Developing New Tools for Video Analysis and Communication to Promote Critical Thinking

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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 paper reports on the learning benefits of tools for analyzing and communicating about video content.

Video Interactions for Teaching and Learning (VITAL) is a Web-based application we developed in 2002-2003 for a graduate level education course on the development of mathematical thinking in young children. The course covers topics ranging from children's informal understanding of basic mathematical concepts to the implications of developmental psychology for formal pedagogy and curriculum. The course is based on the premise that teachers can teach more effectively if they understand and can build upon the mathematics that children have already learned from an early age, with or without limited instruction. Students taking the course learn (1) theories of developmental psychology as they pertain to mathematics, and (2) specific techniques adapted from psychology research, such as naturalistic observation and clinical interviewing. The challenge of the course is to help teachers integrate these theories and techniques into their classroom practice.

The primary function of VITAL is to support the course goals by providing students with access to primary source materials and tools for independent study. The main features of the VITAL environment are (1) a "Digital Library" of course materials including videos and scholarly articles, (2) a video viewing tool that allows students to clip, record notes, and save specific segments of the videos, and (3) a "Workspace" in which students can write "multimedia essays" that incorporate video clips as evidence that supports personal theories about teaching and learning. The multimedia essays are published in VITAL, where the instructor and other students can read them.

One major focus of our research is to determine whether VITAL's tools for video analysis help students to construct meaning from the course material. To the student, the purpose of video clipping is to enable them to use their selections as supporting evidence in multimedia essays, which are required for the course. However, we hypothesize that prior to writing their essays, students gain important insights from their interactions with the videos, a process that involves several meaning-making steps such as excerpting specific clips, naming them, and attaching notes. The writing of the multimedia essay is essential to the learning experience, but we are also interested in examining how interactions with the videos help students learn to observe more closely, acquire an understanding of key concepts, and become familiar with the methods we recommend that they adopt in their classrooms.

Background

The Columbia Center for New Media Teaching and Learning (CCNMTL) developed VITAL in partnership with Prof. Herbert Ginsburg at Teachers College, Columbia University, to support his course on children's development of mathematical thinking. The premise of the 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. 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 (Baroody 1987; Gelman & Gallistel 1986; Ginsburg 1989); the ways in which children use informal mathematics to interpret and understand formal, school mathematics (Arnold et al. 2002; Smith 2001; Copley 1999); 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 (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. 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.

Project Development

A number of key educational goals informed the design of VITAL. Most importantly, the environment had to help future teachers learn to observe children's behavior more closely in order to make informed decisions about teaching. VITAL therefore had to train students to view video carefully, to find evidence, and to be able to cite and describe this evidence explicitly. Our initial thinking about VITAL had been based on a previous technology we had developed which enabled students to select clips of videos and embed them in a discussion board. However, the educational requirements of the VITAL project clearly necessitated a departure from the discussion framework, in order to promote independent study, close viewing, and deeper reflection.

Another requirement that informed our design was the need to make the VITAL environment specific to each student. The environment had to be personalized so that students could securely access their own stored video clips and annotations. We decided to expand upon an emerging trend in Web site development of creating a virtual space for each student's assets (videos clips, annotations, essays) by introducing the notion of student "bins" that stored their artifacts. To support the bins and to store persistent information about the student, we backed the learning environment with a relational database (IBM DB2). By storing student artifacts within a database, we enabled each student to create a persistent portfolio and also allowed administrators to more easily analyze their work. See Fig. 1 for a screenshot of the Workspace, where students access and manage their stored artifacts.

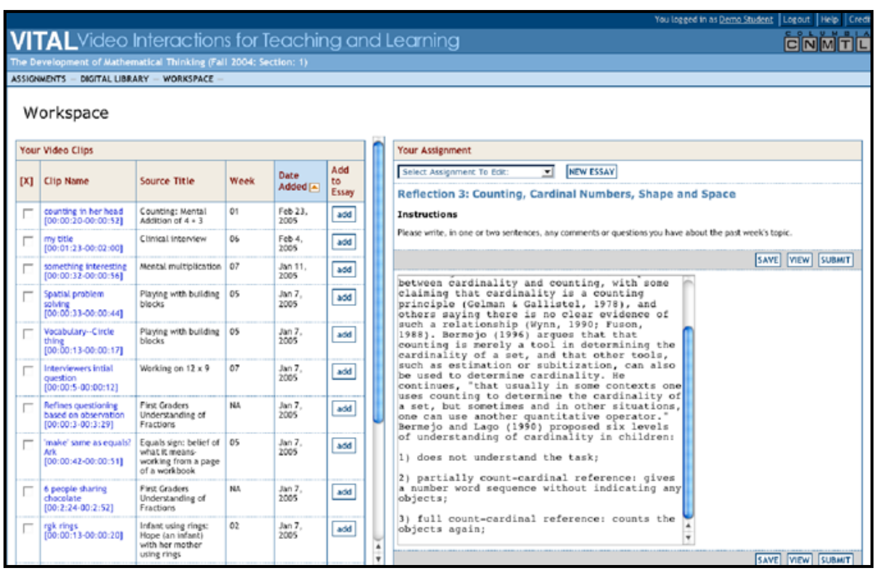

Figure 1: Workspace with Video Clips on left and Essay on right

A third requirement was to provide an extensive archive of primary source materials in an easily accessible format. Video assets were collected, digitized, grouped by topic, and tagged with descriptors. These assets were organized in a "Digital Library," essentially a table of video asset metadata that can be sorted on relevant categories such as the grade level of the research subject and the category of the video content. Each of the videos in the Digital Library contains a running time code that allows the student to specify "start" and "end" points in order to capture a moment of interest. After marking the time codes, the clip can be named, notes recorded, and the clip's time codes are stored in the student's personal database. The student can replay these clips at any time and view their notes on the clip. See Fig. 2.

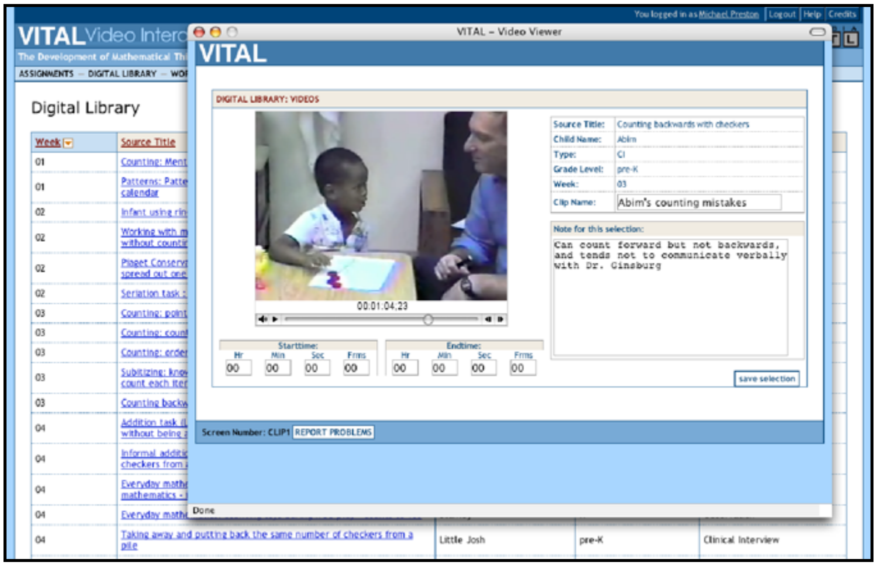

Figure 2: Video Viewer

The software that makes up the learning environment was chosen based on the both curriculum and the Internet distribution model. The application development environment (J2EE/JSP/Tomcat) combined with the relational database allowed us to create dynamic Web pages with rich content as well as thoughtful presentation layer for the learner. This technical framework created a simple division of labor for the development team consisting of: programmers (2), a Web designer, and a project manager. Using storyboards developed by the project manager, the development team worked closely with each other and the project manager. Incorporating agile development techniques such as continuous integration and nightly builds, the team was able to deliver a final product that was on time and under budget.

The VITAL environment affords two types of assignments: multimedia essays that incorporate student-selected video clips as evidence, and video lessons that provide students with guided training in specific techniques. At the end of the semester, students produce an extended multimedia essay in which they must demonstrate mastery of the course content and the techniques illustrated by the video lessons.

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. See Fig. 3.

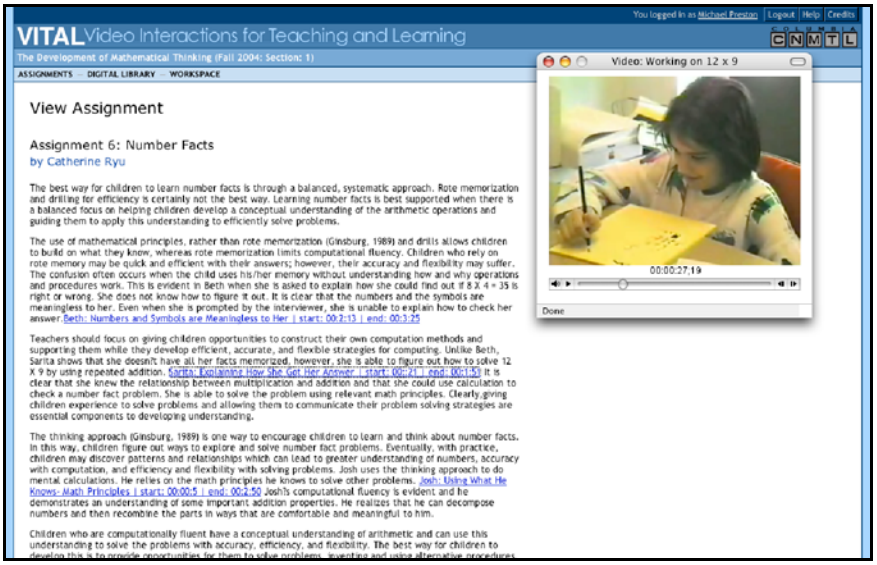

Figure 3: Completed Multimedia Essay with Video

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. See Fig. 4.

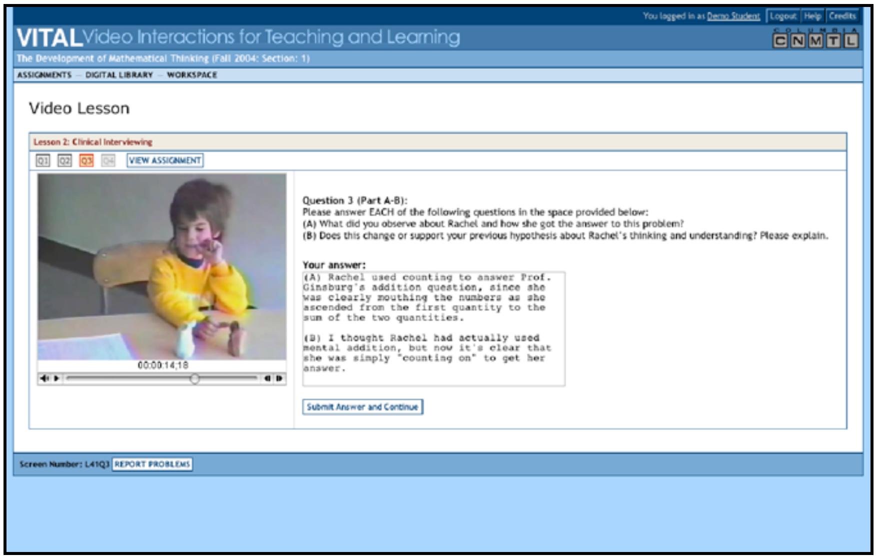

Figure 4: Screen from a Video Lesson

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.

Results

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.

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.

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

References

Arnold, D. H., Fisher, P. H., Doctoroff, G. L., & Dobbs, J. (2002). Accelerating math development in Head Start classrooms. *Journal of Educational Psychology, 99*, 763–770.

Baroody, A. J. (1987). *Children's mathematical thinking: A developmental framework for preschool, primary, and special education teachers*. New York: Teachers College Press.

Beck, R.; King, A., & Marshall, S. (2002). Effects of videocase construction on preservice teachers' observations of teaching. *The Journal of Experimental Education, 70*, 345–361.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (1999). *How people learn: Brain, mind, experience and school.* Washington, DC: National Academy Press.

Bruner, J. S. (1996). *The culture of education.* Cambridge, Mass: Harvard University Press.

Cognition & Technology Group at Vanderbilt. (1993). Anchored instruction and situated cognition revisited. *Educational Technology, 33*, 52– 70.

Cognition & Technology Group at Vanderbilt. (1997). The Jasper Project: Lessons in curriculum, instruction, assessment, and professional development. Mahwah, NJ: Lawrence Erlbaum.

Copley, J. V. (Ed.). (1999). *Mathematics in the early years.* Reston, VA: National Council of Teachers of Mathematics.

Derry, S., & the STEP Team. (2001). The STEP system for collaborative case-based teachers education: Design, evaluation, and future direction. Available at: http://newmedia.colorado.edu/cscl/264.pdf

Dodge, D. T., Colker, L., & Heroman, C. (2002). *The creative curriculum for preschool* (4th ed.). Washington, DC: Teaching Strategies, Inc.

Fennema, E., & Carpenter, T. P. (1996). A longitudinal study of learning to use children's thinking in mathematics instruction. *Journal for Research in Mathematics Education, 27*, 403–434.

Flake, J. (2002). Using videos and virtual learning environments to help prospective teachers construct meaning about children's mathematical thinking. *Journal of Computers in Mathematics and Science Teaching*, *21*, 33–51.

Gelman, R., & Gallistel, C. R. (1986). *The child's understanding of number.* Cambridge, MA: Harvard University Press.

Ginsburg, H. P. (1989). *Children's arithmetic: How they learn it and how you teach it* (2nd ed.). Austin, TX: Pro Ed.

Kuhn, D. (1999). A developmental model of critical thinking. *Educational Researcher*, 28, 16-25, 46.

Lave, J. (1996). Teaching, as learning, in practice. *Mind, Culture, and Activity: An International Journal*, *3*, 149–164.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

Shulman, L. S. (1992). Toward a pedagogy of cases. In J. Shulman (Ed.), *Case methods in teacher education* (pp. 1–30). New York: Teachers College Press.

Smith, S. S. (2001). *Early childhood mathematics* (2nd ed.). Boston, MA: Allyn and Bacon.

Zur, O., & Gelman, R. (2004). Young children can add and subtract by predicting and checking. *Early Childhood Research Quarterly, 19*(1), 121-137.

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