Video Interactions for Teaching and Learning (VITAL): A Learning Environment for Courses in Early Childhood Mathematics Education

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Abstract

This paper discusses recent findings from the study of a Web-based application called Video Interactions for Teaching and Learning (VITAL). VITAL was developed by the Columbia Center for New Media Teaching and Learning (CCNMTL) in partnership with Prof. Herbert P. Ginsburg of Teachers College, Columbia University, for his graduate course on the development of mathematical thinking in young children. The VITAL pedagogy is based on research in three areas: the psychology of mathematical thinking in young children, successful practices for adult learning, and the principles of instructional design and interactive media. This study examines the learning benefits of flexible access to digital video and tools for analyzing video content, and the broader implications of the VITAL pedagogy for the pre-professional development of K-12 mathematics teachers.

Numerous studies show that U.S. students underperform on international mathematics tests as early as kindergarten (Stevenson, Lee, & Stigler, 1986), first grade (Stevenson et al., 1990), and fourth grade (U.S. Department of Education, National Center for Education Statistics, 1997). Within the U.S., there is a disparity in mathematics achievement tied to socioeconomic status, with low-income and minority children showing lower levels of achievement than their peers (National Center for Children in Poverty, 1996; Natriello, McDill, & Pallas, 1990). Several states, including Georgia, New Jersey, New York, and Texas have responded to this disparity by introducing and expanding publicly-funded pre-kindergarten. Such an approach is consistent with national efforts to implement the No Child Left Behind Act (2001) and put programs into place to ensure that all children have equitable, high quality and challenging mathematics opportunities (NCTM, 2000). This effort has created an immediate need to put large numbers of teachers and curricula in place at the early childhood level, often with little time to prepare the former or research the latter.

Research indicates that young children enter school with a competent, informal understanding of key areas of mathematics (Ginsburg, Klein, & Starkey, 1998) and are ready to learn challenging mathematics (Greenes, 1999). Many studies indicate that high-quality education in the early grades can enhance later scholastic achievement (Bowman, Donovan, & Burns, 2001). Furthermore, the National Council of Teachers of Mathematics (NCTM) published school mathematics standards that identify specific learning objectives for very young children, revolutionizing the concept of what mathematics education means and when and where it should begin (NCTM, 1989, 2000).

Given the need to develop and improve the quality of preschool mathematics education, teachers need to be better prepared and trained. However, most current and prospective teachers are under-prepared for the challenge and teacher education programs have not responded effectively to the task. At the college level, courses in teaching early childhood mathematics are rare. On the graduate level, education students are required to take many courses on reading and pedagogy, but usually only one “math methods” course. In sum, teachers and teacher educators have had neither the time nor the resources to prepare adequately to teach mathematics to young children.

To address this need for effective teacher preparation, the Columbia Center for New Media Teaching and Learning (CCNMTL), in partnership with Prof. Herbert Ginsburg at Teachers College, Columbia University, developed a Web-based application called “Video Interactions for Teaching and Learning” (VITAL). This application supports Prof. Ginsburg’s course on children’s development of mathematical thinking by providing online access to materials and activities to deepen students’ understanding of course content and to build skills that can be used in classroom settings. Both the curriculum and the online tools are being revised and expanded for implementation at universities across the country.

The premise of Prof. Ginsburg’s course is that learning about the psychology of mathematical thinking helps education students understand how effective teaching can draw upon children’s developing understanding of mathematics. Topics range from children’s informal understanding of fundamental mathematical concepts to the implications of developmental psychology for pedagogy and curriculum.

Although VITAL is in a relatively early stage of development, its design has benefited greatly from clear pedagogical strategies and learning goals from Prof. Ginsburg’s course. The VITAL design is based on research in three areas: developmental and cognitive psychology of children's mathematical thinking, successful practices for adult learning, and the principles of instructional design and interactive media.

Developmental and cognitive psychology

The literature on the psychology of mathematical thinking underscores the importance of three themes: the "informal mathematics" that children possess on entrance to school; the ways in which children use informal mathematics to interpret and understand formal, school mathematics; and the ways in which effective mathematics education can help children to integrate informal understanding of mathematical concepts with the formal mathematics taught in school.

VITAL offers a compelling, flexible, and focused context that encourages:

(1) Analysis of mathematical thinking as part of the developmental process in early childhood with its links to language, play, and active learning (Baroody, 1987; Gelman & Gallistel, 1986; Ginsburg, 1989; Ginsburg, Cannon, Eisenband & Pappas, 2005)

(2) Exploration of the content and origins of young children's mathematical ideas in natural settings and real-world contexts (Arnold et al., 2002; Smith, 2001; Copley, 1999).

(3) In-depth study of the mathematical content that young children can master such as number relations, counting, use of symbols, spatial relations, and logical inference (Clements, Sarama & DiBiase, 2004; NCTM, 2000; Copley, 1999).

(4) Detailed clinical interview and analyses of children's interpretations of mathematical content (Ginsburg, 1997; Kaplan, et al., 2000).

(5) Examination of how deliberate and systematic teaching and assessment can contribute to the development of mathematical competence, sensible mathematical reasoning, and mastery of conventional concepts and procedures (Zur & Gelman, 2004; Copley, 1999; Fennema & Carpenter, 1996).

Adult learning

Research on adult learning favors an instructional approach in which learning activities are rooted in real life situations (Bransford et al., 1999; Lave, 1996; Bruner, 1996). Therefore, it is important for education students to use cases from everyday life as the basis for their learning (CTGV, 1993; Shulman, 1992). VITAL includes two categories of video cases that are essential for studying early childhood mathematics education: (1) specific episodes that highlight young children's mathematical thinking, such as observations of children playing and clinical interviews of children solving math problems; and (2) cases of teaching practice, which introduce education students to the complexity of classroom instruction.

Instructional technology and interactive media

Digital technologies extend and enhance the way in which students interact with and learn from video case studies. Studies on video case-based instructional approaches have found that students learn more effectively when they are given extended time and multiple opportunities to analyze and interpret cases (Flake, 2002; Derry, 2001; Beck, King & Marshall, 2002; CTGV, 1997).

VITAL extends an instructor's capacity to provide learning activities and tools for students that shape and encourage analysis and critical thought, and foster both independent study and collaboration. The main features of the environment are: (1) a "Digital Library" of course materials including videos and scholarly articles, (2) a "video viewer" that allows users to excerpt specific segments of the videos and annotate them, and (3) a "Workspace" in which users can incorporate their video segments as evidence in "multimedia essays." These essays are then published in the VITAL environment, where instructors and students can read them.

The Digital Library provides students with access to an extended library of video clips that are explicitly linked to the course syllabus. Prior to VITAL, the videos mostly resided on VHS and Hi-8 tapes that were cumbersome to show during lectures and difficult to share with students outside the classroom. With these videos digitized and always available online through VITAL, students can watch them at their convenience and as many times as they like. The ability to view and review clips lets students build understanding at their own pace and practice their observation skills in a simulated context.

VITAL takes advantage of emerging Web technologies to enable students to create, annotate, and save personal video clips, and to embed these clips directly into the body of a multimedia essay. These tools allow students to integrate video content into their writing almost as easily as a text citation, requiring that they begin to think of the videos as evidence that they can use to support their own hypotheses. These video citations also allow the instructor to verify whether students understand the concepts by assessing how effectively they summarize the content and use the clips to substantiate their theories. These tools can also aid students in practicing research skills such as naturalistic observation and clinical interviewing, which can be applied to the classroom context.

This paper offers an exploratory look at our theories about learning in the VITAL context as well as VITAL's implications for the teaching of early childhood math students. We base our analysis primarily on student surveys that asked questions about usability and work habits, along with our examination of student work completed in the VITAL environment. The results of our investigations will inform the research designs that we implement in the future as well as our concurrent revision of the VITAL application itself, in order to better support our target learning activities and goals.

Method of Instruction

Students access their assigned videos each week in the VITAL "Digital Library," through an index of videos linked to specific topics in the syllabus. The videos provide examples of children performing various mathematical tasks in naturalistic settings (e.g., free play), assessment settings (e.g., clinical interviews with a researcher), and classroom lessons led by a teacher. The videos are labeled and can be sorted according to their place in the syllabus, the child's grade level, and the setting. Figure 1 below shows a screenshot of the Digital Library.

Figure 1: Digital Library

Each week, students are required to study approximately five of these videos in addition to their readings from the course syllabus. The weekly topics include:

- Introduction, Framework and History
- Concepts in Infants and Little Children

- Counting, Cardinal Numbers, Shape and Space
- Everyday Mathematics
- Transition to Symbols
- Assessment, Clinical Interview
- Number Facts
- Calculation and Procedures
- Understanding, Constructivism and Manipulatives
- Preschool Curriculum
- Pedagogy
- Textbooks
- Educational TV and New Media

Once a student selects a video, it appears in a separate viewer window that contains tools for composing annotations and clipping excerpts of video. The student must give each clip a title, representing a shorthand description of the video's content. The student can also compose and attach notes about the clip that will help her recall the meaning she constructed/derived when it comes time for her to compose her multimedia essay. Figure 2 below shows a screenshot of the video viewer launched from the Digital Library.

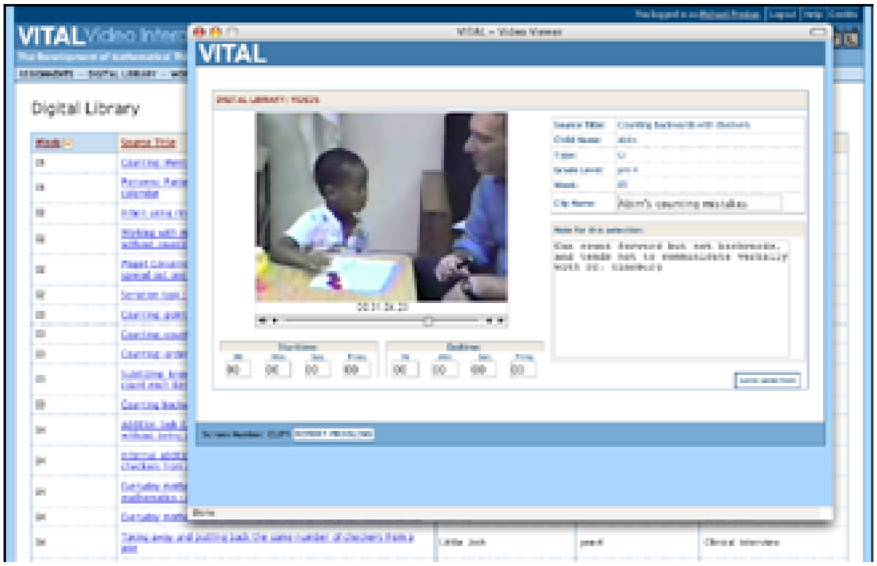

Figure 2: Video Viewer

Saved video clips are stored in the Workspace, where they are listed in an index similar to that of the Digital Library. However, the Workspace differs from the Digital Library in that it contains only clips that have been selected and annotated by the student. The Workspace also provides a multimedia essay writing space that affords text entry as well as the integration of video content as html links that point to the student's saved clips. VITAL enables students to embed clips of video directly in the text of the essay, and it is the student's responsibility to ensure that the video citation is adequately explained and supports her interpretation or argument. Figure 3 below shows a screenshot of the Workspace.

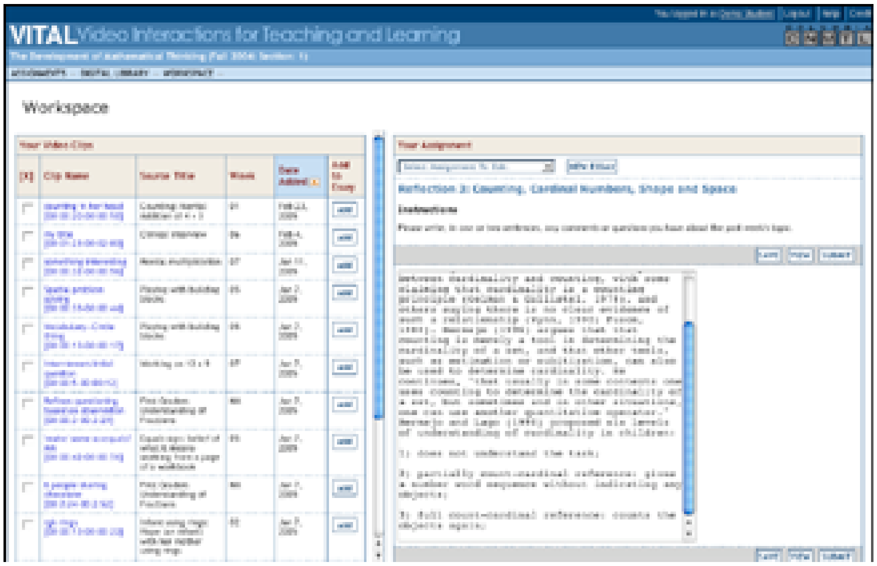

Figure 3: Workspace with Video Clips on left and Essay on right

Students use the Digital Library, video analysis tools, and Workspace to complete three types of assignments:

(1) Short multimedia essays

(2) Guided video-based lessons

(3) A final project, in multimedia essay format

Students who enrolled in “The Development of Mathematical Thinking” in fall 2004 completed six assignments and three guided video lessons in VITAL over 15 weeks. They also completed a final project for which they created and tested a mathematical activity and interviewed their participant about it, often throughout the process. They recorded these interactions on digital videotape, which we added to VITAL to enable the students to cite from their videos in the “results” portion of their 10-15-page research report.

Multimedia essays

Multimedia essays consist of text combined with “quoted” excerpts of digital video, embedded as links into the essay. Multimedia essays are designed to help students focus on each topic by requiring an extended reflection on and analysis of the course materials. There are several videos and readings assigned in each week of the course, along with a guiding question to help students make connections between the readings and videos. Usually the videos illustrate key concepts described in the readings. The students are asked to watch the videos carefully and excerpt the most relevant moment(s) in order to respond to the question or to support the thesis proposed in their essay. VITAL provides tools for reviewing, annotating, and clipping the videos, and for drafting essays with embedded video clips created by students. Students can publish their essays within the VITAL environment and thereby share their work with the instructor and other students. Figure 4 below shows a screenshot of a student's multimedia essay, including a video clip launched from a link embedded in the essay text.

Figure 4: Completed Multimedia Essay with Video

Video lessons

Video lessons consist of a series of screens that requires students to respond to specific video clips and questions. They are designed to help students develop the skills of naturalistic observation and clinical interviewing, fundamental psychological research techniques that can be useful in helping students to learn about children's thinking and learning. During the term, students must complete three video lessons in preparation for the live clinical interview that they will conduct for their final project. The structure of the video lessons creates a more guided experience than the multimedia essays. As the student watches an interview, the video pauses, and the student is prompted to make an assessment of the situation he/she is viewing. The video lessons require the student to analyze the interviewer's techniques and to make and support hypotheses concerning the interviewee's behavior. Figure 5 below shows a screenshot from a video lesson.

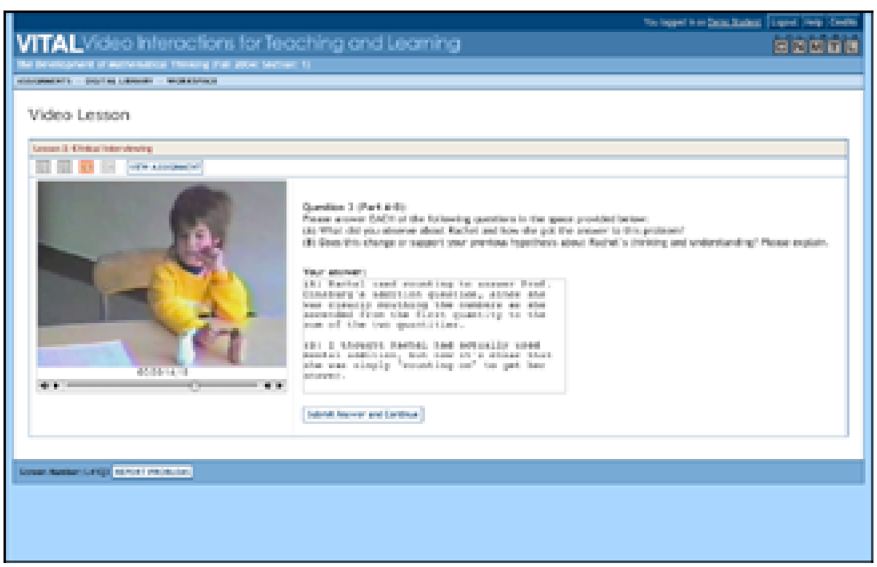

Figure 5: Screen from a Video Lesson

Final projects

The culminating activity for the semester is an independent research project with a report written in VITAL incorporating student-produced video clips that have been added to the Digital Library. For this final project, the students must design a mathematical activity and videotape themselves carrying it out with a child and interviewing the child afterwards. The project gives students an opportunity to integrate the various strands of the course in a single project: selecting a particular psychological topic to investigate, developing an instructional activity based on theory, implementing the activity, using clinical interviewing techniques to assess the child's understanding, and completing an analysis in VITAL using the video as evidence to support the student's original hypothesis.

The act of videotaping and analyzing one's own teaching and interviewing brings home the seriousness of these activities as well as their relationship to the course readings. The final projects are in one sense an extension of the assignments, but in another are distinctive because for many students the projects represent the first time they have had to produce something original, to put their own behavior on the line, and to relate their practice to an academic content and context. The use of video makes this process more salient and immediate than simply writing a traditional paper. An analysis of students' final projects will be a priority for future research on the learning outcomes with respect to both the comprehension of course content and various methodological approaches to teaching and assessment.

Participants

Participants in the VITAL study are the 30-40 Teachers College students per semester who have enrolled in the course in the past three years. Students who take the course are generally pre-service teachers pursuing Masters degrees in early childhood or mathematics education, although the course also draws students from the psychology and instructional technology programs. Most students (approximately two-thirds) who complete the course will go on to teach in the early grades, pre-K through third.

Research Questions

VITAL engages students in a number of activities that were previously not possible in the course. First, now that students can view the course's video content via the Web, they are no longer limited to in-class viewing or going out of their way to borrow video cassettes from the instructor. Second, tools for analyzing the videos were designed to teach students to observe carefully and to use their observations as evidence to support their interpretations of the video. Third, the VITAL environment supports an ongoing dialogue among students and the instructor that extends the learning experience outside the classroom and helps the instructor better assess the students' progress.

These affordances informed our initial research questions:

(1) Does flexible access to video cases improve students' ability to comprehend the psychological and educational content of the course?

(2) Do tools for analyzing video content help students develop critical thinking skills and apply them to the understanding of psychological and educational theory and methodology?

(3) Do asynchronous, Web-based interactions improve the quality of classroom discussion and other face-to-face interactions for students and instructors?

Discussion

(1) Does flexible access to video cases improve students' ability to comprehend the psychological and educational content of the course?

Research has documented the value of video for instruction, specifically for teacher training (Schrader et al., 2003; Masingila & Doerr, 2002; Lampert & Ball, 1996; Copeland & Decker, 1996). We are interested in knowing whether the content and structure of the Digital Library helps students understand the course's key concepts, and whether the videos alone play a meaningful role in helping students link the concepts to classroom practice. "Teachers of young students … need to be knowledgeable about the many ways students learn mathematics, and they need to have high expectations for what can be learned during these early years" (NCTM, 2000). Students should leave the course not only with a sophisticated understanding of early mathematical thinking, but should be able to use it in their everyday practice.

Students were highly positive about having the ability to watch the videos at home, at any time, and as often as they choose. Most students:

- Watched every video in the Digital Library (80%)
- Watched the videos more than once (92%)
- Felt that the videos helped them to understand the course content (96%)
- Helped them to remember the concepts (89%)
- Helped them relate the concepts to their own practice (80%)

Regarding the final point, we would like to examine more closely the transfer of conceptual understanding to the actual classroom practice of teachers. Until we are able to conduct a longitudinal study of program graduates who become early childhood teachers, however, we must rely on students' self-reporting. In the fall 2004 course, most students either agreed or strongly agreed with the following statements about the videos:

- Illustrate the concepts I read about (100%)
- Teach me how to observe children (100%)

- Model techniques for interacting with children (92%)
- Open my mind about what children can do (88%)
- Give me new ideas for teaching (77%)

These results give us an early indication that VITAL improves comprehension (“watching videos helps me understand the course content better”), retention (“watching videos helps me remember the concepts”), and transfer (“watching videos helps me relate the concepts to my own practice”). Beginning with the fall 2005 implementation of the course with VITAL, we plan to test these concepts more rigorously with a series of pre- and post-tests on the material.

(2) Do tools for analyzing video content help students develop critical thinking skills and apply them to the understanding of psychological and educational theory and methodology?

We are interested in assessing whether VITAL’s tools for video analysis promote the acquisition of evidence and critical thinking skills, specifically with regard to how that evidence is used. There is currently a trend toward applying evidence-based assessment skills in the classroom: “Teachers need to determine what students already know and what they still have to learn. Information from a wide variety of classroom assessments … helps teachers plan meaningful tasks that offer support for students whose understandings are not yet complete and helps teachers challenge students who are ready to grapple with new problems and ideas” (NCTM 2000). At the early childhood level, one major curriculum, Creative Curriculum, (Dodge, Colker & Heroman, 2002) requires teachers to observe individual children carefully in order to develop appropriate learning activities for them.

We argue that in order to make assessments based on evidence, teachers need practice in observing children and analyzing their understanding of subject matter, so that they can then make decisions about how to guide learning in the moment. Because VITAL requires students to utilize observations rather than simply theorize from readings, we hypothesize that they will become more accustomed to obtaining evidence and using critical thinking skills to use evidence to support decision-making.

We hypothesize that the video analysis portion of writing essays in VITAL helps train students to be good observers by requiring them to look closely and describe back what they see. More than half of the students from the fall 2004 course reported that the selection of specific clips within each assigned video helped them to focus on the content of the videos (66%). They felt that the naming of their clips also contributed in this regard (77%), which indicates to us that the active process of summarizing clip content into titles is an important part of meaning construction. Students also reported that knowing that they would be using these clips in their essays changed how they watched the videos (73%).

We define critical thinking as the ability to reason about the evidence obtained so as to formulate and discuss hypotheses that could explain the evidence (Kuhn, 1999). Students using VITAL should learn to obtain (and respect) relevant evidence, and to use critical thinking skills to develop, analyze, and debate theories about children's mathematical thinking and learning. The design of the environment should encourage students to acquire and assess evidence with the intention of using it to support an argument or thesis. We measure students' use of evidence in terms of their tendency to make relevant observations in their essays in the form of video clip selections or descriptions of children's behavior from readings or personal experiences, and to cite these observations in support of an argument.

In a preliminary qualitative analysis of eight students' essays over one semester (eight essays each) we developed codes to categorize the ways that students used observations of children's mathematical thinking to write essays. Most of these observations came from the digital videos; however, we also looked for references to children they read about or with whom they had personal interactions. We identified three different ways that students used observations from videos in their essays: "evidence," "analysis," and "connection." Next, we developed more detailed criteria for each category, devising "levels" for connection that vary in terms of complexity and flexibility of thinking. The categories and their levels are specified below:

- Evidence: Reference to a clip or observation to support an argument or statement about children's behavior and/or thinking in general

  Ex: *"Most young children believe that the order in which you count matters. For example, Alexander believed that in counting the hot dogs you had to start at an end, or some would have been 'skipped'."*

- Analysis (of one observation)

  Level 1: Description of child's behavior only

  Ex: *"The following clip shows a child writing the number 5, and she writes it backwards."*

  Level 2: Interpretation of child's ability or beliefs based on behavior

  Ex: *"Tammy believed that the equal sign means 'the end is coming up'... Therefore, to her the equal sign should be placed towards the end of the sentence not the beginning because equal sign means 'the end is coming up'."*

  Level 3: Questioning behavior (e.g., Why did s/he do that?), without a proposed hypothesis/explanation

  Ex: *"...He has obviously created his own rules, but why does he also seem to break them? He consistently writes numbers such as "twenty-one" and "thirty-*

one" as "201, 301." Why does he shift when writing "eighty-four" to "814?" And even more interestingly, why doesn't he write a number in the hundreds with several zeros, such as "100204" for "one hundred twenty-four" instead of "1204" as he writes?"

Level 4: Interpretation of child's level of understanding based on behavior, abilities, and/or beliefs; presentation of one hypothesis

Ex: "I find the clip with Josh very interesting… For a moment there he appeared to understand that there was five checkers when the one was taken away and then placed back. However, he didn't really understand the concept because he wasn't able to do this again. Furthermore, he counted seven (actual was six) and when two was taken away and replaced back, he then counted six as the total; he was not puzzled by his answer. ***To me this demonstrated he didn't understand that subtraction can be reversed by addition****."* (emphasis added)

Level 5: Presentation of at least two hypotheses to explain an observation

Ex: *"What makes Alexander think that one can only count a row of objects from one end or the other? ... To him, the activity of counting entails starting from the '1st' hotdog. Is this simply* ***a question of the order of the activity or does it imply that for him the action of counting is recognizing an intrinsic numerical attribute of those objects on the edges of the set?****"* (emphasis added)

Level 6: Suggestion for another task

Ex: *"...Samantha believed that the same group of candies could be represented by 2 different numbers. She came to a different number when counting again, but the disagreement did not concern her.* ***If Samantha had been counting***

something where the outcome was significant to her (days until her birthday), would she have accepted the different outcomes?" (emphasis added)

- Connection (of two or more observations; i.e., video and video; video and reading; video and personal experience)

    Level 1: Mention of similarity only (e.g., "This is similar to such and such…")

        Ex: *"In the same way that children make errors in counting in English (80, 90, tenny), my cousin (pre-k) made similar errors in learning the numbers in Italian."*

    Level 2: Comparing and contrasting the two (or more) situations

        Ex: "*In the text, the child refused to believe that there were five ducks in a row because they were in the wrong arrangement. Another boy in the videos immediately recognized the number of five object on sight, even though they didn't seem to be arranged in an ordered pattern. Has this boy reached a step in number understanding that the first boy has not? I wonder if the first boy, as we discussed last week, is yet able to separate the ideas of relative size and relative number. I predict that the second boy has reached this stage."*

We found that students actually made fewer video clips in later assignments than in earlier ones, but, based on student feedback, it appears that students simply grew weary of the cumbersomeness of the clipping process and preferred to cite visual evidence with verbal descriptions. While we are working to improve the usability of the clipping tool, we also feel that its more extensive use early on in the course helps introduce students to the methods of close observation, which they continue to apply later in the course even when they make fewer video clips. In addition, the weekly topics gradually transition from developmental psychology to instructional implications (although there are elements of both throughout the course), which may encourage different kinds of approaches to essay writing. In the instructional weeks, students tend to focus more on developing and defending their own theories than describing observed phenomena. Our challenge is to help them make connections between the two throughout the course.

(3) Do asynchronous, Web-based interactions, such the online submission of student work and instructor feedback, improve the quality of classroom discussion and other face-to-face interactions for students and instructors?

The introduction of VITAL to the course created an ongoing, asynchronous dialogue between the instructor and the students. This dialogue took place across online and offline interactions, and repeated cyclically in each week of the course:

(1) Students completed an assignment and "published" it in VITAL
(2) These assignments were graded with comments by the instructor and/or TAs
(3) The instructor gave a lecture citing from and incorporating his feedback on student assignments
(4) Students reflected on what they had learned during the week and "published" their reflections in VITAL after the class session
(5) The instructor began the following week's session with references to interesting student reflections

VITAL creates a mechanism for continuous feedback between the instructor and students that would not otherwise be available in a large lecture course with a midterm and a final paper. This feedback turned out to be highly motivating for students because they knew that their assignments and reflections would be read, feedback would be given, and any interesting points they raised might be addressed during lecture. The instructor also benefited from a continuous flow of information from the students, which enabled him to assess their understanding and address their misconceptions and provide timely feedback. The flow of information also enabled him to be more responsive to specific questions and to adapt his teaching to accommodate the students' unique concerns and interests.

To summarize the impact of VITAL on the course:

(1) The general level of in-class discussion was raised because students had the opportunity to watch the videos in advance of the class meeting, and they usually watched them repeatedly, as our survey results show.

(2) The in-class discussion of the videos was deeper, particularly when students were required to complete an assignment (either a multimedia essay or a guided video lesson). Before VITAL, students saw videos for the first (and only) time during class.

(3) The instructor was able to assess student knowledge via the assignments before class and adjust his lecture accordingly, or even cite from student assignments to address interesting ideas or common misconceptions.

(4) The instructor received feedback from the students at the conclusion of each week, which helped shape the following week's lecture as well as future implementations of the course.

VITAL is more than a constructivist learning environment for students; it is also a space in which instructors can engage in sort of asynchronous clinical interview with students in order to assess their learning, provide feedback, and tailor their instruction in response to an ongoing record of student progress.

Conclusion

Before VITAL, the primary sources for a course on mathematical thinking—and many other courses—were texts such as articles, essays, and textbooks. VITAL has transformed text-based modes of study by offering videos as primary "texts," engaging students in the act of close observation, and helping them develop skills for acquiring and evaluating evidence from observed phenomena.

VITAL has also enhanced the course experience for both instructors and students, creating new channels for feedback in both directions. In addition to its potential for motivating students, VITAL gives instructors key insights into students' understanding of the material and performance on tasks. The final project in particular enables instructors to critique students' fieldwork without having to accompany them into classrooms. The modeling of pedagogical and research techniques, the guided lessons, and the students' active synthesis in their final projects promote the transfer of course concepts to actual practice.

VITAL leads us to new theories about student learning in the context of interactive multimedia environments, as well as new promising practices for the professional development of pre- and in-service teachers. Over the next four years, we intend to expand the use of VITAL to new contexts and new audiences, and to test more rigorously these new theories and practices.

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