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ABSTRACT

During the last decade, United States K-12 schools have approximately tripled their spending on increasingly powerful computers, and have expanded network access and novel computer applications. The number of questions being asked by educators, policymakers, and the general public about the extent to which students are using these educational technologies, for what purposes, and to what effects, has likewise increased. Exploring the human implementation process is thought to be one key to understanding how educational technologies find, purchase, and evolve in local classroom environments. This naturalistic inquiry explored students' classroom experiences during the semester-long process of implementing an interactive learning system, Destination Math, in two eighth grade math classes n a rural mid-Atlantic Junior-Senor High School. Data collection was based on field observations prior to and during the implementation process, semi-structured interviews and focus group interviews with students, and document analysis. Grounded theory methods were used to analyze the data. Findings indicated that students experienced high levels of learner-control when using the interactive learning system for math, given the variety of activity choices afforded by the instructional medium, the multiple pathways to representation of math concepts and the opportunities for math-talk with their peers. For these three reasons, students reported increased interest in math in the Destination Math class, compared with the regular math class. Research observations supported students' self-reports: students' engagement with math, operationally defined as time-on-task, increased in the Destination Math class. These findings suggest that when educational technologies are used to heighten student-control over the learning environment, these instructional tools may increase students' interest in subject matter and their engagement in learning. (Contains 33 references.) (Author/AEF)

Students' Experiences of the Implementation of an Interactive Learning System in Their Eighth Grade Mathematics Classes: An Exploratory Study

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Abstract

During the last decade US K-12 schools have approximately tripled their spending on increasingly powerful computers, expanded network access, and novel computer applications. The number of questions being asked by educators, policymakers, and the general public about the extent to which students are using these educational technologies, for what purposes, and to what effects, has likewise increased. Exploring the human implementation process is thought to be one key to understanding how educational technologies find, purchase and evolve in local classroom environments. This naturalistic inquiry explored students' classroom experiences during the semester-long process of implementing an interactive learning system, Destination Math, in two eighth-grade math classes in a rural mid-Atlantic Junior-Senior High School. Data collection was based on field observations prior to and during the implementation process, semi-structured interviews and focus group interviews with students, and document analysis. Grounded theory methods were used to analyze the data. I found that students experienced high levels of learner-control when using the interactive learning system for math, given the variety of activity choices afforded by the instructional medium, the multiple pathways to representation of math concepts, and the opportunities for math-talk with their peers. For these three reasons, students reported increased interest in math in the Destination Math class, compared with the regular math class. Researcher observations supported students' self-reports: students' engagement with math, operationally defined as time-on-task, increased in the Destination Math class. These findings suggest that when educational technologies are used to heighten student-control over the learning environment, these instructional tools may increase students' interest in subject matter and their engagement in learning.

Introduction

Increasingly powerful computers, expanded network access, and novel computer applications have enlarged both investments in, and expectations for, the transformation of students' classroom learning experiences. During the last decade US K-12 schools have approximately tripled their spending on educational technologies (Quality Education Data [QED], 1999). Improving students' classroom learning experiences by exploiting the appeal of challenging interactive learning technologies is a powerful motivation for such significant investments in educational technologies. However, while investments in educational technologies have steadily increased, not enough money has been spent on educational research (Web Based Education Commission, 2000; Shaw, 2000). Merely because curriculum producers are making software and their school customers are acquiring their products and the hardware to allow them to be used, does not tell us how, or to what extent, the daily lives of typical school children are being affected or changed by these educational technologies (Becker, 1998, p. 20). The present research was designed to enliven and enlighten current discussion of student-use of educational technologies in classrooms, by exploring the implementation of an educational technology in two eighth grade math classes.

This research represents a departure from the early research on educational technologies (1970s and 1980s) which emphasized the learning outcomes value-added model: the decontextualized, cognitive-psych pedigree of researching individual students' interactions with computers. These early studies looked so specifically at particular technologies and their impact on single students, that they contributed little to the larger more challenging project of understanding the roles that technologies can play in addressing the key challenges of learning in classroom contexts. Recent research on educational technologies is characterized by an awareness that the impact of technology on specific aspects of teaching and learning can be "usefully understood only in context" (McMillan Culp, Hawkins, and Honey, 1999, p. 8). Educational technologies alone do not translate into improved instructional outcomes: they matter only when harnessed for particular ends in the social context of classrooms: they must therefore be studied in these contexts. The regular math class, and the DM class, represented the contexts for this naturalistic inquiry. Throughout this fourteen-week study, the focus of the research was on the students' experiences with the interactive learning system in their math class.

Research on classroom innovation has infrequently focused on students' experiences of changes in their classroom learning environments (Hammersley, 1999). While previous research has identified student attitude toward educational technologies as an important variable influencing their learning experiences (Francis & Evans, 1995; Liu, 1999; Christensen, 1997), these studies have not described students' experiences with these novel tools over time and in students' own words. Instead, students' reports of their classroom experiences with educational technologies have focused on the frequency of computer use in specific courses, the type of software utilized, and students' responses to an admittedly rough categorization of activities (Becker, 1994). The purpose of this study was to describe students' experiences with an interactive learning system during one school semester. The main research question asked: How do students experience a classroom innovation in the form of an interactive learning system in their math class, during the semester-long implementation process? This question was operationalized by asking the more informal question: What do students do, say and make in the research context over time?

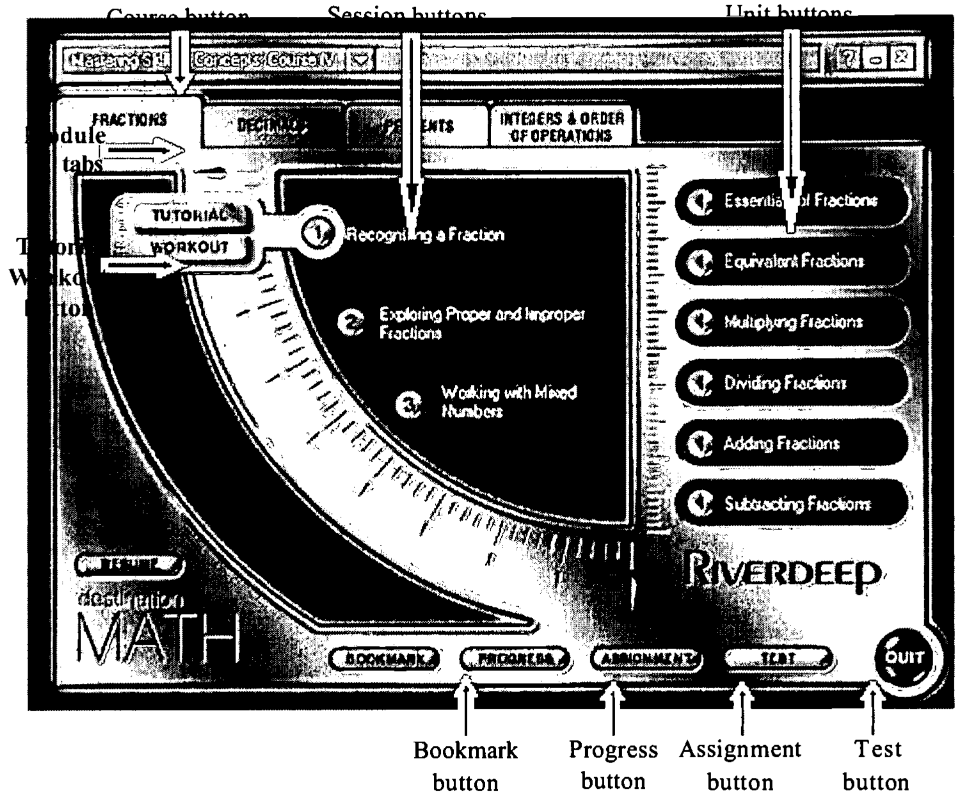
Research Context

Participants

Participants in this study included 32 students (14 and 18) in two lower-level eighth grade math classes. This research began in the regular math class four weeks prior to the implementation of the interactive learning system, and continued during the ten-week implementation process. Qualitative methods were used to explore the process of implementing the interactive learning system, DM, twice weekly, during students' regularly scheduled (40 minute) math period in the computer lab, on Wednesdays and on Thursdays. On alternate days, students and their teacher used the "highly structured" and "highly prescriptive" (Saxon, 2001) text -based math lessons, provided in the district-adopted math curriculum. In this study, the teacher used the Riverdeep (RVDP) Interactive Learning System to revise math concepts previously taught to students using the Saxon math lessons.

Materials

RVDP was founded in Ireland in December 1995 as a developer and provider of technology-based educational solutions for the United States kindergarten through high school, or K-12 market. RVDP offers Internet and CD-ROM based comprehensive courseware and supplemental curricula in math, science, and language arts.
Figure 1. DM Main Menu Screen (Course IV)



In November 2000, the Westridge school district purchased licenses for use of the Riverdeep interactive learning products by all eighth grade students and their teachers, intentionally targeting improvement of students' math skills. RVDP curriculum products for middle school math include *Destination Math* (DM), a comprehensive math program designed to supplement or replace traditional math curricula, and *Tangible Math* ™, a simulation-based math program, which focuses on the development of students' problem solving and analytical skills. In the present study, the teacher chose to implement the DM component of the RVDP suite of learning resources with both her eighth grade math classes. DM comprises five math courses organized in two series or curricula for students in grades four to twelve. Participants in this study used DM Course IV Mastering Skills and Concepts.

Figure 1 presents the structure of DM Course IV, used by students in this study. The course is composed of four *modules*: Fractions, Decimals, Percents, and Integers and Order of Operations, each representing a major topic in the eighth grade math curriculum. Each DM module is further broken down into *units*, which address specific learning objectives and are correlated with state and national standards for mathematics learning. The teacher management system for DM contains a bank of test items that are correlated with specific learning objectives, and organized by unit. Unit buttons for the fractions module are visible to the right of the user's screen in Figure 1. DM units are further divided into three *sessions*. The user enters DM at the session level.

Each DM session comprises a *tutorial* and a *workout*. The user may also access a tutorial or workout as a system-generated *prescribed assignment*, based on the level of mastery of learning objectives demonstrated by the user on assigned tests. From the main menu, DM users may choose to work on a teacher-assigned test, a tutorial, or a workout. During their ten-week use of DM in their math classes at Westridge, students were instructed to complete teacher-assigned DM tests, prescribed assignments, and any additional activities for each unit, before proceeding to the next unit.

Data Collection

Participant observation strategies (observation and conversation) enabled me to take an active role in experiencing and enquiring about (Wolcott, 1999) students' uses of DM in their math classes. In the initial weeks of this study, I focused my classroom observations by detailing elements of the classroom environment (classroom map protocol), and describing the activities of students therein (activity framework protocol). I recorded students' actions and interactions within the DM math class using a small pocket recorder. Written descriptions of participants' coverbal behaviors (expressions, gestures, actions) in their math classes informed and extended students' voice-recorded data. Combined with classroom observations, unscheduled verbal exchanges with students provided valuable opportunities for me to become familiar with "the native communicative repertoire" of participants in the eighth grade math class (Briggs, 1984, p. 24). These classroom conversations provided crucial information on the interaction between the eighth grade students' use of language, and their social behavior, and also between students' social and cultural norms and patterns of interaction in the math class. Ongoing conversations with students informed the development of semi-structured interview guides throughout the data collection process.

I planned exploratory and culminating focus group interviews with students to further explore their experiences with educational technologies and math in general, and with DM in particular. Flick (1998) suggested four processes or elements of group discussions, which I used to structure the focus group interview guide: brief explanation of the research procedure, preparation for the discussion, discussion stimulus, and process discussion (p. 119-120). I held exploratory focus group interviews with students to probe their prior experiences with educational technologies at home and in school, their attitudes toward math, and their expectations for the DM learning system. Culminating focus group sessions in the final week of this research offered opportunities for respondent validation or member checking of my own interpretations of students' experiences with DM in their math class.

I used Patton's (1990) "general interview guide approach" (p. 280) to plan periodic semi-structured interviews with individual students. These interview guides were developed and sequenced using Spradley's (1979) ethnographic questions, the third element in his ethnographic interview (p. 58-68). I used naturalistic sampling (Ball, 1990) to select four students for semi-structured interviews "to generate the information upon which the emergent design and grounded theory can be based" (Lincoln and Guba, 1985, p. 201). Combined with classroom conversations and observations, these individual interviews enabled me to construct portraits (Lawrence-Lightfoot and Hoffman, 1997) or mini-embedded case studies of four students in the teacher's eighth grade math classes (two students from each class). Each individual student portrait served as a rhetorical device, providing vivid renditions of broadly observable patterns of class behavior, thereby directing and redirecting the most fruitful path of research in answering the research questions. These four richly detailed student portraits, grounded in conversation and interview data, facilitated "the on-going joint collection and analysis of data associated with the generation of theory" (Glaser and Strauss, 1967, p. 48).

To further extend my understanding of the research context, I analyzed text documents gathered from the research setting (Glesne and Peshkin, 1992) which included a printed copy of the school mission, the Saxon math texts, students' homework assignments, DM test reports, DM progress reports, and so forth.

Data Analysis

Given the documented need for new, theoretically expressed understandings of students' and teachers' experiences of the classroom implementation of educational technologies, I chose to analyze my transcribed research data (classroom observations, classroom conversations, interviews) and related documents, using grounded theory methods. "The value of the methodology... lies in its ability not only to generate theory but also to ground that theory in data" (Strauss and Corbin, 1998, p. 8). I proceeded from description to conceptual ordering and theorizing (three activities foundational to Strauss and Corbin's theory building process), by iteratively coding transcribed data regarding students' activities in their math class. Strauss and Corbin (1990) explained that coding is "the process of analyzing data" (1990, p. 61), in order to create theory from data.

I developed a systematic three-step process for coding all transcribed data. To generate initial categories and to discover relationships between these categories, I began by coding transcribed exploratory interviews and classroom conversations by hand, using participants' own words (in vivo codes) when possible. I then record coded data electronically using the qualitative data analysis software, *N.5*. In parallel with my use of N.5 to code transcribed data (line-by-line and open coding), I employed the concept-mapping software program, *Inspiration*, to explore relationships within and between concepts evident in the data (axial coding). The multiple representational methods for linking categories, which Inspiration afforded, supported development and refinement of my emerging grounded theory (selective and focused coding) of students' experiences with DM in their math class.

Flick (1998) noted that this combination of multiple methodological practices in a single study is best understood as "a strategy that adds rigor, breadth, complexity, richness, and depth to any inquiry" (p. 231). I employed these methods of data collection and analysis to secure an in-depth and richly-triangulated understanding of students' experiences with an interactive learning system in their math class. Maxwell's (1992) five kinds of understanding and validity in qualitative research (descriptive, interpretive, theoretical, generalizability and evaluative) were used to guide all phases of data collection and data analysis.

Results and Discussion

During the ten-week implementation of DM in their math class, students experienced a level of control over their own learning that they had not experienced in their regular math class using Saxon. Control is relative. Students spoke positively about the level of control afforded to them vis-à-vis math activities, representation of math content and the social context for these activities: the opportunity to interact with their peers, in the DM math class.

Activity Choices

Students who completed their DM tests and prescribed assignments could choose math activities from a suite of DM tutorials (providing repetition of the problem explanation, partial or complete explanation of the problem, and additional practice problems), workouts (sets of complex problems), or progress feedback and reports. Students frequently contrasted the variety and choice of math activities in DM with the limited set of questions in their regular math textbook: "With DM the choices are more fun and there's more of them than over here [regular math class]." Students enjoyed having opportunities to become informed and make choices about their math learning with DM: "Well instead of just, like, being told what to do, you get to think about what you're gonna do. Like you can choose what you wanna do." One student explained that the activity choices in DM enabled him to control what and how he learned math: "You can go with what you want to do, and what you think you're capable of learning. I like that you can go at your own pace... You're not held back by other people." Researcher observations suggest that when using DM, students made instructional choices that supported their own math learning.

For example, as students gained in their understanding of the DM activity system, they used the activity options within DM tests, tutorials and workouts to increase their individual access to detailed explanations of math problems. Although students were not instructed by their teacher to use the DM *test feedback*, *test report*, and *progress report* activity options, they discovered and employed these tools to review, reflect upon, and regulate their own math learning with DM. Students who scored their DM math test used instantaneous test-feedback to compare their own answers to test questions with the correct DM responses provided. The correct-answer feedback provided in DM enabled students to identify the source of their errors by reviewing and reinterpreting both the test question and their own problem solving strategies. As one student explained:

> ...you just say, "Score test!" and then it tells you what you got, and you can go back, and see what the answer should have been and stuff. That kind of makes ya try and figure it out, like, why you didn't get the right answer. It shows you the right answer. So you know how to do it.

The following example represents one-student's verbal response to test-feedback provided on the first part of her test on integers:

> Oh, why did I do that? Oh! I don't know why I did that! This one was easy, from least to greatest. What did I put? [Locating her own response] What the heck! I put them from greatest to least! For [number] 38 [Pause] Oh, I didn't divide! I never found the average. I was supposed to divide by 10! And I bet that's what happened in the last one as well! Now this one is six, negative six. This is positive, this is negative. So how is it equal? [pause] Oh I didn't times it when I got the number! [Pause] I really need to read the questions!

Students used DM test feedback information in this way, to interpret, analyze and improve their own math performance. Clariana (1990) found that students who received correct answers after one missed attempt outperformed students who were required to repeatedly answer questions until reaching the correct answer. Clariana noted that students who received correct answers after one missed attempt used the immediate feedback they received to clarify misunderstandings and use this information to solve successive problems. In the present study, students used immediate test feedback to begin to understand and effect positive changes in their own learning.

Students who completed and scored a teacher-assigned DM test also received a DM test report which provided information regarding the number of correct, incorrect and attempted problems, the students' percentage score, and the student's performance on individual learning objectives assessed within the test. Students learned to use the progress report data provided (e.g., percentage of problems correct for each activity, amount of time spent on each activity, and date the activity was completed) to identify gaps in their progress, plan make-up work and navigate the activity options within DM. They frequently used these accessible and transparent reports of their DM work to critically appraise their own progress with the learning system.

Students' sophisticated use of feedback and report tools to effectively control their own learning in the DM class suggests that learners can develop the skill and will (McCombs & Marzano, 1990) to manage their own learning, given educational technologies which provide detailed, accessible, and instantaneous feedback to s tudents regarding their learning.

Multiple Representations of Math Concepts

Students also contrasted the multiple and dynamic methods for representation of concepts (audio, visual-graphics, visual-text), in the DM scenario-based math problems, with the static problem sets assigned in their regular math textbook. "The workbook pages are just black and white. It's hard to concentrate in the math class. DM is colorful, and it's more fun. It has cool graphics and pictures and things. You can just listen to the math on there." Students frequently noted the benefits of the multiple pathways to learning (speech, graphics, text) provided in each DM tutorial and workout explanation. They suggested that these three modes for representation of problems supported their interest and engagement in math during their completion of DM problem tasks.

Referring to the audio presentation of math concepts in DM, one student insisted, "It makes it [math] more interesting. And the voices, they say it in a fun way, not like in a serious way, or like a baby way." A peer added, "You understand things way better when you're hearing somebody say it than when you're just reading!" Students noted that the visual representation of math concepts in DM also increased their interest in the DM math activity: "If you have something that you see there that catches your eye, you actually want to do it [math activity]." Students liked the use of animated graphics to support scenario-problems in DM, and claimed that these graphic representations of math content supported their understanding of underlying math concepts:

> They give you a lot of pictures and stuff that help. The one sheep thing, like when he was cutting the wool off the sheep to make the things, they had the little sheep in the little circle. Then they colored the circle that had the cut sheep, and they showed you the fractions for how many cut sheep there were to the whole bunch. So, that's a picture that I found helpful to use. Besides trying to figure it out in your head, you have it right there on the computer screen. You can just count it, one by one.

Students noted that in addition to the audio and visual representation of math concepts provided in tutorials and workouts, the step-by step text based explanations of math concepts in DM also supported their engagement in the math activity. One student explained, "They write out the problem for ya in steps. So its easy to follow."

Students suggested that these three formats (speech, graphics, text) for representation of math concepts in DM motivated them to attempt math problems, and sustained their interest in completing difficult word problems:

> I find it hard to do the story problems. I think I got a lot better at 'em in the lab... Because before when I'd do 'em out of the book, I just [pause] I can do 'em, I just keep, well, I have to read that little paragraph thing there and I always get lost.

In their research comparing the performance of sixth grade students using single-representation (SR) and multiple-representation (MR) versions of a computer-based multimedia program for addition and subtraction of signed numbers, Moreno and Mayer (1999) also found that that the benefits of using MRs with students were strongest on difficult problems. Students in the present study claimed that the multiple formats (audio, visual-graphics, visual-text) for representation of math concepts in DM supported their engagement with difficult math problems, by allowing students to choose how they wanted to engage with the math problem.

Given these three formats for representation of math concepts in DM, *control* over the instructional event (the math activity) remained a critical factor motivating students' interest in math when using the interactive learning system to complete math problems. One student explained, "You can decide if you want to listen to the problem, or look at it... so you can't get lost. It [choice of representational formats] makes it [math] more interesting." This research suggests that multiple pathways to learning which support diverse learning preferences among students may positively affect their interest in subject matter. Hannafin and Sullivan (1995) found that students using either *text-plus-static graphics* or *text-plus-animated graphics* methods for presentation of math topics expressed a more positive attitude toward math than those who viewed the text-only version. In this study, the flexibility of the educational technology in facilitating multiple representations of information enabled students to learn in ways that supported their own pedagogical preferences. Consequently, students found math more interesting when learning with the DM interactive learning system which presented math problems through more than one modality, than when using the math text in their regular eighth-grade math class.

Opportunities for Peer Discussion

In the regular math class using the Saxon scheme, students would quietly complete their practice set following the teacher's correction of homework and presentation of the new increment. The teacher neither provided guidelines regarding whether or not students could interact with one another during the DM math class in the computer lab, nor organized formal groups or pairs of collaborators. Students spontaneously devised strategies to extend their experience with DM beyond their individual interactions with the interactive learning system to their peers in the math class. For example, many students made exhaustive efforts to synchronize their use of DM tutorials, workouts and tests with those students seated on either side of them. Students who coordinated their pacing of DM activities in this way consistently demonstrated high levels of interest and enjoyment in the math activity which often proceeded in game-like manner with frequent choruses: "Ready, Set, Go!" "One, two three!" "Marks, set, go!" Students in Mrs. Hall's classes enjoyed learning math with their peers. Many students indicated that the quality of the math experience improved significantly when they had opportunities to work with one-another, and make instructional decisions. One student explained:

> It's a different environment thing. You know you're just sitting around doing things, and you find out something new and neat that you just got to show some one, you know, like the people around you. Or if you're getting frustrated with something, the other people are there to like, talk to you about it.

Students rarely sought assistance with DM math problems from their teacher, relying instead on their peers for math conversation and argumentation. Students' discussions of math while using DM progressed through a sequence of stages that included advice-seeking, advice-giving, evaluation, comparison, clarification, acceptance or rejection of alternative rationales and defense of math claims or assertions. Table 1 presents examples of student math talk at each of these stages:

Table 1. Components of Students' Math-Talk when using DM[a]

Activity	Examples
Request help	"Which one do I click on, here?" (seek advice) "Oh man! What's this about, anyway? (seek help interpreting) "What's an absolute value, again?" (seek definition)
Provide assistance or advice	"Click that one, man!" (provide answer without justification) "Because that's relationship." (provide partial explanation) "Because it's the difference from Jack's home to the school. Do you see that there?" (provide explanation) "Because it's five over two." (provide example of math concept)
Evaluate or compare options	"That looks wrong." (assess) "This one is better." (compare) "Yeah, I had that one figured out, too." (compare, contrast)
Seek clarification	"How do you know it's that one?" (seek justification) "You did what, again?" (seek reiteration of suggestion) "So why did you do that, there?" (seek justification)
Accept option	"That's true." (agree) "Cool!" (accept without indicating motive) "Yeah! That's what I was thinkin' – divide and then simplify. I got that too!" (accept as confirmation)
Reject option	"No it's not! That's a proper fraction there, JM!" (contradict) "No. Eight's the denominator here." (explain) "See, smartie! I told you it was this one, not a whole number!" (self-applaud)
Defend choice	"Oh, no it aint! That's the opposite of an improper fraction, there, GS!" (reject, justify) "It has to be this one – I know those are all wrong!" (justify by elimination) "If you add them up you'll get four sixths, and that has to be two thirds in lowest terms." (recall mathematical proof)

Note. [a]Excerpted text from students' classroom conversations

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The informal nature of students' math-talk (frequently punctuated with vociferous argumentation, lavish expression and theatrical gesture) during their use of DM belied the depth of students' discussion of math concepts. Through the production of argument and counter-argument, students frequently attempted to persuade their peers that certain choices or decisions were preferable to concurrent choices or decisions in resolving DM math problems. Students demanded support and justification for mathematical assertions and claims presented by their peers: these demands were met using mathematical data, facts and evidence.

While this research supports the claim that novel educational technologies can trigger a restructuring of classroom experience, one which extends and elaborates the possibilities for student interaction (Kerr, 1996), it also shows that the social situation for students' use of educational technologies, can be a powerful determinant of their verbal behavior in these learning environments.

Increased Interest and Engagement in Math

For the three reasons discussed (activity choices, multiple representations of math content, and opportunities for peer collaboration) students claimed that using DM increased their interest in, and engagement and productivity with, math: "The choices are just more fun, and there's more of them, and it's more interesting to see an' hear the math. You're just busy all the time." One student explained, "With DM you actually want to do the math, then. And it means you actually want to work harder and, like, get it done, and see how much you can cover and stuff." Another student contrasted his poor work ethic in the regular math class, with his sense of efficacy when learning with DM: "Well here I could actually get my work done. I could actually do my work in here. Over there I would do nothin' cause I'm lazy and it's boring. Here it's a lot better... DM helps. It gets you to like it a little more, so you actually get to do stuff. You want to do work: you don't just sit there."

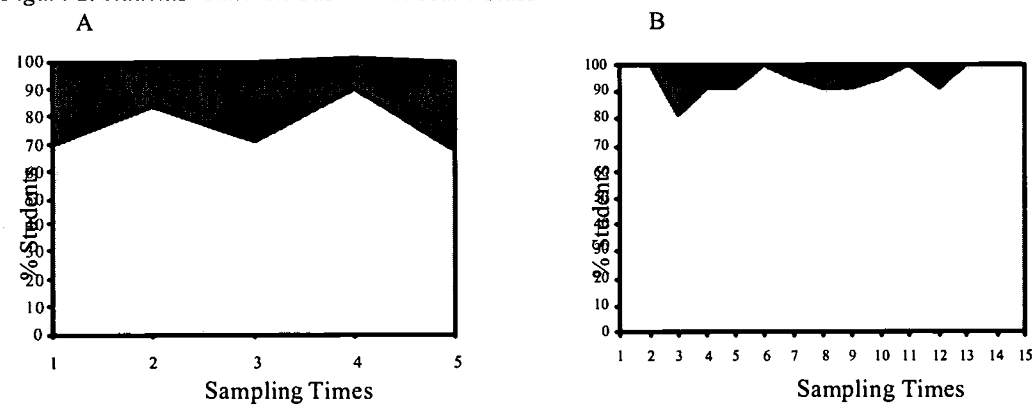
My observations of students' math discussions and activities with DM supported their self-reports of increased engagement with math in the DM class. During their first visits to the computer lab to use DM, I noted that students accessed the system with little delay, engaged in math-talk with one another, completed prescribed assignments, and frequently remained in the computer lab beyond the five-minute bell which signaled the end of math work in the regular math class. To document students' level of engagement with math when using DM, I routinely described the activities of a random sample of approximately one third of the students in each of the eighth grade math classes approximately ten minutes into each class session with DM, occasionally repeating the activity with a new sample of students ten minutes before the end of each session. Table 2 summarizes the activities demonstrated by students while using DM in the computer lab, classified as time-on-task and time-off-task, based on 21 recorded observations (one for each student sample) taken in 15 DM math classes

Table 2. Description of Time-on-Task Categories

Time-on-Task	**Time-off-Task**
Student engaged in math talk: Student discusses math with peer or teacher Student reads or thinks-aloud math	Student talk is not about math: Student asks peer for gum or candy
Student engaged in math activity: Student performs calculations using calculator or paper Student proceeds from one screen to another without visible distraction	Student activity is not about math: Student reads book of English poetry
	Student is disengaged from math activity: Student randomly clicks buttons on screen without obvious purpose or progression Student closes DM program and logs off computer before the 5 minute bell
	Student faults hardware for time-off-task: Student restarts computer Student changes monitor settings Student handles power chords

To further explore students' claims of high levels of engagement with math in the DM class, I used the categories represented in Table 2 to classify the behavior of each student within each observation sample as either on-task or off-task. Figure 2 presents a graphical representation of this time-on-task data, which was taken for students in both their regular math class, during the four-weeks prior to the implementation of DM (Figure 2 A), and in the DM math class during the ten-week implementation process (Figure 2 B):

Figure 2. Students' Time-on-Task in the Math Class



In contrast with Figure 2 A which represents descriptions of students' time-on-task in the regular math class, Figure 2 B shows that an average of 95% of students were found to be on-task with math, when using DM. From the first until the final log, there is very little variation in students' time spent on-task, while using DM. Students' engagement with math in the DM class, defined operationally here as time-on-task, began and remained high throughout this ten-week implementation of the interactive learning system for math. This analysis supports students' claims that they were more interested in math, and more engaged in math activities when using DM, compared with their regular math class, using the Saxon math scheme.

Conclusions and Recommendations

Existing research advocates the use of educational technologies in classrooms to increase students' interest in specific subject matter (Webster, 1990; Yusuf, 1995). The present study supports this claim, and proposes that the level of learner-control afforded to students by an educational technology is positively related to students' level of interest in, and engagement with, the subject matter. Researcher observations of students' use of the interactive learning system in their math class, combined with individual and focus group interviews with students, suggest that the activity choices, multiple representation formats for learning, and opportunities for peer discussion of math concepts which students experienced when they used DM to learn math, increased students' interest in math, and resulted in high levels of engagement with math. Students experienced high levels of control over the instructional enterprise, when using the interactive learning system.

While learner control has generally been used to refer to the delegation of instructional decisions to learners regarding the sequence and pacing of instructional activities and the identification of learning needs (Johnson and Johnson, 1996), this research suggests that learners' decisions regarding the social context for their learning are also critical to our understanding of how learner-control evolves during the classroom implementation of educational technologies. Further exploration of students' math talk while using educational technologies for classroom learning would inform our understanding of how students support one another in developing learner-control strategies during the initial implementation of educational technologies in their classes. This research would enable us to identify strategies that students adopt or co-create to control their own learning using linear and open-ended learning systems in classrooms.

This research suggests that in classroom environments which afford opportunities for students to display what they know and what they can do when using motivational educational technologies, students' classroom conversations, or math-talk may provide compelling evidence of their understanding of math concepts. Implications for classroom practice include providing opportunities for students to engage in sense-making practices with their peers as they work to understand mathematical concepts. As educators, we are called to redress our unfamiliarity with children's ways with words (Heath 1983) - their ways of organizing their experience and expressing meaning, and examine how technology enhanced learning environments may provide a catalyst for exploring evidence of understanding in students' classroom conversations.

This study shows that by increasing students' opportunities exert their own instructional preferences in learning required course content, educational technologies may positively influence students' interest in, and engagement with, subject matter. In light of the tangible benefits for students, this research challenges us to further explore the evolution of learner-control in technology-enhanced learning environments, and thus re-examine the role of the learner in instructional contexts.

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