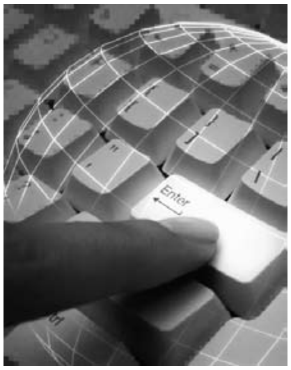

Promoting Reflection among Science Student Teachers using a Web-based Video Analysis Tool

Lynn A. Bryan and Art Recesso

Abstract

Recent efforts to design teacher education experiences using reflection as a philosophical orientation (Abell & Bryan, 1997) have shown that such experiences are influencing the way that teachers think about their practice, specifically teachers' personal beliefs about teaching and learning. In this paper, we introduce the design and implementation of a video analysis tool that we are using to promote self-reflection and collaborative reflection in capstone courses for student teachers. Our use of this video analysis tool, VAT (http://VAT.uga.edu/), is based on a theoretically grounded rationale that draws on the parallels between conceptual change teaching (Posner, Strike, Hewson, & Gertzog, 1982) and coaching reflective practice. The description of our VAT implementation in student teaching courses is organized according to the three elements of the parallels between conceptual change learning and reflection in teacher development. In addition, we discuss the central role and necessity of student teachers working through tensions in thinking in the processes of learning to teach and refining one's practices.

> When teachers have the time and opportunity to describe their own views about learning and teaching, to conduct research on their own teaching, and to compare, contrast, and revise their views, they come to understand the nature of exemplary science teaching. (National Research Council, 1996, p. 67)

Two decades ago, Donald Schön (1983, 1987) popularized the notion of reflection in professional practices. Much of what teacher education calls a reflective approach is grounded in the works of Dewey (1933), and has been shaped by the venerable works of thinkers such as Tolstoy, Vygotsky, Piaget, and Wittgenstein, among others (Schön, 1988). Schön's notion of reflection-in-action and reflection-on-action provided a way to fundamentally rethink how we view the relationship between theory and professional practice. Entire teacher education programs (Valli, 1992, 1997) to content-specific teacher education courses (in linguistics & ESL—Dong, 1998; mathematics—Artzt, 1999; music—Barry, 1994; physical education—O'Sullivan & Tsangaridou, 1997; reading—Hollingsworth, 1989; science—Abell, Bryan, & Anderson, 1998; Nichols, Tippins, & Weiseman, 1997) have been designed to move away from a view of teaching as a "bag of tricks" to a view of learning to teach that is influenced by prior experiences, beliefs, knowledge, and attitudes.

Recent efforts to design science teacher education experiences using reflection as a philosophical orientation (Abell & Bryan, 1997) have shown that such experiences are influencing the way that teachers think about their practice, specifically teachers' personal beliefs about teaching and learning. Furthermore, research examining the influence of reflection in teacher education contexts substantiates that purposefully designed experiences that are discrepant with and challenge teachers' beliefs may be valuable teaching tools. Hence, it behooves teacher educators to examine and determine this: How can teacher educators, university supervisors, and cooperating teachers design experiences that help prospective teachers articulate, analyze, and refine ways of conceptualizing teaching and learning?

More than a decade of case studies within science education research (Brickhouse & Bodner, 1992; Briscoe, 1991; Bryan, 2003; Bryan & Abell, 1999; Haney & McArthur, 2002; Levitt, 2002; Simmons, et al., 1999; Stuart & Thurlow, 2000; Tobin & LaMaster, 1995; Yerrick, Parke, & Nugent, 1997) contribute to a consensus that change in teacher thinking is unlikely to occur without purposeful, systematic inquiry about one's beliefs and practice. Prospective teachers who are able to reflect—that is, frame issues of teaching and learning, confront their beliefs about these issues, respond to tensions in their thinking, and experiment with alternative solutions to issues of teaching and learning—develop a deeper understanding of their practice. It is incumbent upon teacher educators to design experiences utilizing viable methods and tools that offer support for evidence-based improvements in practice through self-reflection and collaborative reflection. To this end, we introduce and discuss in this paper the use of a tool, Video Analysis Tool (VAT), for supporting self-reflection and collaborative reflection experiences in a secondary science teacher education course.

Video Analysis Tool to Promote Reflection

Simply stated, VAT is a Web-based, video analysis tool designed to systematically examine one's teaching practices (Recesso & Hannafin, 2003; Recesso, et al., in press). The use of video playback for analyzing one's teaching is not necessarily a new strategy (Bloom, 1969; Winn, 1974). However, all too often, the use of video playback in the analysis of one's teaching is neither purposeful, nor systematic. In contrast, the use of digital video delivered through Web-based technologies as described in this paper is rooted in a reflection orientation to teacher preparation. The goal of our use of this video capture, ingestion, and streaming process is to encourage student teachers to begin untangling the web of deeply entrenched, and often unexplored beliefs about teaching and learning. VAT allows us as teacher educators to design scaffolded coding and analysis experiences for teachers with an aim of fostering in them a disposition for systemic inquiry. VAT users examine the links between espoused beliefs and enacted practices, and the means through which learning to teach can be documented, analyzed, and assessed. VAT uses the metaphor of a camera lens to describe the instruments within the systems that enables a user to analyze and reflect on practices. A lens (e.g., rubric) enables users to focus on specific teaching/learning events that often are embedded in the complex, multi-dimensional environment of a classroom, and simultaneously reduces the "noise" from extraneous classroom aspects while amplifying critical actions and consequences within the event (Recesso & Hannafin,

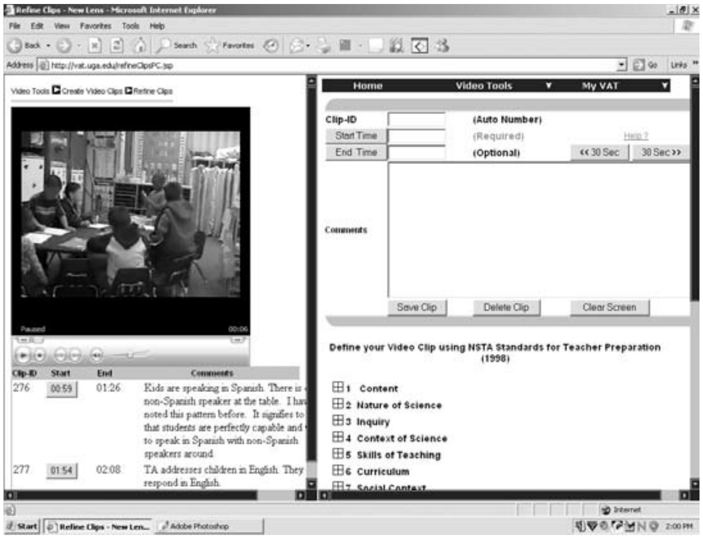

Figure 1. Refine video clip

Figure 2. View video clip

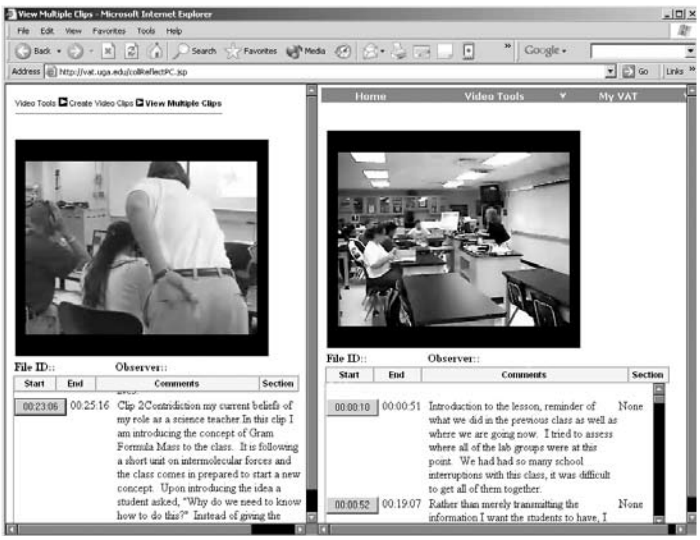

Figure 3. Collaborative reflection

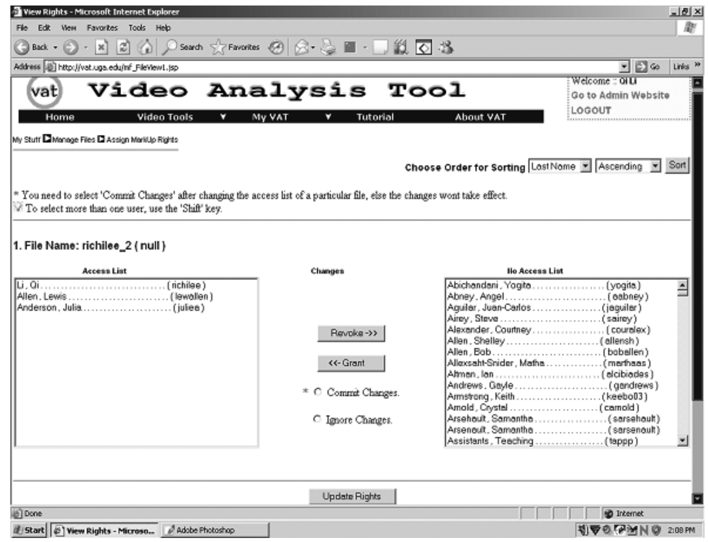

Figure 4. Assign markup rights

2003). In addition, VAT is a means of promoting reflective practice and assisting prospective teachers in changing their view of teaching from a "bag of tricks" notion in which the "tricks" apply to any given classroom situation, to a view of teaching as a practice grounded in a system of values, theories, and assumptions (Schön, 1983). Our use of VAT in science teacher education centers on thinking and acting on those aspects of teaching that raise questions, frustrate, confuse, and/or perplex.

Technical Aspects of VAT

VAT provides video capture and analysis tools used to define and reflect upon evidence of practices (see http://VAT.uga.edu/). Practices are recorded through video cameras and stored on a secure server for markup and analysis. In live capture, an Internet Protocol (IP) video camera is pre-installed in a classroom and configured remotely based on the specifications uploaded by the VAT user. Video practices are streamed across the local school system, Internet 2, and LambdaRail (http://www.nlr.net) backbone to a remote server which then stores the evidence, enabling a rater to observe practices unobtrusively with minimal classroom disruption or interference. Neither the teacher educator nor prospective teacher needs to upload, replace, adjust, or otherwise be bothered with the technology during teaching as the process is automated with preset triggers. The technology enables on-demand support of the prospective teacher as defined by needs and is no longer limited by geography or schedule conflicts. The teacher educator, for example, may participate in the field experience without having to travel long distances. An on-line tutorial provides a description of how evidence is collected and analyzed (see http://VAT.uga.edu/tutorial.htm).

The person wishing to analyze video (the "rater"), accesses the video using video tools available through VAT. The video tools allow the rater to create clips, refine clips, view clips, and engage in collaborative reflection. Through refine clips (Figure 1), the rater will view the overall video as she/he "chunks' the video into clips that are of particular interest. Clips may be created initially by simply designating start and stop times for individual segments. The rater then uses the refine clips function to go into more detail with each segment. For example, the rater may choose to align particular practices demonstrated in segments with criteria of interest, such as teaching benchmarks, state standards, or quality of practice rubrics. In addition, the rater may insert reflective commentary that will be associated with the refined clip. The final set of marked-up clips for a single individual across multiple events, or multiple individuals across a single event, then may be accessed using the "view my clips" tool (Figure 2).

Additionally, through "view multiple clips" (Figure 3), raters can share their clips and reflections with other practitioners in order to collaboratively compare, contrast, and reflect upon their perspectives and practices.

This multi-view function of VAT provides users with the ability to see two videos at one time and compare the coding of each. For example, a cooperating teacher and the student teacher may wish to see how the other analyzed a particular video clip. With the collaborative reflection tool, they are able to call up their individual analyses of a clip and view the two separate analyses side by side. Alternatively, the partners may have chosen different clips from the same video to show as evidence for a particular practice (e.g., leading a discussion to help students' make sense of the findings in a science investigation). In this case, though the partners may have chosen different video clips as evidence for a practice, they are able to view each others' chosen clip and corresponding analysis on the same computer screen. Finally, the person who creates the video and uploads it into the system (e.g., teacher) always retains the right to grant or restrict the permission for others to view and/or analyze his/her video through manage files functions (Figure 4).

Theoretical Framework for Use of VAT

The use of VAT for promoting reflection during the field experiences described in this paper is based on the assumption that changing one's practice is a matter of teacher learning (Tobin & LaMaster, 1995). More specifically, learning to teach science can be likened to learning science (Bryan, Abell, & Anderson, 1996). Prospective teachers enter into teacher education programs with beliefs and knowledge about teaching and learning; and like students of science, students of teaching often adhere strongly to their ideas. Like teachers of science, science teacher educators are responsible for helping students clarify and refine their beliefs and for providing ways to perturb teacher's existing beliefs so that learning through accommodation can occur (Posner, Strike, Hewson, & Gertzog, 1982; von Glasersfeld, 1987). Coaching reflective practice in teacher preparation is a means by which science teacher educators may assist prospective teachers in uncovering and confronting their beliefs and guide them through a process of conceptual change as they become science teachers.

Parallels between Reflection and Conceptual Change

In their work to develop a preservice science methods course grounded in a reflection orientation to teacher education, Bryan, Abell, & Anderson (1996) drew several parallels between conceptual change learning of science and reflection in teacher development. In both processes, the learners work to clarify and refine their beliefs and apply new understandings to solving practical problems. The actions by both the science learner engaged in conceptual change learning and the student of teaching engaged in reflective practice are described in greater detail in Table 1.

The model for conceptual change learning and the proposed analog of reflective practice consist of three student actions: explication/clarification of existing ideas, modification/refinement of those ideas, and application of new understandings. A concomitant set of actions defines the instructor's role in both conceptual change teaching and in coaching reflection. The teacher/teacher educator must begin with an appreciation of the students' ideas and then offer opportunities for conceptual change/reflection. These instructor actions are further delineated in Table 2.

It should be noted that although it is useful in reconceptualizing science teacher education, this analogy breaks down in several places. In conceptual change teaching, the science teacher typically guides the learner in understanding a single accepted scientific view of the concept. However, in the process of coaching reflection, the teacher educator is not striving to bring the beginning reflective practitioner toward one accepted view of teaching and learning, as decisions about and solutions to problems of teaching and learning most often are heavily influenced by contextual factors. Teachers develop and refine their beliefs and solutions based on the community, school, and classroom contexts in which they are engaged. Hence, what works for one teacher in her situation may be unique and not fully applicable to another similar situation. Secondly, in conceptual change teaching, the teacher generally focuses the students' attention on one or a small number of scientific concepts at a time. However, in reflecting on the complex nature of teaching and learning, students of teaching might focus on multiple issues. Classrooms are complex ecosystems; variables may be impossible to detect or separate. One student cannot attend to all facets of the classroom simultaneously. In addition, two observers of the same event may view things differently depending on the lenses

Table 1: Conceptual Change Learning Versus Reflective Practice: Learner Actions

Science learner[a]	Student of teaching[b]
Makes explicit her ideas about the science concept; explores concept.	Makes explicit her beliefs; identifies and frames issues of practice.
Clarifies her view of the concept; considers others' points of view; recognizes discrepancies among views and resolves the discrepancies.	Clarifies her beliefs about the issues by recognizing the similarities to others' situations and the uniqueness of her own situation; resolves inconsistencies in her thinking.
Applies refined explanation to solve a new problem; may have to refine ideas and reevaluate solutions.	Determines solution for resolving issue; implements solution and examines implications and consequences of solution; may have to refine ideas and reevaluate solutions.

Note. From: Bryan, L., Abell, S., & Anderson, M. (1996, January). Coaching reflective practice among preservice elementary teachers. Paper presented at the annual meeting of the Association for the Education of Teachers in Science, Seattle, WA. aSee Cosgrove and Osborne (1985). bSee Ross (1989).

Table 2: Conceptual Change Learning Versus Reflective Practice: Instructor Actions

Science teacher[a]	Teacher educator
Ascertains students' existing ideas about the science concept; involves students in exploration of concept.	Ascertains students' beliefs; guides students in identifying and framing issues of practice.
Provides experiences that perturb students' thinking; provides opportunities for students to compare their views with other students' and experts' views; assists students in clarifying new understanding of the science concept.	Provides experiences that perturb students' beliefs, provides opportunities for students to compare their views with other students' and experts' views; helps students clarify new frames from which they can interpret practice.
Provides opportunities for students to apply new ideas to practical situations.	Provides opportunities for students to apply solutions and determine the consequences and implications of the solutions.

Note. From: Bryan, L., Abell, S., & Anderson, M. (1996, January). Coaching reflective practice among preservice elementary teachers. Paper presented at the annual meeting of the Association for the Education of Teachers in Science, Seattle, WA. [a]See Cosgrove and Osborne (1985).

employed. The issues that students of teaching choose to individually or collaboratively frame largely depend on their beliefs, experiences, interests, and disciplinary backgrounds (Barnes, 1992).

Context of VAT Implementation

The reflection/conceptual change analogy provided a useful framework for redesigning the use of video analysis assignments in the secondary science program at the University of Georgia. The secondary science student teaching experience at the University of Georgia takes place over an 11-week period. In general, the main aspects of the student teaching program are as follows: Student teachers meet with their supervisor on the first day of the semester, at which time they receive a syllabus that details information about the observation/evaluation process, student teaching seminars, and assignments. Typically, students are observed by their supervisor three to six times. Cooperating teachers are asked to make several formal, recorded observations during the 11 weeks. The Department of Science Education provides an instrument for recording observations. The university supervisor is responsible for arranging the times and duration of the observations and determining the nature of subsequent conferences with the student and/or cooperating teacher. Conferences with the student teacher and/or cooperating teacher range from approximately 10 minutes to one hour.

During the semester in which they are student teaching, prospective teachers enroll in two additional courses: A reflections course and a professional development course. The reflections course consists of weekly seminars during the 11 weeks that the student teachers are in the field, and 20-25 hours of course work at the university after student teaching has ended. A faculty member coordinates and conducts the reflections course. The weekly seminars provide an opportunity "to reflect on the experiences of student teaching, plan for future actions, and to address topics of importance" (Syllabus, ESCI 5470/7470, University of Georgia, p. 2). Student teachers also have the opportunity to discuss with peers their concerns and experiences from their classrooms. Assignments for student teachers include completing a "beliefs statement," video capture and analysis of two teaching episodes, a teacher inquiry project, and a professional portfolio. Keeping a log or journal is optional.

Like other researchers engaged in teacher thinking research, we found that the prospective teachers whom we supervised had difficulties confronting, analyzing, and evaluating their own practice (Calderhead, 1988; Pavlovic & Friedland, 1997; Tann, 1993). The VCR-based video playback/analysis was completed as an assignment and held little meaning for the students, cooperating teachers, and university supervisors. In some instances, student teachers were not required to complete the assignment. When student teachers did complete the video capture and analysis, their analyses of practice often focused on classroom management skills or student teacher behavior patterns (e.g., saying "Okay" too often; calculations of average wait time). Like other researchers, we found common barriers to using video playback as a tool to promote reflective thinking and teaching included the student teacher's: (a) inability to identify and frame issues in teaching and learning; (b) reluctance to engage in self-criticism; (c) fear of revealing too many perceived areas of improvement; (d) insecurity with, lack of knowledge or distrust of the supervisor's and/or cooperating teacher's role in evaluating the student teacher's performance; and (e) time limitations that restrict collaborative interactions to promote reflective and critical thinking (Abell, Bryan, & Anderson, 1998; Pavlovic & Friedland, 1997).

However, to abandon the use of video playback for these reasons seemed to be throwing away a valuable tool for promoting reflective practice among prospective and novice teachers. Instead, we began to address some of the barriers by grounding the use of video playback in a specific orientation to teacher education. When the use of video playback becomes directed, systematic and purposeful, student teachers develop an ability to step back from their practice—an important step in considering why certain practices occurred and what the consequences and implications of those practices were. In addition, video playback allows the student teachers to break down the lesson into manageable parts and work on selected beliefs, practices, and skills. Furthermore, video playback allows the student teachers to view the same practice from different frames, helping the student teachers to appreciate their own learning and development as a professional. Helping student teachers learn about their own learning will help them appreciate what their students need in terms of learning (Bryan & Abell, 1999; Calderhead, 1988).

This paper describes our initial work to build a theory of evidence-based approaches to reflection and develop practical applications of VAT in teacher education. We draw upon examples that have been generated from the formative stages that informed a larger ongoing research initiative (Recesso & Hannafin, 2003). This is the first of multiple iterative cycles of design, development, and field-testing used to bring theory into practice through the engineering of prototypical systems. Each stage of design, development, and field-testing has focused on the ultimate goal of building and refining a Web-based system that supports purposeful, systematic video-based reflection for its users. Thus, at this stage, our intent was to determine how preservice teachers were able to employ our design of VAT to reflect on their practices. Specifically, we were interested not only in usability issues of VAT but also in the problems/issues/dilemmas of practice that student teachers framed and in how they use VAT to reflect on their own science teaching practices. The implementation process that we draw upon for this paper permitted us to make improvements to VAT both during and after the student teaching and course experiences throughout the semester.

The student teachers who were involved in our initial implementation of VAT were enrolled in the reflections course, ESCI 5470/7470, which met weekly for 15 weeks during the semester that student teachers were in the field. Student teachers met with their instructor (Dr. Bryan) for three hours, once per week. Seven student teachers were enrolled in the course. (It should be noted that since our work with VAT began in 2003, the enrollment for this course has varied from semester to semester—from a low of four to a high of 24). Dr. Bryan also served as the university supervisor for two of the student teachers in the course. Four student teachers were graduate students working toward certification and a M.Ed. in science education; three student teachers were undergraduate students working toward certification and a B.S. in secondary science education. Students ranged in age from 22 to mid-50s. During the semester, we videotaped each class session, collected written documents (belief statements, course assignments), and cataloged VAT analyses.

Using VAT to Coach Reflective Practice: Applying the Analogy

Drawing on the above discussion of the parallels between conceptual change teaching and coaching reflective practice, we describe in this section a VAT process that we currently use in a preservice secondary science teacher education course that includes field experiences. The discussion is organized according to the three elements of the parallels between conceptual change learning of science and reflection in teacher development found in Table 1.

In Coaching Reflective Practice, the Teacher Educator Ascertains Students' Beliefs and Guides Students in Identifying and Framing Issues of Practice. Prospective teachers were introduced to VAT on the first night of the course. Each prospective teacher had access to a laptop computer and practiced with VAT using mock data pre-loaded into the system. They became familiar with a sample rubric aligned with National Science Teachers Association (NSTA) Standards for Science Teacher Preparation (1998) to use as one lens for analyzing the practices that they saw in the mock video data (Figures 1 and 2 show screen shots of a small part of the NSTA rubric). The teacher educator then asked students to explore VAT by going through two similar procedures: (1)

Choose a 5-10 second scene in the mock video data and associate that scene with an NSTA indicator on the rubric for which you believe the teacher shows competency; then, insert in the comment section your rationale for why you aligned the practice with the chosen indicator; and (2) Choose an NSTA indicator on the rubric for which you would like to evaluate the teacher's competency, and find a 5-10 second scene in which you believe the teacher met, to some degree, that competency; then, insert in the comment section your reasoning for choosing that scene and explain the level of competency that you believe the teacher demonstrates in that scene. For VAT training sessions, the teacher educator a priori may choose: the lens for analysis, specific indicators to use within the lens, the timeframe of mock video data for viewing, and/or specific attributes of practice demonstrated in the mock video for students to analyze. By the end of the VAT training, prospective teachers began to demonstrate proficiency with VAT and how it would help them understand the difference between espousing beliefs and enacting those beliefs in their practices.

Making beliefs explicit. Before the field experiences began, prospective teachers wrote a narrative that focused on their vision of teaching science and on their beliefs about science teaching and learning. They described how they saw themselves as teachers of science and their beliefs about: (a) how students learn science, (b) the role of the teacher in the science classroom, and (c) the role of students in the science classroom. The vision and beliefs statements were used in conjunction with video evidence of practices that the student teachers recorded.

Over the next four weeks, each prospective teacher progressed through multiple stages of reflection, two of which (evidence collection and analysis) were instantiated in the VAT tool (see Figures 1-4). Each prospective teacher used VAT to analyze their practices, generate reflections about issues of teaching and learning, and open opportunities to discuss these issues with peers and teacher educators. In general, analysis involved the user employing a combination of Web-based functions (e.g., video playback), time coding video into segments, and associating the segments with a lens. Because the task of analyzing their practice was new, and VAT itself was new to the students, we predetermined a lens for analysis.

Framing Issues of Practice

Prospective teachers often have a very broad conceptual understanding of practices and student learning, but little experience from which to examine or understand their meaning. To address another common barrier to using video analysis (the inability to identify and frame issues in teaching and learning), we assisted students in identifying issues of practice to frame by providing the prospective teachers with questions purposefully designed to use as a lens for analysis, to encourage a comparison of beliefs and practice, and more specifically to identify consistencies and discrepancies between beliefs and actions: (1) From evidence in your teaching practices, find instances/examples that you think resonate with or illustrate your current beliefs about science teaching and learning. Explain why you think these episodes resonate with or illustrate your current beliefs; and (2) From evidence in your teaching practices, find instances of your teaching that you think contradict your current beliefs about science teaching and student learning. Explain why you think these episodes contradict your current beliefs.

For our classes, prospective teachers were required to capture at least one but no more than three lessons on video that they would use for video analysis. It should be noted, however, that they often collected other forms of evidence as they progress through the semester (e.g., student work, emails, assessments, lesson plans). A typical sequence of analysis looked like the following: First, the prospective teacher revisited his/her beliefs statement. Next, they accessed their classroom video evidence through VAT using Internet Explorer on a PC. Analysis began as the prospective teacher entered VAT and used the refine clips function. At first, most prospective teachers conducted a general review of the video—marking multiple start-times of events demonstrating resonance or contradiction to stated beliefs. The general review and mark-up of video would be refined in the next stage of analysis.

In Coaching Reflection, the Teacher Educator Provides Experiences That Perturb Students' Beliefs, Provides Opportunities for Students to Compare Their Views With Other Students' and Experts' Views, and Helps Students Clarify New Frames From Which They Can Interpret Practice. In this part of the analysis, the prospective teacher had to determine which video clips portrayed practices that were most resonant and most discrepant with his/her stated beliefs. She/he used the refine clips function to select a specific video file. The markup of events was completed by adding end times, using pull-down menus and checkboxes to associate events with the resonance or contradiction, and writing a reflection. The prospective teacher then chose a limited number of events to analyze. The purpose of choosing a limited number of events was two-fold: to address students' potential fear of revealing too many perceived areas of improvement, and to help them focus with more depth on enhancing or modifying one or two practices at a time, as opposed to conquering a multitude of practices with little depth. The reflection was not an account of what happened. It was an analysis in which the prospective teacher compared and contrasted stated beliefs with direct evidence from his or her recorded practice. The prospective teacher articulated the "whys"—why a clip was resonant with stated beliefs or why a clip was contradictory to a stated belief. Prospective teachers were encouraged to illuminate their thinking about the practice(s) featured in the clip. For example, in her reflection on a video clip that she identified as resonant with her initial belief statements, Catherine wrote about how she promoted students' creativity and facilitated their teaching one another:

> The girls are performing their play on viral meningitis for the class, and clarifying the symptoms and mode of transmission so that their classmates can take notes. Science is so much more than taking notes or learning new vocabulary terms. In order for students to stay interested in any subject, including science, they have to become active participants in their own learning. Allowing my students to express their creativity by teaching one another through these simple plays allows them to be in control of the lesson, and in doing so, they assume the role of teacher as well as student. My students should be as involved in a lesson, if not more so, than I am. Having them put on these short plays takes the spotlight off me and places it on them, where it belongs (VAT file, Sept. 2).

Catherine felt that this clip was evidence of her belief, enacted in practice, that science must relate to students' lives and that they should be active in their learning:

> If students are going to understand basic science content, it's important that we relate science to something in their lives, something that they already have a conceptual framework for. While in my classroom … my students should be as involved with a lesson, if not more so, that I am (Initial Beliefs Statement, Aug. 23).

For a novice teacher like Catherine, finding some evidence of desirable practices affirms her ability to make sound pedagogical decisions.

After completing an analysis cycle, prospective teachers presented their clips and analyses to each other in a seminar format. Open and frank discussions about issues presented in this seminar helped prospective teachers to: (1) consider the perspectives of others in the situation that was portrayed in the clip; (2) recognize that their peers had similar struggles and that they were not the only student teachers working through teaching and learning issues; and (3) appreciate the value of collaboration and mentoring as one learns to teach. In Catherine's case, the discussion focused on linking learning theories to teaching strategies: Why is teaching others a beneficial activity for students? In terms of theories of learning, what do students gain? In terms of theories of learning, why is it important for science to be relevant to students' lives? Allowing prospective teachers to go through the analysis cycle individually before engaging in a discussion about their practices gives them the opportunity to think through their reasoning for choosing the resonant (or contradictory) clip and prepare for follow up discussions with the instructor and her peers. Ideally, the discussions encourage prospective teachers to make more explicit the link between what we know from educational scholarship and evidence they present from their practices.

On the other hand, prospective teachers also felt vulnerability associated with making their teaching practices known. They also experienced some frustration with the complexity of decisions involved in the everyday life of a classroom. One of the central concerns that student teachers brought to class discussions involved how to manage the varying levels of motivation, interest, and ability of their science students. In the following example, Sandy described a student who had fallen behind in her biology class, despite having performed well during the first part of the semester:

> Keep your eye on the bottom right hand corner. Karen is the student in my biology class with one of the two failing grades. She is constantly putting her head down on the desk. When Karen asks me questions, she is looking for me to give her the exact answers. She is falling further and further behind in the class with each passing lesson. She doesn't complete her homework assignments which are taken up for a grade. After the last test I pulled her aside and asked her if she studied. She told me she spent her night at dance team tryouts and didn't have time. (VAT file, Oct. 22)

Sandy's frustration stemmed from two factors. First, she knew that Karen could do well in the course, as evidenced from her completed assignments and test grades for the first four weeks of the semester. Second, Sandy was perplexed with how to set the pace in her class: "How can I keep pace with the students who are engaged and actively participating and still meet the needs of a student like Karen?" (VAT file, Oct. 22). What Sandy found out by sharing her teaching dilemma in class was that others face the same challenges, and those such challenges are not necessarily an indicator of poor teaching skills. In addition, by allowing peers to ask questions about Sandy's decision-making process, to inquire more about Karen's school performance, and to make suggestions, Sandy determined ways that she could follow up with Karen that she had not thought of on her own.

In Coaching Reflection, the Teacher Educator Provides Opportunities for Students to Apply Solutions and Determine the Consequences and Implications of the Solutions. After prospective teachers had a chance to examine their video and create clips of evidence to support their answers for the reflection questions, they provided concrete solutions or alternatives to the issues that they perceived as pertinent to their learning to teach: (a) What are some reasonable ways that you can change the actions that you cited as contradicting your beliefs to be more resonant with your beliefs? (b) What do you anticipate will be the outcome of these solutions? The answers to these questions were entered through the VAT interface that directly aligned written reflections with segments of video.

Identifying specific actions that are discrepant with their beliefs assists prospective teachers in focusing on one or two "burning issues" to address in their teaching. This stage of the reflection cycle allows students to consider multiple alternatives that may be viable and those that may not be realistic. Rather than seeing video analysis as a process of self-criticism, we aimed to help student teachers view video analysis as a problem-solving process in which there is no one right or technical answer to complex issues and dilemmas of classroom instruction. By engaging in the VAT analysis of practice and solutions to teaching issues, prospective teachers become better prepared to think through and tackle more demanding issues about their teaching. They also become better prepared to engage in thoughtful, structured dialog during supervisory conferences. When the teacher educator reviews the prospective teacher's VAT analysis prior to observations and conferences, observations can be more focused on the specific needs and concerns of the prospective teacher. Furthermore, the prospective teacher's VAT analysis lends rich, visual insight into his or her beliefs and interpretations of practice: elements that are essential for a teacher educator to understand if she/he takes seriously the responsibility of designing ways to best facilitate teachers' development of professional knowledge.

Finally, prospective teachers were encouraged to implement viable solutions in practice. Once a solution or alternative was conceived, prospective teachers made explicit plans to carry them out in practice. Each prospective teacher recorded an episode of teaching in which she/he implemented the solutions. During this stage of the cycle, the prospective teacher not only has the chance to make use of his or her ideas in actual classroom practice, but she/he is encouraged to examine the extent to which the outcomes of the solutions/alternatives are successful. For some, the field experiences affirm beliefs about teaching and learning; for most, the field experience becomes a theory-changing phase of the learning-to-teach process. After examining the replay of their teaching, prospective teachers may recognize that their beliefs and practice are not completely resonant or that their beliefs are inadequate to guide their actions. They may rethink issues that frustrate, confuse, or perplex them. While the reflection process was not always comfortable for our prospective teachers, they often were aware (and appreciative) of the learning benefits associated with explicating and working through tensions in their beliefs:

> It literally was like a light bulb went off. In any situation, you can be frustrated and you don't know why it is. And then when I finally figured out why it was, it was a total light bulb. So I think that the conflict of what I believe and what I was doing-—if I had never understood that, then I would just be in the same place. I would continue thinking I was doing what I said I wanted to do. So if I had not been forced to think about it, I would have never realized it. And having realized it has made me be able to take the steps I need to correct it or to improve. So I think the tension is uncomfortable, and it is uncomfortable knowing that I'm doing something that I don't want to be doing. But it is beneficial because now I can change. (Marianne, Interview, Dec. 1).

The description of VAT implementation in this section is just one example how VAT is being utilized in our secondary science methods courses. Faculty are engaging in remote live observations of student teachers from their offices through VAT and are able to provide on-demand communication and assistance to teachers in the field, and enhance interactions with cooperating teachers.

Discussion

The VAT tool is transforming the way we help prospective teachers articulate, analyze, and refine ways of conceptualizing teaching and learning in the process of developing professional knowledge. One immediate outcome of using VAT in our student teaching courses is that the prospective teachers more quickly became aware of and appreciated the complex nature of learning and the activity of teaching. They began to "look below the surface," viewing their decisions not as right or wrong, but in degrees of appropriateness and applicability.

From this experience, prospective teachers often became cognizant of tensions in their teaching. Recognizing discrepancies can lead to productive tensions in thinking about teaching and learning. Specifically, recognizing tensions in one's thinking about teaching and learning is the first step in learning from experiences. Tensions in thinking are productive in that they can highlight the inconsistencies between a teacher's beliefs and her actual practice. Research has shown that such encounters yield feedback and stimulate reframing and revising of beliefs about teaching and learning (Bryan, 2003; Bryan & Abell, 1999; Russell & Munby, 1991). For example, in the case of Charles, a student teacher of chemistry and physical science, comparing and contrasting his espoused beliefs with his actual classroom practice started him on a constructive path of sorting through which outcomes to his teaching were desirable versus undesirable. Charles had just finished a lesson on how to predict the composition of ionic compounds. He felt he had done a thorough job of explaining how to balance the charges in a compound, working through numerous examples in an interactive manner with the class. Charles recounted the situation from which he framed his dilemma to his peers in the reflections course, showing and referring to the video clips that he analyzed on VAT:

> We were talking about ions, ionic bonding. Say if I was doing this right here (Charles writes the same problem on the board that he was working on with the student in his video). I said you have these two elements, and you need to have a charge and you need to make it form a compound, which is like the formula of it, and we sent through the whole thing—that the charges need to equal and the overall charge has to be zero. Basically, we went over that and over that and eventually most of them were able to figure it out—If the charges are going to be equal, you have a negative-two charge here and you have a negative-three charge, so the positive charge is going to be six and the negative charge is going to be six, alright, and the overall charge is zero. Most of them are able to figure out. But what I had to do with (this girl), when they were doing practice problems, (she) was like, "I just don't understand what's going on. I have no idea what's happening" (VAT file, Oct. 1).

The last third of the class period was devoted to students practicing making predictions about the composition of ionic compounds. During this time, the student asked for Charles' help. She claimed that she did not understand anything that he explained. As Charles began to diagnose how to help her, she stated that she simply wanted him to "show (her) where the numbers go." Charles proceeded to show her how to perform a simple crisscrossing of numbers to arrive at the answer:

> I questioned and questioned, and I finally just went, "Okay, you take the three and move it down here and you take the two and move it down here." But if you do that, and (the students) are like, "Oh, I can do that," then they get the right answer but when you ask them what they understand, they have no idea. I feel like what I am doing a lot of times, especially with this, is I was teaching them to get the right answer, but not teaching them what is really going on … teach them to think, teach them to reason (VAT file, Oct. 1).

When he saw his teaching practices on VAT, Charles realized that what he did and what the student asked for were contradictory to the outcomes that he desired for his teaching. He realized that this student (and perhaps many others) was interested in efficiency more than understanding, i.e., they want to know the algorithm, but not what the algorithm means or why it makes sense. This contradicted his original envisioned role as a science teacher, which was to help students "become skilled at critical thinking and reasoning" and help students interact with abstract ideas through labs or models ... to come to a greater level of understanding" (Initial Belief Statement, Aug. 24). Charles further contemplated the issue of motivation to learn. How does he motivate students to desire to know the "whys." For example, why do the iron and oxygen ions combine to form Fe_2O_3?

Examining his practice in relation to his beliefs helped facilitate the framing of important questions about the learning processes of classroom science instruction. Charles realized that he could not simply show students how to figure out a problem and expect that they would understand or be interested in why the problem is solved in the manner it is solved. There was much more to the process of learning and much more to the activity of teaching, and motivation was just one of the influences.

Just as Charles realized that there is more to learning how to approach and solve a chemistry problem than simply applying a rote sequence of actions, teacher educators must recognize that student teachers need more than one-size-fits-all strategies for learning to teach. Student teachers' interpretations are fundamental to the analysis process of VAT. Rather than confronting them with alternative conceptions and administering prescriptions for improving practice, we seek to give student teachers shared responsibility in their learning. That said, student teachers' interpretations of their practice may not always be the same as the teacher educators' interpretation. It is essential that teacher educators understand student teachers' experiences, beliefs, and interpretations of practice, so that they may coach to their student teachers' needs. Like students of science, students of teaching construct their own understandings and meanings based on their existing conceptions about teaching and learning.

Developing reflective practice using VAT requires a great deal of thought, commitment, and motivation on the part of prospective teachers and teacher educators. Optimally, a student teacher would engage in a collaborative reflection relationship. Although teacher educators cannot be expected to develop such a relationship with each individual student teacher, given the accessible, Web-based nature of VAT, others involved in the student teaching experience could be challenged to participate. A collaborative reflection relationship between the student teacher and a cooperating teacher and/or supervising teacher who is particularly good at analyzing and talking about her own practice is practical yet ideal. Furthermore, it should be expected that student teachers will make mistakes. Hence, they need someone with whom they can develop a relationship in which they can be honest about failures, yet be offered the expertise to help them analyze and learn from the failures. We must create environments that give student teachers time for careful planning and reflection. Environments such as VAT in which student teachers, cooperating teachers, and university supervisors connect through a Web interface at virtually any time and any location to review and discuss the same slice of classroom events and through which they communicate to each other about what they see and how they interpret the evidence are making it much easier for educational professionals to develop such a community of reflective practitioners (Hill, Hannafin, & Recesso, in press; Sherin & van Es, 2005; Wiley, 2001).

VAT Limitations/Considerations. While the advantages of using VAT are many, there are limitations and considerations to take into account before using the tool. We have uncovered technical challenges in our work with area schools, such as (a) schools blocking video streaming into the school (hence, no video resources for teachers to use); (b) limited bandwidth, causing schools to be concerned about streaming across their networks; and (c) a limited expertise among school technology coordinators, who are ultimately responsible for managing the school's network. Within a classroom, the major concern was the viewing range of the video camera. Mounted video cameras may limit the viewing area unless a wide-angle lens is attached to the camera. Most student teachers used a digital video camera mounted on a tripod to record their practices. Because the cooperating teacher was in the room during instruction, she/he usually maneuvered the camera to follow the teachers and/or zoom in on classroom events. Clearly, users can overcome all of these issues, but they can take time and effort.

In our work with student teachers, we have encountered few barriers to the use of VAT that were attributed to student teachers' skills, ability, or willingness. Student teachers generally needed only 30-60 minutes of class time to become familiar with and navigate through VAT. We made sure that all student teachers had access to PCs with a Windows operating system (XP, 2000, 98), Internet Explorer 6.0+, and Windows Media Player 9 or higher. Additionally, viewing video in VAT requires that all video files be in Windows Media Video format (wmv). Video file conversion programs are freely available for download on the Web. Through the support of a U.S. Department of Education PT3 grant (Recesso & Hannafin, 2003), we provided support to the student teachers and faculty by converting and uploading the files for them. Considering the issues of sustainability beyond the grant life, we have begun to work towards automating the process. The Internet protocol cameras automatically send the video to mass storage on campus, where it is automatically converted to the appropriate file format and made available to the users. Using human-operated digital video cameras does not provide this efficiency. In a recent implementation with one course of 26 elementary education preservice teachers, we found the teachers amenable to converting the files and uploading remotely through a new VAT file upload function. We provided a short training session, software, laptops, video cameras, and "cheat sheet" cards, illustrating the three-step process. The major barrier to this process was not a technical issue, but rather management issues related to sharing and scheduling the cameras.

Expanding the Use of VAT

As digital video technology becomes more readily available and easier to use by novices, video playback and editing systems like VAT are becoming more appealing for use in teacher education (Yerrick, Ross, & Molebash, 2005). Prior to VAT implementation, we found that VCR-based analyses were becoming cumbersome for students and the instructor. Students had to make sure to queue the video before submitting their analysis to the instructor; they had to keep track of start and stop times for multiple clips and report those times to the instructor; they could not view more than one clip at a time; and they had to find a VCR (in a DVD era) to use. While these issues were not insurmountable, they introduced inconveniences that the students and instructors faced semester after semester (e.g., many students own a laptop and DVD player, but not a VCR; students occasionally forget to document start and stop times).

In comparison, digital video playback and editing has introduced the ability to analyze, manipulate, and share video in new and powerful ways. In terms of convenience, users have the ability to access the video on demand anywhere or anytime they have Internet access. This level of accessibility means, for example, that the cooperating teacher or university supervisor is able to analyze the student teachers' practice in real time, sharing their analysis immediately after the student teacher observation. Unlike analog video viewed from a VCR, the Web-based interface functions of a digital video editing system enable users to deconstruct complex events by "chunking" relevant video clips and extracting them out of the overall video for finer grain analysis. Each analyzed video clip is cataloged in a menu, where users can choose the clips they wish to view, rather than rewinding through a videotape. Users can share selected clips of intricate parts of practice with others or choose to let others chunk, extract, and analyze the whole video (Recesso et al. in press, 2006; Sherin & van Es, 2005; Hoadley & Pea, 2002). Fully, these are affordances previously available only to those with experience using complex video editing suites.

Applications for digital playback and editing systems like VAT go beyond teacher education courses and programs. It became apparent in our work that VAT has the potential to be a continuous support system for teachers as they transition across their career continuum. Clearly, VAT as a Web-based technology could follow the teacher into the field. The first-year teacher could capture video in the classroom and collaborate with building-level peers and mentors. The complexity of the classroom environment can easily overwhelm beginning teachers. Thus, beginning teachers often revert to models of instruction that contradict values in the domain (Darling-Hammond, 1997). Access to a familiar support tool may provide a level of support that is enough to focus on finer-grained attributes of classroom practice—i.e., success through improvement of the parts rather than the whole.

Participants in the initial teacher education implementation of VAT have entered the field, accepting teaching positions in local schools. We have partnered with graduate programs, mentors, and academic coaches to provide continuous access to VAT. Elementary education, for example, has a fifth-year masters program enabling us to continue our collaboration with several graduates who are now induction teachers. Local mentors of preservice student teachers and induction teachers attend VAT training sessions. They have begun to inform us, as the applications for observing and providing feedback in the field. The Georgia Teacher Success Model initiative has initiated the use of VAT as a new support mechanism for teacher assessment and growth. Fully, we expect our investigation with new populations of VAT users will reveal more systematic ways to reflect using evidence, the need to collect and organize a wider variety of evidence (e.g., student work samples) in VAT, and ways to report progress made over time (e.g. portfolios).

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Lynn Bryan is an associate professor of science education with a joint appointment in the Department of Curriculum and Instruction and the Department of Physics at Purdue University. Her research encompasses three major areas: teacher knowledge and beliefs, sociocultural influences on science teaching and learning (particularly in international classrooms), and science teacher education in the context of innovative technologies.

Lynn A. Bryan, PhD
Purdue University
Department of Curriculum & Instruction and Department of Physics
Beering Hall of Liberal Arts and Education
100 N. University St.
West Lafayette, IN 47907-2098
labryan@purdue.edu

Art Recesso is an associate research scientist in the Learning & Performance Support Laboratory at the University of Georgia. His research centers on use of evidence for decision making and assessment of teacher and leader practices. He also develops Web-based decision support systems for improving performance, practice, and organizational structures.

Art Recesso, PhD
University of Georgia
Learning and Performance Support Laboratory
612 Aderhold Hall
Athens, GA 30602
arecesso@uga.edu