Developing Pre-Service Teachers' Professional Vision Through Collaborative Multimedia Artifacts

Andi M. Rehak, Andrea S. Gomoll, Cindy E. Hmelo-Silver, and Joshua A. Danish
amstrack@indiana.edu, agomoll@indiana.edu, chmelosi@indiana.edu, jdanish@indiana.edu
Indiana University

Abstract: Effective teachers are constantly adapting their classroom practice to best meet students' needs. However, it is difficult to adapt one's teaching practices without first noticing the key features of classroom activity. This kind of noticing—professional vision—is a cultivated skill that requires a combination of understanding theory and experience with practice. When theory-practice connections are not strong, teachers tend to fall back on "what works." Demands to support pre-service teachers in developing stronger theory-practice connections are increasing, yet this remains a challenging goal. The qualitative analysis presented in this paper offers insight into how creation of multimedia artifacts can support pre-service teachers in connecting theory to practice while developing their professional vision. Findings suggest the process of creating and collaboratively refining multimedia artifacts in small groups improves pre-service teachers' ability to make theory-practice connections and provides opportunity for them to exercise their emerging professional vision.

Keywords: pre-service teachers, collaborative learning, professional vision, activity theory, video case studies

Introduction

Effective teachers need to understand student learning and adapt classroom practice to meet learners' needs on a daily basis. In the demanding classroom environment, teachers tend to fall back on "what works" approaches if strong connections between theory and practice are not made during pre-service experiences (Ball & Forzani, 2009). Often, teacher education relies on practicum experiences to establish these connections, yet there is little evidence to support that pre-service teachers make theory-practice connections during practicums (Allsopp, DeMarie, Alvarez-McHatton, & Doone, 2006). Furthermore, teacher training programs and assessments are beginning to ask pre-service teachers to observe, describe, and evaluate others' teaching practices and their own in order to obtain licensure (e.g., edTPA, 2015). This study explores pre-service teachers' development of this ability to see the classroom in this expert manner as *professional vision*—the ability to use a theoretical lens to support noticing key features in a learning environment, interpreting them, and then responding (Sherin, 2001). We explored the development of this skill by looking at the ways in which students annotated classroom video and gave one another feedback. Viewing classroom video provides a unique opportunity for students to explore the complexities of practice and to see how learning theories apply to the classroom (Van Es & Sherin, 2002).

To explore the potential for using shared video resources to support the development of professional vision, we made use of the RUanalytic tool (see Maher, Palius, Maher, Hmelo-Silver, & Sigley, 2014). The RUanalytic tool is a video annotation tool that was designed to work with a large video repository, the Video Mosaic Collaborative (VMC). This video repository houses an extensive video collection from a longitudinal study of mathematics learning in K-12 classrooms (http://videomosaic.org/). Users of the tool are able to create a multimedia artifact consisting of "events" clipped from VMC videos and written annotations of these events. The final product is a VMCAnalytic, a multimedia artifact that plays the clipped events in sequence, accompanied with the author's text descriptions. This video annotation tool has been developed and used in previous research to support pre-service and in-service teachers' development of pedagogical skills, including teacher professional development with a focus on mathematics education (Maher et al., 2014).

Informed by the parameters of the edTPA assessment (edTPA, 2015) and university guidelines (Kunzman, 2014), two class sessions of activities involving the video annotation tool were collaboratively designed by a team of researchers of which the course instructor was a member. Our conjecture was that creating multimedia artifacts would provide a unique opportunity for pre-service teachers to observe moments in a classroom and then connect learning theories to these moments as a means of developing professional vision. This study was driven by the following research questions: (1) How do these pre-service teachers use learning theory when describing episodes of teaching and learning? (2) How do these pre-service teachers' multimedia artifacts change during class activities with peers? (3) What is the nature of these pre-service teachers' professional vision as displayed in their multimedia artifacts?

Theoretical perspectives

Our design was guided by activity theory (Engeström, 2014), which is rooted in Vygotsky's (1978) sociocultural theory of learning. Activity theory asserts that collective human activity and thus learning, is a process mediated by both individual and sociocultural factors (Engeström, 2014). Mediators "stand between" a subject and object of activity; subjects view their objective through the lens of the mediators they are using, and the mediator thus transforms the entire activity. The subject is the individual or group of individuals (e.g., students) engaging in activity. Object refers to the overarching motivations for the activity as realized by the subject (Cole, 1996). Because the object of activity is constructed by the subject, it may or may not be aligned to what the designer of activity intended the object to be (Rajala & Sannino, 2015). From an activity theory perspective, mediating artifacts are the products and practices of the culture. Although distinct, these mediators cannot, and do not, function independent of one another and thus need to be analyzed as interrelated (Roth, 2007). Here, professional vision acted as a mediator, shaping student activity and learning. We were interested in the groups' objects of activity, as well as the ways in which the RUanalytic tool mediated students' articulation of professional vision.

A crucial element of teaching is being able to see key features of a learning environment and respond to them. The development of professional vision involves honing the practice of teaching through attention to noticing these salient features in the classroom (Borko, 2004). Professional vision involves "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group" (Goodwin, 1994, p.606). Goodwin's definition highlights how cognition and perception are intertwined with the social norms of a discipline. Thus, developing expertise within a given discipline requires the ability to "see" the world through the lens of that social group (Stevens & Hall, 1998). In a classroom setting, teachers' professional vision mediates active noticing and the interpretation of key elements of the environment, including student reasoning and features of peer interaction (Maher et al., 2014; Sherin, 2001; 2007). This skill includes identifying student strategies, inferring student levels of understanding, and developing a response based on these levels of understanding. Noticing in this capacity is complex and variable (Jacobs, Lamb, & Phillip, 2010). The reflective use of classroom video over time mediates changes in noticing and interpretations of what was noticed (Sherin & van Es, 2005). As pre-service and in-service teachers develop expertise in the skill of interpreting classroom situations, they use their understanding of learning theory to isolate the important features of what is happening. In this process of noticing, they then connect the specific evidence and learning theories to support conclusions about how to respond. Professional vision mediates their teaching activity and is continually under construction. Professional vision develops as students become enculturated into the teaching community.

Additionally, we were interested in how the opportunity to engage in activity with a particular division of labor informed by *collaborative learning* (CL; O'Donnell & Hmelo-Silver, 2013) contributed to pre-service teachers' multimedia artifact construction. In CL, group members mutually influence one another and participate equally in knowledge building (O'Donnell & Hmelo-Silver, 2013), making CL valuable for helping students to see themselves as members of a community (Hakkarainen et al., 2013). This sociocultural perspective of CL frames our work to integrate learners into not only a classroom community, but also into a larger community of educators. To explore the impact of peer interactions, we examined pre and post-collaboration versions of multimedia artifacts, and analyzed video of two groups of pre-service teachers creating their multimedia artifacts through the lens of activity theory to better understand student interactions.

Methods

Participants

The participants in this study included 27 pre-service teachers enrolled in "Educational Psychology for Elementary Teachers," at a large Midwestern University. The course covers seven core units: behaviorism, social cognitive theory, information processing theory, constructivism, sociocultural theories, motivation, and assessment. These students intended to teach primary grade students (5-12 year olds). The students in this course ranged from first to third-year undergraduate students; 22 of the 27 were female. They worked in groups of 3-5 students that were previously organized by the instructor. In our activity theory driven analysis, the interactions and multimedia artifacts of two randomly selected groups of three students are examined with the aim of understanding the role of collaboration in the articulation of pre-service teachers' professional vision.

Activity design

Our goal was to provide an opportunity for the students to see theory in action (see Gomoll et al, 2016), while beginning to recognize how learning, and principles of learning theories, might be experienced in real classrooms. The research team selected short video clips (7-12 minutes long) from the repository that showed both students

and teachers in action. These were selected with attention to length and connection to several theoretical frameworks covered in the course (i.e. behaviorism, constructivism, social cognitive theory, information processing, and sociocultural theories).

Prior to the first day of activities, students were asked to independently view an assigned video clip and to write down three "interesting" moments. Students in each small group worked from the same video clip, while each group had a different video. The open-ended prompt was intended to help the students see the video as something relevant to them, and to help prepare them for the class session's activities. In class, students were asked to examine the same videos again, but to explain their highlighted moments using learning theory. To do this, students independently created a multimedia artifact where they connected their chosen events and provided accompanying descriptions, which articulated how learning theories covered within the course would explain the success or failure of selected events. Students were provided with the opportunity to identify new events if they felt their initial choices did not support this analysis, but few did. In the following class session, students of the same group provided feedback on one another's multimedia artifacts—allowing them to explore the differences in how they had connected theory to the same videos. Following this feedback, students had the opportunity to edit their work to reflect the feedback they had received. The final product created by students was a multimedia artifact with three "events," or short clips, selected from the longer video. Each of these events, about thirty seconds to one minute in duration, was annotated with a description pointing the reader to important episodes of teaching and learning.

Data sources

All version histories of multimedia artifacts were archived to track changes in each student's artifact over time. During the two class periods in which students worked on their multimedia artifacts, three video cameras captured whole class activity and two small groups' interactions (Group A and D). Only two students in group A were present on the second day of the intervention, Natalie and Isabella (pseudonyms). Addison, Riley, and Isaac comprised group D. Students also took notes about their peer feedback during the second day via Etherpad—an online platform that allows multiple participants to type in a text document at once. Students participated in an in-person whole-class debriefing session at the end of the experience. While prior analysis has addressed the multimedia artifacts created by all students during this intervention (see Gomoll et al., 2016), here we focus on the multimedia artifacts of two groups, A and D that were randomly chosen to be video recorded. This additional data source allowed a more fine-grained examination of group collaboration in the face-to-face classroom environment as well as students' final multimedia artifacts. The last version of the VMCanalytic from day 1 is considered the pre-collaboration analytic, and the final version of the VMCanalytic, the one students submitted for the course assignment was considered the post-collaboration version.

Analysis

Viewing each small group as an activity system helped us to better understand the nature of students' professional vision articulated in their multimedia artifacts. We analyzed student artifacts and video of two groups of pre-service teachers' collaborative work constructing and refining multimedia artifacts—comparing the activity systems of these two groups to each other and to the activity system envisioned by the instructor. The two groups show the curriculum being reinterpreted by the students as they constructed unique group-specific activity systems, allowing us to construct contrasting cases. Neither of the activity systems was identical to the activity system intended by the designers, yet both led to productive outcomes in the form of satisfactory multimedia artifacts. We began with a representation of the *intended* activity system for small group work as envisioned by the curriculum designers (see Figure 1). Underlying the object of students articulating their professional vision and revising their multimedia artifacts is the assumption that the assignment requirements students mediate activity in such a ways that students would utilize learning theory in their description, and therefore find theory useful for making sense of classroom interactions. Utilizing theory as a mediator in examining classroom interactions is a precondition for students to enact professional vision. Students were placed into small groups where the physical arrangement and shared video were intended to foster collaboration. The first day was largely individual work as students constructed the initial version of their artifacts; we focus here on the second day in which there was intentional peer collaboration. In the second session, the video annotation tool, instructor prompt, and nature of collaboration mediated students' activity and revisions in all three activity systems- researchers' intended, group A's enacted, and group D's enacted. These mediators did however function in different ways in the three activity systems. Three key differences stand out across these three activity systems: (a) the constructed object, (b) the role of the Etherpad document, and (c) the resultant multimedia artifacts.

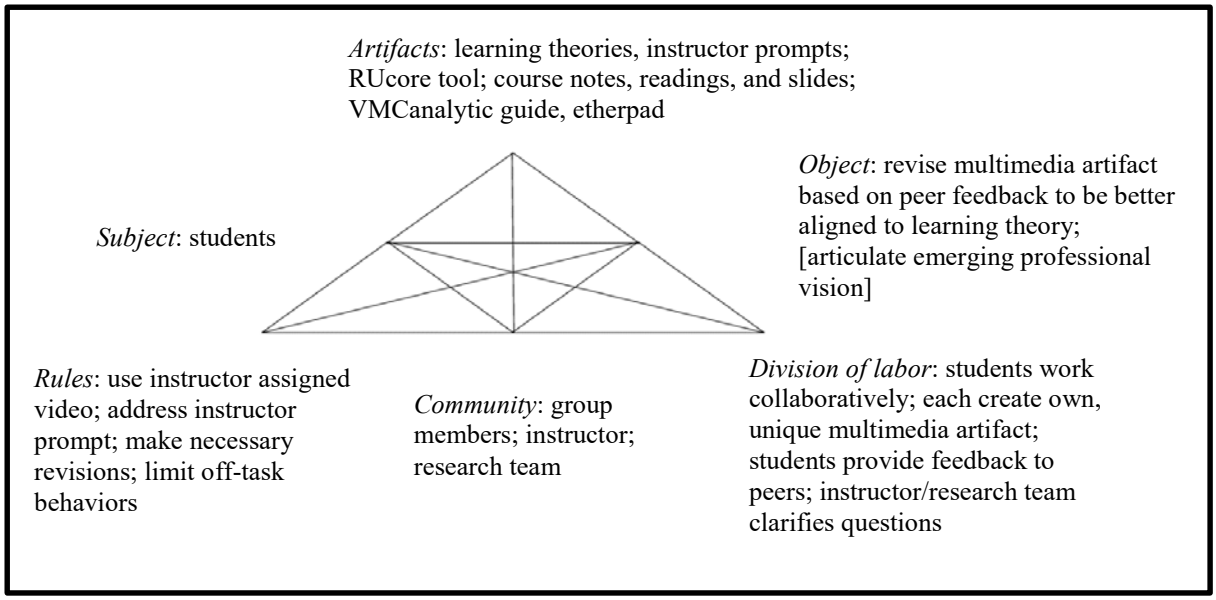

Figure 1. Intended activity system for class session two.

In group A, the students' object seemed to be to finish their multimedia artifacts and to document review of each other's artifacts in the group Etherpad. The nature of Group A's collaboration was not as rich and interactive as the designers had intended, but their activity was neither disruptive nor inappropriate according to norms of this particular classroom. With the object of completing the task, the group's key mediators were the instructor prompt and course slides, and less so learning theory. In group D, the students' object seemed to be to finish their multimedia artifact, but also to provide peers with meaningful feedback, and address this feedback in revisions to their multimedia artifacts. The students in group D were not as attentive to taking notes in their Etherpad, and instead engaged in conversation debating specifics of theories and concepts. Learning theory was a key mediator in their activity. Group discussions led two of the students, Isaac and Addison, to refer to their course notes and the instructor's course slides. While the richness of their collaboration was not entirely captured in their Etherpad, all three students referred back to the notes as they revised their multimedia artifacts. While we saw that students were not directly oriented to articulating their emerging professional vision, our conjecture that due to the assignment requirements, students would apply learning theory and therefore make claims rooted in theory concerning teaching practice providing evidence of their emerging professional vision was supported. Further, we believed that the differing nature of collaboration would have a direct impact on students' professional vision in their revised artifacts.

In order to gain insight into how the differing activity systems affected students' revisions to, and final multimedia artifacts, a qualitative coding scheme was developed to trace professional vision. The multimedia artifact version histories for the five students were examined to get a sense of the levels at which students were able to connect theory to practice before and after collaboration. The first and final versions of each event were coded using a coding scheme adapted from Sherin & van Es's (2002; 2009) teacher professional vision scoring rubric. Event versions were coded as (a) atheoretical noticing (b) theory-based noticing without interpretation (c) theory-based noticing and interpretation, or (d) theory-based noticing, interpretation, and response. Table 1 explains the code criterion and how the codes build on one another. In some events students merely mentioned a learning theory without defining it in any way or articulating a connection between it and the rest of their annotation. Even though these annotations technically named a theory, such events were classified as atheoretical noticing. Examining the multimedia artifacts through the professional vision codes allowed us to better understand how students' professional vision and noticing changed (if at all) after collaboration with their peers. By allowing us to trace the impact of collaboration on students' multimedia artifacts, these professional vision codes supported our activity theory analysis by providing a means of comparing professional vision across students, events, and revisions. Together, our activity theory analysis and professional vision coding provide a picture of emergent professional vision for two student groups—highlighting improvements in theory-practice connections and differences in the groups' objects of activity and use of mediators.

Table 1: Professional vision codes

Code	Description	Example excerpts
Atheoretical noticing	Annotations only explain what happened in the event, but do not connect the actions of the students and/or teachers to theory.	"In this clip, two students work to solve a fraction problem. The instructor comes to the table and give (sic) them feedback. The feedback the teacher gives is bad because the students do not seem to understand it. The teacher walks away from the table."
Theory-based (T-b) noticing only	Annotations include references to learned theories and concepts, and provides explicit support from the video for these references. Implications for teaching and learning are addressed at the level of description and some evaluation, but do not reach interpretation of teaching practice.	"Meredith is brought in the center of the screen during this clip. Interestingly enough, though, she finds herself not raising her hand when the teacher asks if it's (sic) okay for two/tenths to be called one/fifth…It relates to Information Processing because she is modeling the information that she believes is true. Although she was the first student to prove that two/tenths is equal to one/fifth, when she sees another example she challenges her understanding because the example given by the two boys before her is not the same. This can also be Information Processing Theory because Meredith may have a schema that there may only ever be one correct answer, or way, to show that something is the same."
Theory-based (T-b) noticing and interpretation	Annotations provide a description of the important features of the interaction, address a learning theory or concept, ties this theory to explicit video evidence, and evaluate this evidence as it relates to teaching practice (i.e. this was "good" because…)	"Here, the two girls seem to divide themselves into separate roles with relatively little communication. [Student name] takes each of the stacks and determines the duplicates which she then gives to [Student name] to deconstruct. One of the elements within Sociocultural theory is the Activity Triangle diagram. One of the triangles in this diagram is focused on division of labor; who is responsible for what. Due to the clarity of each students (sic) distinct role, this theory would confirm that this is a beneficial strategy."
Theory-based (T-b) noticing, interpretation, and response	Annotations include description of classroom actions, evaluation, and interpretation. Authors introduce a concept or theory, tie it to explicit video evidence, and interpret this evidence to make clear suggestions about how it influences their work as future teachers.	"…The girl in this video has a misconception as to what 14-5 is because she believes it is 8, but the middle boy believes it is 9 (he is right). Although he is right, he seems to be second guessing himself and modeling after the girl. They then work together at the end of this clip, all doing the same thing, using the cubes. This relates to the cognitive theory, and the teacher must address the problem so that Jamie builds correct schema for future math."

As the coding examples show, not all students applied learning theory accurately, despite making theory based observations and interpretations. Because of this, an additional set of codes was then developed and used to address how appropriately the learning theories were used in the multimedia artifacts. The first and final versions of each event were then coded for application of learning theory using four codes: (a) no/unclear use of theory (b) inaccurate or inappropriate use of theory, (c) approaching appropriate use of theory, and (d) appropriate use of theory. Finally, the authors noted instances when post-collaboration event versions included new theoretical concepts, extended interpretations, or included evaluative statements (i.e. "I think this is bad for learning …"). Together these two coding schemes and our observations of post-collaboration additions allowed us to explore changes in students' use of learning theories and articulation of professional vision.

Results

While the pre-service teachers did not take up the designed activities exactly as the research team had intended, all students submitted satisfactory multimedia artifacts. The instructor and research group's intended object of activity was to help students further connect learning theories to actual teaching practice, but both groups analyzed were more oriented towards directly fulfilling assignment requirements than understanding and applying learning theories. However, only one post-collaboration event was categorized as atheoretical noticing; all other events reached at least t-b noticing. Four students' (Isaac, Riley, Natalie, and Isabella) post-collaboration modifications resulted in a change in their articulation of professional vision. Isaac and Riley both moved from atheoretical noticing to t-b noticing in two of their event descriptions. Because professional vision is develops over time and through practice, it is not surprising that few students' articulation of their professional vision changed throughout

this one-week intervention. Yet, evidence of post-collaboration changes in students' multimedia artifact descriptions suggests that some students benefited more than others from discussing their own and each other's multimedia artifacts.

Four of the six students achieved t-b noticing + interpretation in at least one of their final events. This improvement is meaningful given the brief nature of the intervention. As students prepare for student teaching and the challenges of everyday classroom practice, they must notice, interpret, and respond. In these students' multimedia artifact construction, we see progress towards this long-term objective on a short time-scale. Moving from t-b noticing + interpretation to t-b noticing + interpretation + response requires pre-service teachers to articulate how they would handle this particular episode in their own classrooms or how the teacher in the video could have improved his/her response. Overall, students' multimedia artifact descriptions improved post-collaboration for students in both groups. Students increased the number of theories referenced in their final versions of events and articulated more appropriate uses of learning theory suggesting the RUanalytic tool and the activity design constructed a useful space for students to practice making theory-practice connections.

In both groups, two of the three students improved their articulation of professional vision after collaboration in at least one event. These shifts were supported by the detailed feedback provided in the group Etherpad documents, and suggest that discussing multimedia artifacts with peers typically had a positive impact on articulation of professional vision and use of learning theory. Isaac's first version of event 3 was categorized as no/unclear use of theory; he writes, "…Although [Meredith] was one of the students to prove that two-tenths is equal to one/fifth, when she sees another examples she challenges her understanding because the example given by the two boys before her is not the same. It's almost like she is changing her mind, not because she wrong, but because she trying to grasp a different understanding." In reviewing this event description Riley and Addison write, "Clip 3: I didn't notice this at first but LOVE that you caught it and explained it. Add modeling to the end. Great use of imformation *[sic]* processing! Misconceptions are also what she is struggling with." While Isaac did not state that he was using information processing his two group members assume he is drawing upon something having to do with this theory. Isaac took up this feedback and revised his event description to explicitly define and use information processing to articulate Meredith's struggle as a misconception that there is only one way to show two fractions are equivalent. Isaac's final event 3 was classified as appropriate use of learning theory and t-b noticing.

In collaboration, small groups were able to draw connections from interactions in their video clips to course theories, and some students were able to connect these noticings to the kinds of responses they would take as teachers. While reviewing each other's multimedia artifacts, groups re-watched certain events repeatedly to reach a consensus on what was occurring in the interaction. Furthermore, they encouraged each other to look beyond their first impressions of which theories applied to an event—seeing that multiple theoretical concepts could be applied to just one interaction. This kind of connection from theory to practice was the primary learning outcome intended by the research team, and seems to have been reached by all participants in these two groups, though there was room for improvement in how theory was applied by most students. In each of Isabella and Addison's final event descriptions their use of theory was categorized as either appropriate use or approaching appropriate use of learning theory. This means both pre-service teachers had few, if any, misconceptions concerning the learning theories each chose to support her observations and interpretations. While Riley, Isaac, and Natalie made many modifications to their use of learning theory post-collaboration, they each had one final event that was categorized as inappropriate or inaccurate use of learning theory.

Presenting and discussing their multimedia artifacts in their groups did improve all students' definitions of concepts and overall application of learning theory, but some students still struggled to define or apply theories accurately despite discussing them during collaboration. For the students with events classified as inaccurate use of theory post-collaboration, either the Etherpad was not employed as an artifact to guide their revisions, or the nuances of the theory discussed were not taken up by the student or effectively captured in the Etherpad. This is visible in the changes Isaac made to his event 1 description. An excerpt from Isaac's first version of this event read as follows, "…This thought process could be relevant when speaking about the Zone of Proximal Development in Social Cultural Theory. // Meredith is trying to understand the concept of fractions before sharing it with her classmates. This enhances her ZPD because her thoughts go from a personal learning experience to a whole class learning experience." Upon review of Isaac's work, Riley and Addison provided him with the following feedback regarding the first event in their Etherpad, "Clip 1: Add modeling to the begining *[sic]* of the clip where Meredith is modeling her way of figuring out the problem. Add what ZPD means. Did you include the concepts of building new schemas in clip 1?" Here, Riley and Addison suggested adding additional theoretical connections to an event and modifying use of theory to be more articulate. Review of the video recordings of this group's interactions revealed that Isaac and Addison returned to their class notes to clarify their understanding of information processing. Ideally, Isaac would have also reviewed his notes from the unit on sociocultural theories

as well and recognized that his use of ZPD was not aligned with how Vygotsky defined it. Examination of Isaac's final event descriptions suggested that he took up the suggestion to define ZPD and ignored the recommendation of adding concepts from other theories. Isaac's final version had an additional sentence (where the double slashes are in the event description above), which read, "The Zone of Proximal Development is the area and environment that a student feels comfortable with." But because Isaac's definition of ZPD was not accurate, his application of this theoretical concept remained an inappropriate use of theory. While not accurate, Isaac utilizes his understanding of ZPD as some sort of movement from a personal to a social learning experience to understand why Meredith first works independently before offering her solution to the rest of the class. Isaac's event one description is an instance of t-b noticing that is based on an inaccurate understanding of learning theory. The struggle to appropriately employ learning theory is not surprising considering this is a well-documented challenge in teacher education. Further, students' use of the RUanalytic tool was limited to one week of activities. In future iterations we intend to integrate the tool throughout the semester to provide greater opportunities for connecting theory to practice.

In analyzing the interactions and artifacts created by the pre-service teachers in this educational psychology course, we found that multimedia artifact creation allowed students to (a) parse student-teacher and peer interactions that are typically overlooked when just watching a video of classroom activity or observing a classroom in person, (b) relate aspects of different learning theories to concrete moments of teaching and learning, (c) solidify or reify their beliefs on how teaching and learning should unfold, and (d) review course materials and notes productively. Many students recommended greater integration of the tool into course activities across the semester because they found it useful in making sense of the learning theories and connecting theory to practice. The course instructor also believed this was a useful tool for similar reasons.

Significance

Through analysis of two groups of pre-service teachers' collaborative activity systems and their descriptions of classroom videos, we gain insight into how to support future teachers to think differently about theory and the ways it can play out in the classroom. Our activity theory analysis reveals that although students did not take up prompts in the way the instructor/research team intended; students constructed activity systems that were productive for their own objects of completing the assignment. These results suggest that students may not view theory as necessary to interpreting classroom interactions, and therefore did not appropriate the intended object due to a lack of relevance. Activity theory was a productive lens for understanding how students take up curriculum. Although group A's collaboration was more mechanical than desired, both groups were productive in connecting theory to practice, highlighting the value of integrating video of classrooms into course activities.

Teaching is a practice-centered career. As pre-service teachers gain experience refining their own teaching practice (through student teaching and extensive classroom observation), they fine-tune important skills. When pre-service teachers engage in teaching practice early on, the application of theory is often lost. As first through third year pre-service teachers, it is not surprising that these students' professional vision did not improve dramatically across one week. What is impressive is that all students made theory-based noticings. The activity of annotating real classroom video allowed students to demonstrate their ability to articulate theory-practice connections. Our results show that constructing a multimedia artifact provides the opportunity for pre-service teachers to see how theory can be part of their professional vision, but that they may also need to engage in collaborative discussions to make the most out of these opportunities, at least initially.

Together, the findings suggest that integrating more multimedia activities in pre-service teaching coursework has the potential to greatly improve students' ability to contextualize course concepts and more directly support their emerging professional vision. Interacting with the VMC repository and RUanalytic tool throughout an entire course, rather than in a week-long intervention, may allow students to more closely appropriate the intended activity system of using a video annotation tool to mediate evidence-based use of theory and development of professional vision. In future work, we hope to examine how video annotation practices might be integrated throughout pre-service teachers' undergraduate careers—moving from the annotation of VMC video to the annotation of peer teaching and eventually of their own teaching practice. As pre-service teachers move through course and practicum experiences, they must learn to meaningfully observe students and appropriately respond (Ball & Forzani, 2009; Sherin, 2001). Observation in this capacity is a complex skill that involves fine-tuned attention, disciplinary knowledge, and an applied understanding of theory (Eberbach & Crowley, 2009). Video annotation in general, and the RUanalytic tool in particular, might be leveraged as a form of scaffolded training for pre-service teachers as they develop professional vision.

References

Agnew, G., Mills, C. M., & Maher, C. A. (2010, January). VMCAnalytic: Developing a collaborative video analysis tool for education faculty and practicing educators. In *System Sciences (HICSS), 2010 43rd Hawaii International Conference on* (pp. 1-10). IEEE.

Allsopp, D. H., DeMarie, D., Alvarez-McHatton, P., & Doone, E. (2006). Bridging the gap between theory and practice: Connecting courses with field experiences. *Teacher Education Quarterly*, 19–35.

Ball, D.L., & Forzani, F.M. (2009). The work of teaching and the challenge for teacher education. *Journal of Teacher Education, 60*(5), 497-511.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational researcher*, *33*(8), 3-15.

Cole, M. (1996). Putting culture in the middle. In *Cultural Psychology: A once and future discipline* (pp. 116-145). Cambridge, MA: Blknpa Press of Harvard University Press.

Eberbach, C., & Crowley, K. (2009). From everyday to scientific: How children learn to observe the biological world. *Review of Educational Research, 79*, 39-68.

edTPA. (2015). *About edTPA: Overview*. Retrieved from http://edtpa.aacte.org/about-edtpa

Engeström, Y. (1987/2014) *Learning by expanding: An activity-theoretical approach to developmental research* (2nd ed.). New York, NY: Cambridge University Press.

Goodwin, C. (1994). Professional vision. *American anthropologist*, *96*(3), 606-633.

Gomoll, A., Rehak, A. M., Novak, W., Andrade, A., Saleh, A., Hmelo-Silver, C., & Danish, J. A. (2016). Paper to be presented at the American Education Research Association National Conference in Washington DC.

Haikkarainen, K., Paavola, S., Kangas, K., Seitamaa-Hakkarainen, P. (2013). Sociocultural perspectives on collaborative learning: Toward collaborative knowledge creation. In C.E. Hmelo-Silver, C.A. Chinn, C.K. Chan, & A. O'Donnell (Eds.), *International handbook of collaborative learning* (pp. 57-73). New York: Routledge.

Jacobs, V. R., Lamb, L. L., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education*, 169-202.

Kuh, G. D., Kinzie, J., Schuh, J. H., & Whitt, E. J. (2005). *Student success in college: Creating conditions that matter*. San Francisco, CA: Jossey-Bass.

Kunzman, R. (2014). "It could be so many learning theories": Multimedia artifacts and professional vision in pre-service teachers. IUB teacher education: In pursuit of coherence, consistency, and quality. Bloomington, IN: School of Education, Indiana University.

Maher, C. A., Palius, M. F., Maher, J. A., Hmelo-Silver, C. E., & Sigley, R. (2014). Teachers can learn to attend to students' reasoning using videos as a tool. *Issues in Teacher Education, 23*(1), 31-47.

O'Donnell & Hmelo-Silver, (2013). Introduction what is collaborative learning?:An overview. In C.E. Hmelo-Silver, C.A. Chinn, C.K. Chan, & A. O'Donnell (Eds.), *International handbook of collaborative learning* (pp. 1-16). New York: Routledge.

Rajala, A., & Sannino, A. (2015). Students' deviations from a learning task: An activity-theoretical analysis. *International Journal of Educational Research,* 70, 31–46.

Roth, W. M. (2007). On mediation: Toward a cultural-historical understanding. *Theory Psychology,* 20, 641-665.

Sherin, M. G. (2001). Developing a professional vision of classroom events. In T.Wood, B. S. Nelson, & J. Warfield (Eds.) *Beyond classical pedagogy: Teaching elementary school mathematics* (pp. 75-93). Hillsdale, NJ: Erlbaum.

Sherin, M. G. (2007). The development of teachers' professional vision in video clubs. In Goldman, R., Pea, R., Denny, S. (Eds.) *Video research in the learning sciences* (pp. 383-395). New York: Routledge.

Sherin, M., & van Es, E. (2005). Using video to support teachers' ability to notice classroom interactions. *Journal of technology and teacher education*, *13*(3), 475-491.

Stevens, R., & Hall, R. (1998). Disciplined perception: Learning to see in technoscience. In Lampert, M., Blunk, M. (Eds.) *Talking mathematics in school: Studies of teaching and learning* (pp. 107-149). Cambridge, UK: Cambridge University Press.

van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education, 10*(4), 571-596.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.