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ABSTRACT

Classroom with a View (CView) is an interactive multimedia environment designed to provide students with opportunities to observe, discuss, and analyze classroom practice in a mediated environment in which students work in pairs exploring a database of videotaped mathematics and science lessons. CView was designed using a description of the teacher's role in a constructivist mathematics class, cognitive flexibility theory, metacognitive theory, constructivist learning theory, and conceptual change theory. This environment was studied over a ten week period in four methods classrooms. Students indicated that three of the four conditions precipitating conceptual change--intelligibility, plausibility, and fruitfulness--were met by working in the environment. CView was found to support student learning in ways parallel to the support a constructivist oriented teacher would offer children. Results indicated that the integrated content, structure, and tools in the environment promoted students' understandings of teaching and learning. Contains 30 references. (Author)

Aspects of Interactive Multimedia Environment Supporting Beginning Mathematics and Science Teachers' Construction of Knowledge About Teaching and Learning

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Aspects of Interactive Multimedia Environment Supporting Beginning Mathematics and Science Teachers' Construction of Knowledge About Teaching and Learning

Abstract

It is difficult to provide teacher-preparation students with classroom experiences that connect constructivist learning theory to teaching practice. Classroom with a View (CView), an interactive multimedia environment, provided students with opportunities to observe, discuss, and analyze classroom practice in a mediated environment. Students worked in pairs exploring a database of videotaped mathematics and science lessons. CView was designed using a description of the teacher's role in a constructivist mathematics class (Cobb et al., 1991), cognitive flexibility theory (Spiro & Jehng, 1993), metacognitive theory (Schoenfeld, 1992), constructivist learning theory (Cobb, 1994a), and conceptual change theory (Stofflett, 1994). The environment was studied over a ten week period in four methods classrooms.

Students indicated that three of the four conditions precipitating conceptual change--intelligibility, plausibility, and fruitfulness--were met by working in the environment. CView was found to support student learning in ways parallel to the support a constructivist oriented teacher would offer children (Cobb et al., 1991). Results indicated that the integrated content, structure and tools in the environment promoted students' understandings of teaching and learning.

Aspects of Interactive Multimedia Environment Supporting Beginning Mathematics and Science Teachers' Construction of Knowledge About Teaching and Learning

Teacher educators have difficulties providing teacher-preparation students with classroom experiences connecting constructivist learning theory to teaching practice. Although contemporary thinking and reform in both mathematics and science education are grounded in constructivist learning theory (AAAS, 1993; NCTM, 1989, 1991, 1995), educators are just beginning to define a constructivist pedagogy (Brown, 1994; Simon, 1995, 1995a; Steffe & D'Ambrosio, 1995; Cobb, 1994a). This task is complicated by the multiplicity of ways teachers have reorganized their practice to reflect a constructivist orientation (Cobb, 1994) and by a lack of teachers who are implementing current reform ideas (Simon, 1995). Long-term teacher enhancement projects across the U.S. are encouraging teachers to explore constructivist learning theory and to reorient their practice from a constructivist perspective (Grouws & Schultz, in press). Researchers in these projects report that teachers are changing their practices in ways that reflect a constructivist orientation (Brown & Smith, 1994; Cobb, Wood, Yackel & McNeal, 1992; Schultz, Hart, Najee-Ullah, Nash & Jones, 1993; Shifter & Fosnot, 1993).

The Atlanta Math Project (AMP, 1990-1994) was a long-term teacher enhancement project that encouraged mathematics teachers to investigate constructivist learning theory. AMP teachers were supported in summer inservices and during the school year for four years as they changed their teaching practices to be in alignment with the National Council of Teachers of Mathematics Standards (NCTM, 1989, 1991). AMP's method of teacher enhancement was adapted to science education in the Georgia State University Center of the Georgia Initiative for

Mathematics and Science (GIMS/GSU, 1992-1997). Mathematics teachers who participated in AMP and GSU/GIMS are now in their sixth year of purposefully reflecting on and changing their teaching practice. Over time these teachers have developed individual ways of connecting constructivist learning theory to their teaching practice (Hart, 1992; Schultz, et al., 1993).

Interactive Multimedia Environments Designed for Mathematics Teacher Preparation

Research in the field of interactive multimedia environments designed for teacher preparation is scant at this time. Several projects are under development for a variety of teacher education purposes, three sharing the goal of mathematics teacher preparation.

In 1989 Lampert and Ball videotaped an entire year of teaching in their respective fifth grade and third grade classrooms (Brandt, 1994; Lampert & Ball, 1990). They also collected children's work, test scores, interviews, and anecdotal information, as well as teachers' journals and interviews throughout the year. The data has been organized and made available to teacher-preparation students in electronic format. Teacher-preparation students are encouraged to investigate an aspect of teaching, such as creating classroom climate, by studying the data collected from one teacher and her class. The students work in self-directed small groups as they carry out their investigation. The video data in Ball's project is contained on videodisc, Lampert's is on videotape. Both systems incorporate a hypertext interface that serves as a data catalogue and allows students to access information. Both systems are housed in multimedia computer labs, one at the University of Michigan and the other at Michigan University. Neither system is portable.

Barron and Goldman, at Vanderbilt University, have developed an interactive multimedia lesson which allow teacher-preparation students to compare and contrast an experienced teacher's

way of conducting an early elementary mathematics lesson to a novice teacher's way of conducting the same lesson (Bowers, Barron, & Goldman, 1994). The lessons, which are contained on CD ROM, are used in whole-class instruction guided by a teacher educator. Barron and Goldman's project is portable, but requires an expert facilitator.

Classroom with a View

The environment focused on in this study is Classroom with a View (CView). CView was designed to provide opportunities for teacher-preparation students to observe, discuss, and analyze classroom practice. Students working in pairs explored a video database of AMP and GIMS teachers' lessons. The pairs composed written, collaborative responses to questions embedded in the program.

CView's functionality was designed using a description of the teacher's role in a constructivist classroom (Cobb et al., 1991). Cobb et al. indicated that (a) highlighting conflicts between alternative interpretations or solutions for mathematics problems that students produce, (b) helping students produce productive small groups, and (c) facilitating mathematical dialogue between students, would be ways a constructivist-oriented mathematics teacher would support children's learning. CView supports teacher-preparation students' learning in parallel ways. Students worked in small groups, produced collaborative essays, talked about alternative interpretations of classroom practice, and engaged in pedagogical dialogue. Table 1 shows CView's contents.

Cognitive flexibility theory (Spiro & Jehng, 1993) guided the design of the environment's structure. Cognitive flexibility theory suggests that complex subject matter can be presented so that the content is not oversimplified. Directing students to look at complex content from several

Table 1
Contents of Classroom with a View

Lesson 1: Assessing Prior Knowledge
Probing Student Ideas
Managing Diverse Responses
Lesson 2: Activities to Construct New Knowledge and Skills
Open-Ended Questions
Hands-on Activities
Cooperative Group Activities
Lesson 3: Processing New Knowledge and Skills
Focusing on Main Ideas
Think About Thinking
Applying to New Problems

perspectives, and purposefully blurring categories, or classification schemes, of content may help students develop a flexible mental model of the content. A flexible mental model may be more useful when content, in this case pedagogical knowledge, is applied in a real world context, in this case the teacher-preparation student's future classroom. CView's content is structured into overlapping groupings of representations. Questions embedded in the environment encourage students to consider the representations from multiple perspectives. Salient teaching episodes were identified in videotapes of 10 classroom teacher's lessons. These clips were grouped together illustrating different teachers' approaches to certain teaching strategies. Most strategies are represented in several categories. For example, open-ended questions are found in every category, not just in the subsection labeled 'Open-Ended Questions'. Strategies encouraging children to think about thinking are found in 'Managing Diverse Responses', 'Hands-on Activities', and 'Managing Cooperative Groups', as well as 'Thinking About Thinking' sections.

Each lesson begins with a focusing question designed to elicit students' prior knowledge about the topic and frame students' thinking. A series of clips illustrating the strategy form the body of the lesson. The lesson ends with a summary question focused on the children's

perspective of the teaching strategies represented. The contents and flow of Lesson 1 are included in Table 2.

Table 2

Contents of Lesson 1

Assessing Prior Knowledge

- Focusing question: What do you already know about assessing prior knowledge?
  What meaning do teachers make of assessing prior knowledge?
  - Section 1: Probing Student Ideas
    - clip 1 - Ceci
    - clip 2 - Jane
    - clip 3 - Lynn
    - clip 4 - Suzi
    - clip 5 - Ceci
    - clip 6 - Chris
    - clip 7 - Rebecca
    - video question: What did teachers and students do and say?
  - Section 2: Managing Diverse Responses
    - clip 1 - Ceci
    - clip 2 - Ceci
    - clip 3 - Jane
    - clip 4 - Ceci
    - clip 5 - Ceci
    - clip 6 - Chris
    - clip 7 - Chris
    - clip 8 - Chris
    - video question: What did teachers and students do and say?
  - Summary Question: What meaning did students make of the teaching events?

Authentic video filmed by teachers in their own classrooms was chosen to illustrate classroom practice in CView. Earlier studies have identified authentic video as valuable for precipitating conceptual change in teacher-preparation students (Daniel, 1994; Keys & Daniel, 1994). Stofflett (1994) applied conceptual change theory (Posner, Strike, Hewson, & Gertzog, 1982) to promoting teacher change. Four conditions precipitate teachers exchanging their old conceptions of teaching for new ones. These are intelligibility-- the new concept must make sense or be understandable; plausibility--the new concept must appear doable in practice;

dissatisfaction--the old concept must appear less useful; and fruitful--the new concept must appear have some advantage over the old concept. Students in earlier studies (Daniel, 1994; Keys & Daniel, 1994) suggested that authentic video promoted dissatisfaction with didactic teaching, intelligibility and plausibility of constructivist oriented teaching, and increased the apparent fruitfulness of constructivist oriented teaching.

Methodology

This exploratory study focused on describing and interpreting how CView impacted students' construction of knowledge about teaching and learning mathematics and science. A constructivist paradigm of inquiry (Guba & Lincoln, 1994) focused on interpreting students' experience using CView. Three guiding questions focused the study on teacher-preparation students' learning in a small-group context. Findings related to research question 3 will be reported in this article. Findings related to research questions 1 and 2 have been reported elsewhere (Daniel, 1996, in press)

1. What are teacher-preparation students' interpretations of teaching episodes represented on CView?
2. In what type of pedagogical discourse do teacher-preparation students engage when using CView?
3. What aspects of CView support teacher-preparation students' construction of understandings about teaching and learning?

Participants and Context

The study took place in four methods courses over 10 weeks. The courses were middle childhood education science methods, middle childhood mathematics concepts, secondary science

methods, and secondary mathematics methods. Data sources for the study were 39 students, four course instructors, and participant observer researcher. Students worked in CView on multimedia computers, machines which could display video and play sound. These computers are in a resource center for education students that also contains print materials and other audio-visual tools.

Methods and Procedures

Verbal, text, numerical, and observation data was collected and analyzed. Verbal data was student preinterviews, think-aloud protocols students produced while using CView, student postinterviews, and instructor interviews collected on videotape and audiotape. Text data was collected in student writings produced using CView and questionnaires. Observational data was collected by myself while facilitating students' work in the environment. Numerical data were collected in a Likert scale instrument designed to measure change in student attitudes about the strategies represented in CView over time, and in Likert scale items on the questionnaire.

Verbal, text, and observational data were studied using the constant comparative method (Strauss & Corbin, 1994). The data were transformed and analyzed through transcription and open coding. Each group had an individual set of codes. A second set of codes that incorporated themes across groups was identified and the data were recoded. Data display methods, matrices and flow charts (Miles & Huberman, 1994) were used to confirm trends and patterns in the data. Numerical data was studied using descriptive statistics and t-tests. Results were triangulated by incorporating multiple data sources, data types, and analysis methods into the study.

What Aspects of CView Supported Teacher-Preparation Students' Construction of Understanding About Learning and Teaching?

Students indicated that the video clips and collaborative writing were the most important aspects of CView for promoting their understanding of teaching strategies. Participant observation and analysis of think-aloud protocols indicate the structure and tools included in CView also influenced students' learning with CView.

Authentic Video and Conceptual Change: Seeing is Believing

When students began working in CView they expressed the belief that teachers should immediately tell children if their responses to questions posed to determine children's existing knowledge about a science or mathematical concept were correct or incorrect, and that misconceptions or errors should be immediately corrected. The students believed that this should be done to clear up children's misconceptions. The first lesson in CView, Assessing Prior Knowledge, contains video clips of teachers allowing children to voice their prior knowledge, which is sometimes erroneous, then explore the topic, and eventually correct their misconceptions, either on their own or through peer review. The students in this study were initially uncomfortable, upset and confused by this teaching strategy. As they studied the lesson and video clips they began to explain and justify this strategy as a method to encourage children to reason for themselves and to create a sense of community in the classroom. Students completed this lesson by writing teaching strategies that they believed would be effective for assessing children's prior knowledge and for managing divergent responses. Each student wrote a strategy that included self-assessment or peer-assessment to correct misconceptions, rather than the teacher telling the children if theirs response are right or wrong. This indicated that students constructed meaning for an unfamiliar teaching strategy as they worked in CView. Students' self reports of their learning in the postinterviews and the open-ended questionnaire responses

triangulate this change. The questionnaire given to all students after completing the program included the question, *If you learned something from working in CView, what was it?* which was responded to by 34 of the 39 participants. These responses often included the words "see" and "real." Students indicated that seeing teaching strategies enacted by teachers in school classrooms changed their perceptions about the strategies. They perceived the strategies as more plausible, fruitful, and intelligible--three of the four conditions necessary for conceptual change (Posner et al., 1982; Stofflet, 1994)--after working in CView.

In the following sections, text data collected in the questionnaires are presented with verbal data collected in think-aloud protocols and interviews. If data collected were verbal the participant was identified with an uppercase code, such as K or M. If the data were taken from questionnaires, which were an anonymous format, the participant was identified by a lowercase education course code w, x, y, or z.

Student responses indicated that seeing the strategies implemented in classrooms added plausibility to the strategy. Open-ended questionnaire responses from eight students of the 34 responding students and postinterview responses from 10 of the 12 students in purposive sample were coded plausibility. K and M's responses are examples of the teaching strategies represented in CView being perceived as more plausible.

K: The videos showed that it could be done. What the instructors were talking about in methods class could be done in a school.

M: My ideas about the feasibility [of the strategies] changed. I saw them in action.

Students indicated that they were better able to see relationships between teachers' actions and student learning by working in CView. This increased the students' perceptions of the

fruitfulness of the strategies. Open-ended responses to the questionnaire from ten of the 34 responding students and postinterview responses from 11 of the 12 groups in the purposive sample were coded fruitful. H and x's responses are examples of teaching strategies represented in CView being perceived as more fruitful.

x: The new method is being used and it seems to be helpful.

H: We got to see the teacher do it then the student respond. We could hear their responses. It lets you actually see that this does work.

Students indicated that the teaching episodes in CView connected with their coursework and made it more comprehensible. This connection between educational theory and classroom practice increased their perception of the intelligibility of the teaching strategies represented in CView. Open-ended questionnaire responses from 30 of the 34 responding participants and postinterview responses from all 12 groups in the purposive sample were coded intelligibility. G, S, and x's responses are examples of teaching strategies being perceived as more intelligible.

x: I learned how open-ended questions are asked by real teachers and how to handle children's responses.

G: It reinforced the ideas. You can hear them asking, "Well, what do you think?" Then you see some concrete examples of how they are teaching and the responses they are getting from students.

S: I was a little unclear about some things in the book [graphic representations for fractions]. It connected things we've heard about and read about, now we got to see it.

Experiencing Collaborative Writing

Working with a partner was an essential part of CView. The students worked cooperatively to solve the problems of navigation and composing collaborative writings. Two postinterview questions focused on students' experience working with a partner and their

experience composing collaborative writings. Four questionnaire items were related to working with a partner.

Student B indicated that the experience of working in a group gave her more empathy for how children might feel about working in groups.

B: It helped me understand what the kids are going through when they do this kind of work in class. It helped me to understand how kids feel and the extent of work involved in doing collaborative work.

Students K and M found that producing collaborative writings was more difficult than working alone.

K: I think it would have been easier without a partner. We were trying to collaborate on our ideas. He doesn't look at the questions as I would. I don't think either one of us was right, and that was really hard.

M: It was harder because you are trying to mesh your perspectives. But you are also getting more perspectives. I guess that makes it kind of good. I learned more, too.

Student S suggested that her thinking was not represented in the collaborative writing.

S: In collaborative writing, what you are thinking and the finished typed words may not match.

Students L and J indicated that working in a team was fun, and that the responsibility they felt towards their team members motivated them to complete the lessons.

L: It made it more enjoyable.

J: The biggest thing was that we did it. I think if I were doing this all alone it would have been pushed off all the time.

L: We had a commitment to the group.

Many students, including C and z, indicated that the collaborative writing was useful because it encouraged them to process information with a partner.

C: The collaborative writing helped us think about what we saw.

z: I learned how exploring something with another person is helpful. You can help each

other understand if it's something new and having someone to verbalize your thoughts to helps you understand them yourself.

Students expressed that the collaborative writing activity added greater depth to their thinking. Students A, T, w and y suggested that the collaborative product was better than individual written responses would have been.

A: We see slightly different things and the sum of the parts was greater than the whole. So we bounce off each other.

T: The fact that we had to share what we thought, put it in writing, triggered more things. Maybe it made the ideas more complete.

y: My partners helped me think of more answers to the questions. We saw things a little differently, and the answers we each gave rounded out the understanding the other person had.

w: Collaborative writing lets me know about my peers' thinking. Even if different from my own, I would be gaining that much more knowledge. Good social skills.

Many students expressed that working with a group in CView increased their knowledge of what it is like to work in problem-solving groups. Some students related this directly to how children feel working in groups. Although all the students indicated that working with a partner or partners was beneficial, the experience was more difficult for some than for others. Comments regarding the experience ranged from, "Working with a partner was the best part about it," to "I would rather do the assignment alone." For students with little experience working in groups, CView posed a significant problem in learning how to function in a group.

How Students Made Use of CView's Structure and Tools

The CView environment integrates content about teaching and learning with a structure designed to help students build a flexible mental model of teaching. CView contains an introduction, doors, textboxes with transcriptions and context of video clips, video clips, program

outline, second information dimension, and a word processor. These tools were included to aid students in the tasks of navigating the information space and collaborative writing.

Student learning is anchored in a context that is both internal and external to CView. The internal content is the information space. Information is contained in the context of teaching episodes, which are embedded in the context of Snapfinger School. The external context is social, working in small groups, and parallels the context that children represented in CView are working in. The contextual information, navigation aids, and introduction appeared to most useful to students.

Contextual information. To view the video clip students double clicked the mouse on the name on the door icon. When the video was over the door closed. To watch the video clip again students clicked on the door again. The video clips were reviewed by some students during the video part of their work, other students reviewed video clips as they were answering the video questions.

Each screen that contained a video clip also contained a scrolling textbox. The textbox contained the children's grade level, the lesson topic, some indication of what was going on in the classroom prior to the clip, and a transcription of the dialogue in the video clip. To view the contents of the textbox the students placed the mouse on the box and moved through the document, similar to scrolling through a document in a word processor. This could be done at any time, before, during, or after watching the video clip. Some students read the textbox both before and after watching the video clip. A pattern of first reading the transcription, then viewing the video clips was used by all groups observed in the study. Some groups read, watched, and then read again. Some groups tried different orderings of reading and watching before they fell

into the read-then-watch pattern. Student A's description of his group's procedure was representative of the behaviors of all the groups in the study:

A: Read it first, and then make sense of it, then listen to it the way it is presented. That worked for us.

There is evidence in the transcribed think-aloud protocols that the students read the textbox for most, if not all, video clips, and that the transcribed information was helpful to their sense-making of the teaching event. Students J and M commented on discrepancies between their understanding of the video clip and the transcriptions:

J: Examine the contents of the cup. That's what she said.
M: I thought she was saying to sort them.
J: The transcription said that.

After viewing a video clip not accompanied by a transcription of children's dialogue student J noted:

J: It's a hands-on experiment. I don't have a clue what they said.

Student G suggested that a transcription gave meaning to the children's activity in the video clip:

G: Making a book with mirrors, or something. I could read but I couldn't really hear anything any particular student was saying. If that text wasn't there, then I wouldn't have known what they were doing.

Students linked the lesson's topic to strategies in several think-aloud protocols and in postinterviews. G linked a lesson on ocean currents to student designed experiments in the next example as she composed a response to a video question.

G: That teacher who was talking about ocean currents: "I want you to design your own experiment but do it so that another student can look at what you did and repeat your experiment from how you document it,"[rephrases teacher's statement]

K linked a lesson about`t finding the area of a trapezoid to the strategy of applying prior knowledge to new problems in mathematics in the next example.

K: What about like that math lesson, the finding the formula for the area of the trapezoid. Without saying it. They used what they already knew about triangles.

Navigation. The video clips were accessed by clicking the mouse on an icon, drawn to look like a classroom door. The door was titled with the teacher's first name on a nameplate. Both the door metaphor and the teacher's name were helpful to students. Many students used the metaphor "Knock on the door" or "Open the door" for clicking on the door with the mouse. The metaphor was extended to statements such as "Chris will answer the door" or "Let's see what's inside the door." Students C and M use of the metaphor of knocking on the door and going in and out of a door is typical.

C: Should we knock on the door again?
M: No, I just got out.

Talk about opening the door was usually confined to the beginning of the lesson. The students used the metaphor to get accustomed to clicking on the icon to see video. After they were comfortable with the procedure they did not use the knocking metaphor. In the following example students N, G, and P used the name of the teacher, which was on the door, as a handle for the strategies as they composed their response to the video question.

N: They had to, Ceci, Suzi, they did comparison. Suzi's was alike comparison, Ceci's was-
G: I think Ceci, Suzi did the water. Ceci did the rocks, Suzi did the water and Lynn did the birds.
P: Ceci light, and Lynn's is the difference in the birds.
N: Ceci did light comparisons, and rock comparison, classify rocks.

Some groups used the teacher's name to navigate in the program, as S and T, and C and K did in following examples.

S: Who are we on?
T: Chris. And then Jane.

C: Deborah. Do we want to go to Ceci?
K: No.
C: Go to Suzi.

Having the teacher's name on the door also served as a friendly introduction. Student G greeted the teacher by name when the video started.

G: There's Ceci!

Introduction. Three screens made up the introduction to the program. The first was a view of Snapfinger Elementary School from the street, the second a view of Snapfinger's main entrance, and the third a view of Snapfinger's foyer. The sequence of photographs was chosen to simulate entering the school. The text on these screens, one or two sentences each, explained the purpose of CView and why the teachers represented in CView were chosen. The introduction engaged students. All students read the introductory remarks, and some questioned me, the participant observer, about the Atlanta Math Project and Georgia Initiative for Mathematics and Science after they had completed their lesson.

Student Satisfaction with CView's Content

The questionnaire given to students after working in CView included a Likert scale item asking, *Did you find the program to be: very useful or a waste of time?* included choices ranging from very useful (5), to waste of time (1). The mean response score was 4.05, with standard deviation .89. It contained another yes or no question that asked , *Did you learn anything from using the program?* Responses were 37 yes, 1 no, 1 no-response. This indicated that in general the students found CView to be a good use of time and to promote learning.

The secondary education students were less satisfied than the middle childhood education students. There appears to be to two reasons for secondary students' dissatisfaction. Secondary education students did not want to see subject matter content out of their field, and they did not want to see middle school aged children. Table 4.2 contains the number of students who indicated that content or age of children was a problem.

Although four of the secondary education students suggested that viewing younger children was not optimal, two of the secondary students did not agree. Student A suggested that:

A: The forms, the procedures are the same [for all learners]. The same thinking process is going on. You address it at a higher level. The kind of open-ended questions you are going to ask are going to be much deeper. But still the process is the same.

Table 4. 2

Number of Secondary Students Dissatisfied with CView's Content

Problem	Yes	No	No Comment	Total
Only want to see mathematics or science?	4	2	9	13
Only want to see high school aged children ?	4	2	7	13

One middle childhood education student said that CView duplicated her coursework. She questioned the value of spending time seeing and hearing the strategies over again. This student then suggested that the multimedia environment was more convenient and inclusive than the classroom they had observed with their education professor. "It cut right to the chase. We saw 10 teachers in 40 minutes without driving or waiting around to get started."

Conclusion

The results of this study indicate that a constructivist orientation can be assumed when planning computer-based instruction, and that a computer-based environment can model some

aspects of teaching with a constructivist orientation. The integrated structure, content, and tools of CView supported student learning in a manner that is consistent with a teaching philosophy oriented by constructivist learning theory.

Interactive multimedia connected teacher-preparation students with inservice teachers whose practice is in alignment with national standards. In this way, university-based theory, which students were learning in education courses, was connected to school-based applications. The environment allowed students to study teaching in a way that cannot be replicated by on-site observations or through viewing videotaped lessons.

Studying many teachers anchored theory about learning in the concrete practice of teaching. The interactive multimedia environment framed students' thinking as they observed classrooms. It allowed them to travel into many different classrooms quickly to compare and contrast what many teachers were doing with respect to one strategy. This could not happen in real-life observation, text, or viewing of classroom lessons on tape.

The pattern of reading, watching, repeating, and interpreting was closely tied to the content, structure, and tools in the environment. The in-depth study of salient teaching episodes was facilitated by cutting the task into understandable pieces, which could be held in working memory. Each episode could be immediately reviewed, and the dialogue was available on screen for further clarification. The students took advantage of their control of the environment to review and reread. Students rehearsed the dialogue before and after seeing it. This supported students' processing and retention of information during the time span between question prompts. Longer teaching episodes, such as a full lesson, could not be held in memory, repeated, and reenacted in the way that the short episodes were.

As they watched the clips, students were observed imitating the body movements of teachers and students. They repeated dialogue with the inflection, facial expression, intonation, and body movements of the people in the environment. This would not happen in a text environment.

When students were composing responses to questions, they discussed how to generalize the actions and dialogue they saw on the clips. The juxtaposition of several different teaching styles in a short time period within the environment encouraged students to move from particular instances to general themes in the teachers' actions.

The visual content of the program impacted student learning in ways that text and lecture could not. Students developed understanding of the strategies indicating that three conditions of conceptual change, intelligibility, plausibility, and fruitfulness (Stofflett, 1994), were met by working in the environment. The questions for group discussion and collaborative writing focused students' attention on aspects of teaching events that may not have come to their attention in less structured environments (Goldman, Barron, & Witherspoon, 1992). The structure of overlapping groupings of strategies, looked at through both learners' and teachers' perspectives, which was based on cognitive flexibility theory (Spiro & Jehng, 1993), helped students develop connections between teachers' actions and student learning. The collaborative writing and discussion were identified by students as a powerful means for developing more complete understanding of the teaching strategies represented in CView. The environment was successful because it integrated content, structure, and tools to help students further their understanding of teaching from a constructivist perspective.

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