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

1. Project summary

This paper discusses a Web application called Video Interactions for Teaching and Learning (VITAL). We first developed VITAL for a graduate level education course on the development of mathematical thinking in young children, covering 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. The course aims to introduce teachers to (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 these goals by providing access to primary source materials and tools for independent study. The main features of the environment are (1) a "Digital Library" of course materials including videos and scholarly articles, (2) a video viewing tool that allows users to clip, record notes, and save specific segments of the videos, and (3) a workspace in which users can write "multimedia essays" that incorporate video clips as evidence that supports personal theories about teaching and learning. The multimedia essays are published in the VITAL environment, where the instructor and other students can read them.

2. Major goals

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 selecting "start "and "end" points, naming the clip, and annotating it. While the writing of the multimedia essay is essential to the learning experience, we are 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.

3. Research foundations

The design of the VITAL environment has been informed by three areas of research: (1) developmental and cognitive psychology, (2) adult learning, and (3) instructional design theory.

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.

The course is based on the following research findings: (1) robust and surprisingly effective mathematical thinking develops in the years before school (Ginsburg, Klein, & Starkey, 1998); (2) children use their already existing informal knowledge of mathematics as a basis for assimilating school mathematics (Baroody, 1987); (3) effective mathematics education needs to help children integrate their informal (often incomplete and sometimes incorrect) understanding of mathematics with what needs to be learned in school (Resnick, 1989, 1992); and (4) the mathematical abilities of low-income and minority students are often poorly appreciated (Ginsburg, 1986). One of the major messages of VITAL is that all children, including low-income and minority children, are capable of learning mathematics; that teachers need to recognize and appreciate these children's abilities; and that mathematics education needs to build upon the children's strengths.

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

(1) Analysis of mathematical thinking as part of the developmental process in early childhood with its links to language, play, and active learning (Copley, 1999).
(2) Exploration of the content and origins of young children's mathematical ideas in natural settings and real-world contexts (Arnold et al, 2002; Copley, 1999; Smith, 2001).
(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 (Copley, 1999; NCTM, 2000).
(4) Detailed observation 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 and mastery of conventional concepts and procedures (see 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 beneficial for teachers to use cases from everyday life as the content of their curricular activities (CTGV, 1993; Shulman, 1992). VITAL includes two categories of video cases that are essential for studying early childhood mathematics education: (1) specific episodes in the development of 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 demonstrate complexity of both one-on-one and classroom interactions.

Instructional technology and interactive media: Digital technologies extend and enhance the way in which students interact with and learn from video case studies. Studies that focused 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 the capacity of an instructor of mathematics education to provide learning activities and tools for teachers that shape and encourage analysis and critical thought. VITAL enables students to create, annotate, and save customized segments of source videos in a personal workspace, and to embed their clips directly into the body of an essay by generating an html link to their video clip. This combination of tools allows users to cite concrete video evidence in support of their ideas, which in turn allows the instructor to verify whether users understand the concepts discussed in their essays.

4. Technical background

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 users 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 users 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 reflection, rather than on a dialogue with other users based on potentially less reflective responses to video.

Another requirement that informed our design was the need to make the VITAL environment specific to each user. The environment had to be personalized so that users 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 user's assets (videos clips, annotations, essays) by introducing the notion of user "bins" that stored their artifacts. To support the bins and to store persistent information about the user, we backed the learning environment with a relational database (IBM DB2). By storing user artifacts within a database, we enabled each user to create a persistent portfolio and also allowed administrators to more easily analyze their work (see Figure A for a screenshot of the Workspace, where users access and manage their stored artifacts).

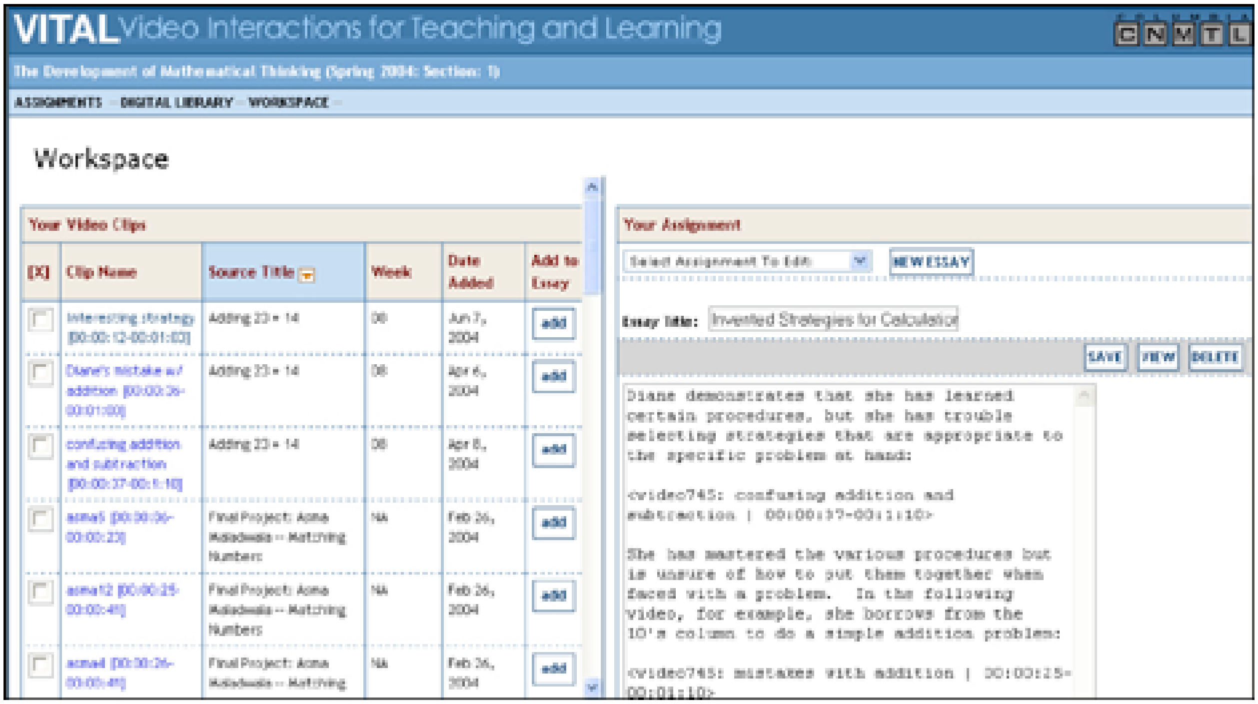
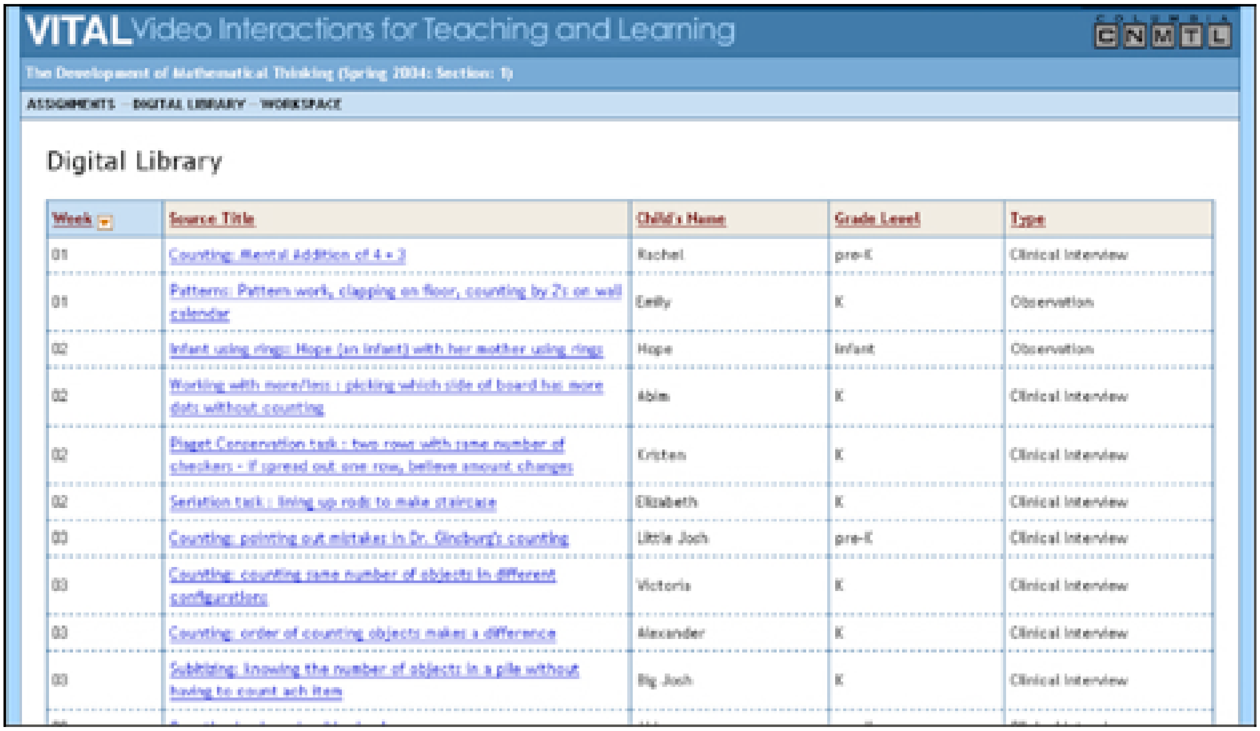


Figure A: Workspace

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" (see Figure B), 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 (observation, clinical interview, etc.).



Week	Source Title	Child's Name	Grade Level	Type
01	Counting: Mental Addition of 4 + 3	Rachel	pre-K	Clinical Interview
01	Patterns: Pattern work, clapping on floor, counting by 2's on wall calendar	Emily	K	Observation
02	Infant using rings: Hope (an infant) with her mother using rings	Hope	Infant	Observation
02	Working with more/less : picking which side of board has more dots without counting	Abim	K	Clinical Interview
02	Piaget Conservation task : two rows with same number of checkers - if spread out one row, believe amount changes	Kristen	K	Clinical Interview
02	Seriation task : lining up rods to make staircase	Elizabeth	K	Clinical Interview
03	Counting: pointing out mistakes in Dr. Ginsburg's counting	Little Josh	pre-K	Clinical Interview
03	Counting: counting same number of objects in different configurations	Victoria	K	Clinical Interview
03	Counting: order of counting objects makes a difference	Alexander	K	Clinical Interview
03	Subitizing: knowing the number of objects in a pile without having to count ach item	Big Josh	K	Clinical Interview

Figure B: Digital Library

To see a sample of the videos contained in the Digital Library, please visit http://ccnmtl.columbia.edu/vital/nsf/ (requires a high-speed connection and the most recent version of the QuickTime player).

Each of the videos in the Digital Library contains a running time code that allows the user 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 user's personal database. The user can replay these clips at any time and view their notes on the clip (see Figure C).

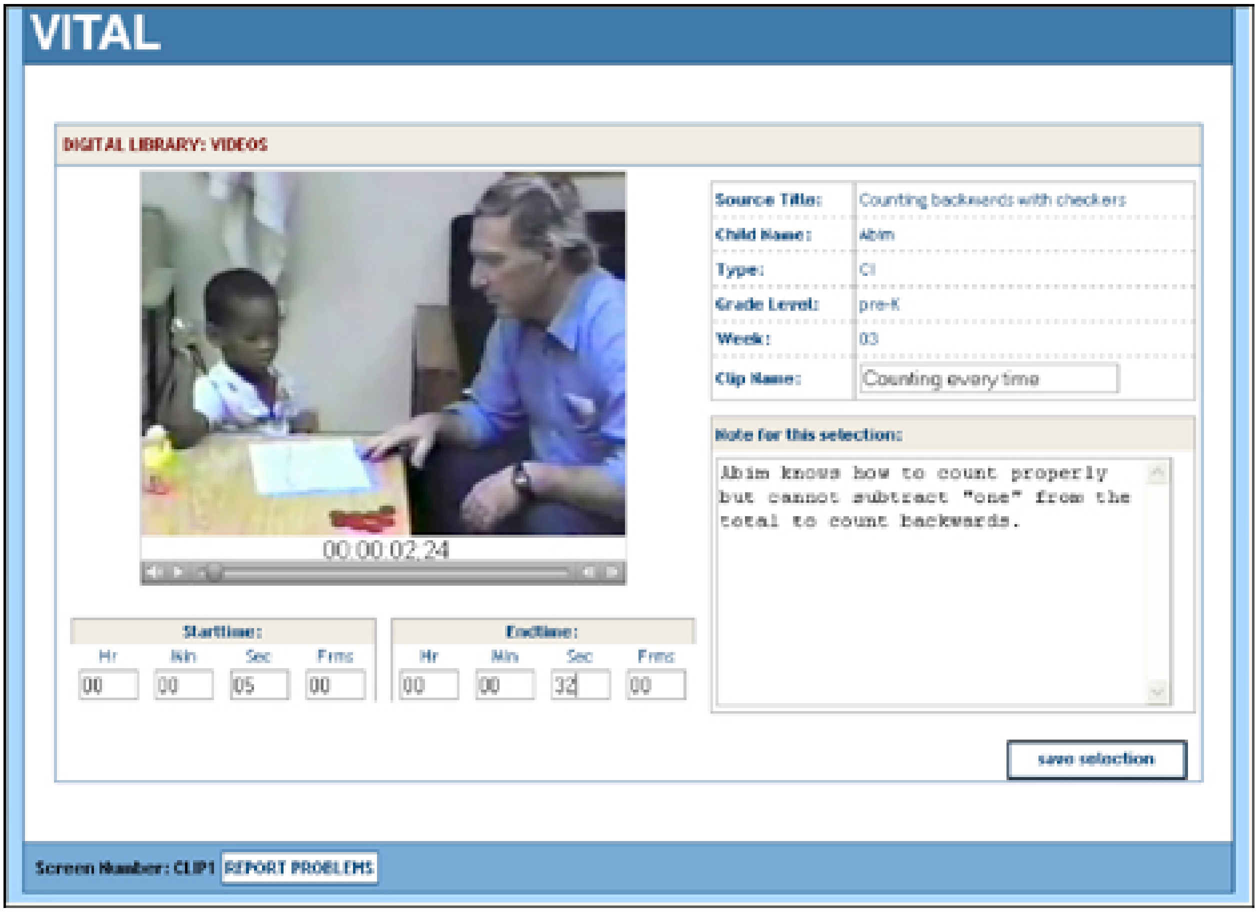


Figure C: Video Viewer

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 educational technologist, 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.

5. Experimental validation

In spring 2003, we implemented the pilot version of VITAL with approximately 40 pre-service teachers and graduate students in related fields. We conducted a preliminary investigation to learn how well the VITAL system functioned (usability), how users engaged with the system, and how effectively it promoted learning. We collected a variety of quantitative and qualitative data about users' learning experiences and outcomes, and the impact of the VITAL design. Based on these results, we are focusing our current research on the specific processes in which users engage with the environment and whether the processes contribute to (or detract from) learning.

Our preliminary findings include:

(1) Flexible access to course materials improved learning.

Providing users with access to the videos turned out to be one of the most popular and useful features. Users were universally positive about having the ability to watch the videos wherever and whenever they chose. They found the videos to be critical for understanding the course content. Regarding the video content, one user wrote: "The videos helped to bring the readings to life." In response to the question "How helpful were the videos in the Digital Library in terms of allowing you to understand the topic of the class each week?" the majority of users responded "very helpful." (On a 1-5 scale where 1 was "very helpful" and 5 was "not helpful," M=1.33, S=0.53.)

Users were also better prepared for lecture each week than in past instances of the course. When the instructor reviewed the videos during lecture, users were ready to discuss them in detail because they were already quite familiar with the content. They also had more time to formulate their own interpretations before class, which can be attributed to variables such as flexible access to the videos and tools for annotating video clips and writing essays. Our current research focuses on specific practices related to video viewing and analysis, to better understand how these tools promote analysis and facilitate critical thinking.

(2) Creating video clips helped teach observation skills and course content.

Users learned very quickly how to excerpt video clips and write essays. They rated the process to be "helpful" for understanding the course content. (M=2.05, S=1.00) The writing of essays was deemed "helpful" to "somewhat helpful" for preparing to attend lecture each week. (M=2.33, S=0.98)

A significant number of users (14 of 39) felt that writing the essays was helpful. Users also appreciated the ability to view, excerpt, and annotate the videos in the library. Nearly all of the users embedded videos in their essays, and many users easily integrated the video content, with explanatory text that demonstrated an understanding of the video clips' meaning. Some users eventually abandoned the video embedding process in favor of text-only citations of video, because embedding clips involved too many steps: clipping a video in one screen, accessing it in another, inserting the clip as a link into the essay, and then moving the link to the appropriate place. However, we hypothesize that these many steps contributed to the learning process, and the clips themselves (including start and end time codes, clip names, and annotations) represent learning artifacts that are equally important to the multimedia essays.

(3) Assignments and reflections created an ongoing dialogue with the instructor.

An unanticipated, positive outcome of the intervention was the development of an asynchronous dialogue between the instructor and the users. This dialogue was conducted both online and offline in the following sequence, in each week of the course:

1. Users completed an assignment and "published" it in VITAL
2. The instructor gave a lecture incorporating his feedback on user assignments
3. Users reflected on what they had learned during the week and "published" their reflections within a day after the class session
4. The instructor began the next week's session with some comments on interesting reflections

The cycle of activities was highly motivational for the users, who knew that their assignments and reflections would be read and possibly addressed during lecture. The instructor also benefited, as he had a better sense of what users understood (and did not understand), as well as their unique concerns as representatives of different fields. He was able to be more responsive to specific concerns and to how different readings, videos, and lectures were received.

6. Future work and implications for others

The results of our investigation, including data collection and analysis from the Fall 2004 course instance, will (1) help us to improve VITAL and create a model course for other universities across the country, addressing the need for teacher professional development in mathematics for the early grades; and (2) enrich the conversation about the purposeful use of digital technologies in professional education in the educational community at large. These are also the objectives of a five-year, NSF-funded project that we initiated this summer.

We are also concurrently redeveloping VITAL to accommodate other courses at the university that rely on the close viewing and analysis of video, including disciplines ranging from social work to the history of dance.

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