrate this activity into future classes using the “Course Wall” feature of our learning management system. As we shape the curriculum for our STEM teacher candidates the possibilities are almost limitless, as almost any text, video, or image can be shared with the group in real time as we discuss any relevant topic in STEM teacher education.

## Creating an Effective Classroom Learning Community

Beginning teachers must learn how to create an effective classroom learning community. We are beginning to implement an assignment that is threaded through the whole program to help our candidates develop a classroom management plan that they can bring to interviews for their first classroom teaching job. In term one, candidates use theory from their learning and social context courses and observations from their fieldwork to construct an initial plan. In term two, candidates build on this plan by utilizing more knowledge of their students from their fieldwork experiences and ideas from their content-specific pedagogy classes. In term three, candidates further refine their plan using their experiences from GPA. Finally, in term four, candidates reflect on all of the experiences in the program to finish the classroom management plan they will bring into their first year of teaching. Throughout the process, candidates participate in online forums to receive and provide feedback and questions to their peers. Four different faculty members also share their questions and ideas with the candidates. Assignments like this, which candidates co-construct as they grow as teachers, prepare them for their first year teaching in a K-12 context.

One area that still needs development is using our technology and online program to connect teachers as they enter the teaching profession. Although alumni are frequently brought into the synchronous classroom to discuss a myriad of teaching topics, we have not created an asynchronous space for our alumni to work together to plan STEM lessons, receive support and encouragement, dialogue about the implementation of lessons, discuss how they scaffold learning for students in their unique context, or develop and critique assessments. Connecting our alumni and current teacher candidates will help all these STEM teacher participants construct a deeper understanding of what it means to teach science in high-needs contexts.

## Incorporate New Technologies

From advances in the features of our synchronous Adobe® Connect™ platform to applications and content that can be incorporated into our teacher candidates' asynchronous time, it is important that we continue to develop our program. As bandwidth has increased for all of our participants, it has become easier to stream student teaching videos during synchronous class time. As we further develop our program, it is critical that we take full advantage of technologies that provide opportunities to bring actual K-12 practice into our university-based course discussions. Deepening the connections between the K-12 context and the university coursework will improve teacher education.

## Research on the Science Teacher Candidates in the STEM TPP

The next step in the authors' collaboration is a research study involving thirty of the teacher candidates who have been in the online STEM TPP. We plan to investigate the candidates' perspectives on the sociocultural/constructivist grounded activities and how these experiences in the program affect their STEM teaching. We believe that these assignments are preparing our STEM teacher candidates for their first teaching positions. However, surveying and interviewing our alumni will provide feedback that we can use to enhance the program. We look forward to integrating new technological tools that can deepen our candidates' experiences as they participate in our program and prepare to teach science in high-needs K-12 contexts.

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