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Have Your π and Eat it Too! Using a Course Website to Facilitate Student-Centered Learning and Improve the Effectiveness of the High School Mathematics Experience

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Using a course website to facilitate student-centered learning and improve the effectiveness of the high school mathematics experience.

A Synthesis Project Presented

by

JEFFREY L. BRETSCH

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Critical and Creative Thinking Program

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ABSTRACT

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May 2005

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The National Council of Teachers of Mathematics recommends that teachers provide their students with opportunities for student-centered learning. This often occurs in the form of discovery learning, hands-on learning, and interdisciplinary learning. These types of learning experiences fall under the umbrella of the educational theory of constructivism. Constructivism, in short, asserts that meaningful learning occurs when students actively construct their own understanding, making connections and drawing their own conclusions in response to genuine experiences.

Many educators would agree that this type of learning is the ideal, but is not generally feasible due to the broad nature of the mathematics curriculum and the limited time available in class. I am proposing that a course website can serve to remove some of these obstacles and facilitate this type of independent learning. Designing these activities to be completed at home via the web has shifted the responsibility for individual discovery to the individual learner's

time. The instructor can provide students with opportunities to discover and construct their own meaning while minimizing the amount of class time that must be committed. Also, the loosely structured and non-linear organizational structure of the web opens up limitless possibilities for student exploration. Students are able to generate their own resources to be analyzed, synthesized, and evaluated in the context of what needs to be learned. It is this responsibility and freedom to explore that ultimately will foster the habits of mind and problem solving skills that educators so desire our students to have, but find so difficult to teach. These are skills that must be discovered by each learner on their own in their own time. The website that I have proposed in this synthesis can function as a powerful tool for facilitating that discovery.

This synthesis provides a detailed description of this website and specific ways in which it works to achieve its three goals of improving communication with students and their parents, improving student attitudes about math class, and developing problem-solving and higher-order thinking skills.

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CHAPTER 1:

INTRODUCTION

Mention student-centered learning to most high school math teachers and their response might sound something like this: "I wish I could, I really do, but there's just not enough time! The curriculum is incredibly broad, and I have to stay focused if I hope to cover all of the material. I need to prepare my students for the next class in the sequence, not to mention the state exam!" The breadth of topics covered in the high school mathematics curriculum can be imposing. At the same time, state standards are demanding an increased focus on literacy, communication, and higher-order thinking skills such as applying, evaluating, and analyzing. Just being able to "do the math" is no longer enough. Our students are expected to think like a mathematician, talk like a mathematician, and apply math in unfamiliar non-routine settings. There is just not enough time in the school day to do it all.

If mathematics educators hope to help students move past routine and simplistic thinking about mathematics, the National Council of Teachers of Mathematics recommends that we provide students with opportunities for student-centered learning. This often occurs in the form of discovery learning, hands-on learning, and interdisciplinary learning. These types of learning experiences fall under the umbrella of what is known as constructivism. Constructivism, in short, asserts that meaningful learning occurs when students actively construct their own understanding, making connections and drawing their own conclusions in response to genuine experiences. These types of experiences offer tremendous potential for the intellectual growth of our students as confident problem-solvers and logical thinkers and communicators. As such, it is short-sighted for teachers to dismiss them simply because they are too time-consuming. Having said that, finding a way to make the time becomes the challenge.

The question guiding this project is: What happens when constructivist teaching is put into practice in the context of math courses that require broad coverage? Is there a way to both effectively cover the breadth of our curriculum as well as reap the benefits of constructivist learning? Can we math teachers have our pi and eat it too?

Past Experiences & A New Direction

In my attempts to integrate constructivist learning experiences in my own classroom, I was continually frustrated with the amount of class time required to administrate such activities. Organizing groups, giving instructions, passing out papers, and at times even traveling to a computer lab or other outside location can quickly eat up a large portion of the class period before any actual learning has taken place. I also struggled with maintaining appropriate pacing. Due to absences, chattiness, or a handful of other factors, some groups or individuals would often lag far behind the others, making it difficult for the class to move on. This creates wasted class time for the rest of the students as they wait for their peers. Other problems involve participation. It is difficult to ensure that all students are participating in a meaningful way in the activity. At times, after spending three or four hours of class time attempting to help the students learn for themselves what I felt I could have taught them through one hour of direct instruction, I have been tempted to abandon constructivist teaching as highly valuable, but too costly. However, rather than abandon the idea altogether, I decided to explore ways to enable students to participate in constructivist activities on their own, outside of class.

I hypothesized that a class website might facilitate this type of independent learning. The loosely structured and non-linear organizational structure of the web opens up limitless possibilities for student exploration. Students are able to locate resources on their own and then analyze, synthesize, and evaluate those resources in the context of what needs to be learned. Using the web allows an activity to contain a series of specific destinations, while allowing for a wide variety of roads to get to those destinations.

Designing these activities to be completed at home via the web has shifted the responsibility for individual discovery to the individual learner's time. As Shaw (2003) states, "One of the unquestionable benefits that computer technology holds for education is the ability to overcome the limitations of time and space that are created by school schedules and classroom walls" (p. 47). To return to my earlier question, is there a way to both cover the breadth of our curriculum as well as reap the benefits of constructivist learning? Web-based constructivist learning activities allow us to finally say yes! Students are provided opportunities to discover and construct their own meaning while minimizing the amount of class time that must be committed. These independent web-based activities offer other benefits as well. For one, individuals are free to learn at their own pace without the time constraints of the classroom. Also, when the students come to class to discuss the material, each individual has already had the opportunity to process the information in their own way and form their own unique conclusions. This process will work to increase participation and variety in student responses as well as reduce wasted class time.

Designing a website to provide opportunities for student-centered learning assumes that student-centered learning is beneficial and worth the investment on the part of the teacher. As I have stated earlier, I believe that it is. Explaining why I ascribe such value to these types of learning experiences deserves some attention. As such, before describing the specifics of the individual learning activities or of the website in general, I feel it would be helpful to acquaint the reader with the origins of, essence of, and critiques of the educational philosophy known as constructivism. Readers already familiar with the literature concerning constructivism may wish to advance to the material in chapters three through five. These chapters specifically address the application of the course website to teaching with the constructivist model as well as improving the students' mathematics experience in a more general sense.

CHAPTER 2:

INVESTIGATING CONSTRUCTIVISM

Learning in the Traditional Classroom

Research has shown that instruction in the modern mathematics classroom is still typically characterized by a teacher's direct instruction with extended periods of individual practice on routine tasks (NCTM 1989, 1991). The teacher's central role in the traditional classroom is to transmit knowledge to learners and the student's role is to absorb this information. This direct-instructional method, often referred to as the transmission model of learning, is primarily concerned with the end product of the learning process, namely content-area knowledge. Learning is seen as essentially a matter of effectively storing information for later recall (Iran-Nejad, 1995). The goal of this type of instruction is to transmit a body of knowledge from the instructor's brain to the student's brain in the most efficient manner possible.

Constructivist Learning: A Response to the Traditional Approach

Reformers such as Dewey and Bruner have taken issue with educational philosophies that define learning as a product. One of Bruner's major critiques of the traditional approach is that "too much school learning takes the form of step-by-step study of verbal or numerical statements or formulas that students can reproduce on cue but are unable to use outside the classroom." (Bruner, cited in Snowman, 2003, p. 302). He contends that the traditional content-centered mode of instruction has de-contextualized mathematics such that the knowledge acquired becomes disconnected from reality in the mind of students. They are unable to apply their knowledge outside of the highly structured and specific context in which they learned it.

In response to this perceived shortcoming of the traditional approach, Bruner shifts the focus away from learning as a measurable and objective *product* and toward learning as a *process* involving discovery and the individual's creation of meaning. His view of education has largely influenced the philosophy that has come to be referred to as constructivism. In his book, The Having of Wonderful Ideas, Duckworth (1987) summarizes the essence of constructivism as follows: "Meaning is not given to us in our encounters, but it is given by us, constructed by us, each in our own way, according to how our understanding is currently organized" (Duckworth, cited in Iran-Nejad, p. 112). In other words, meaning is not passively received, but rather is actively constructed by the learner. According to psychologist Jean Piaget, meaningful learning is a natural result of an intrinsic drive to resolve inconsistencies and contradictions through the processes of assimilating information into existing schemes and developing new schemes in response to novel or discrepant ideas (Piaget, cited in Snowman, p. 304). The teacher's role is to provide students with opportunities to do just that. Bruner envisioned discovery learning as "a roller-coaster ride of successive disequilibria and equilibria terminating in the attainment or discovery of a desired cognitive state" (Gadanidis, 1994, p. 92). He believed that true learning involves "figuring out how to use what you already know in order to go beyond what you already think." (1983, p. 183). If students are given sufficient opportunities to find their own solutions to problems, they will develop more than just content mastery, they will develop problem solving skills as well.

Another highly significant byproduct is the sense of confidence that comes from learning to find your own way through problem situations. Bruner would describe this as learning *how* to learn *as* you learn. As such, the most important goal of education is seen as teaching children how to think and solve problems (Iran-Nejad, 1995). Mathematics is seen as a tool for developing the mind, a means to an end. This is a dramatic shift from the traditional focus on content mastery. As a crude, but helpful analogy, allow me to compare the student's mind to a computer. The focus of constructivist instruction is not simply to fill the hard drive with as much information as possible, but to make the processor more powerful and thus better able to handle future problems.

Advocates of constructivism claim that this type of learning promises to deliver higher levels of literacy, multiple forms of literacy, self-reliance, cooperation, problem-solving skills, and satisfaction with school (Iran-Nejad, 1995). In the constructivist classroom, the students organize information, explore the learning environment, conduct learning activities, and monitor their own learning (p. 17). According to educational researchers Airasian and Walsh, "Reorienting instruction to non-rote outcomes makes such skills as generalizing, analyzing, synthesizing, and evaluating very important. From an instructional point of view, it puts much more of the onus on the student to construct personal meanings and interpretations" (Airasian and Walsh, 1997, p. 446). In this type of learning, the student is in the driver's seat, the teacher acts as a co-pilot or navigator when students lose their way. This is consistent with the Principles and Standards for School Mathematics set forth by the National Council of Teachers of Mathematics in which they call for a more student-centered math classroom that de-emphasizes rote memorization of isolated skills and facts and emphasizes problem solving and communication, whereby students can gain mathematical power (Draper, 2002).

Difficulties with Implementing the Constructivist Approach

The constructivist approach to education certainly has a lot to offer. It opens the door to connected and authentic ways of knowing. It allows the learner to make their own connections and to explore subjects in greater depth. One major problem mathematics teachers face when trying to teach with a constructivist approach is that a large investment of class time is required for this type of teaching to be effective. This time commitment proves to be a particularly significant obstacle for the advanced or honors-level educator. The breadth of the curriculum is so substantial that there is little extra time for enrichment opportunities or projects. Too often the teacher is forced to choose between sacrificing curriculum content and sacrificing the authentic learning experiences that serve to deepen the students understanding. With the state and federal government as well as local officials increasingly focused on high-stakes testing, accountability and standards, it is not a surprise that many teachers will opt for the latter and sacrifice the enrichment opportunities in favor of covering their required curriculum. This leaves many a progressive educator in a difficult position. We are taught to value instruction that promotes depth of understanding, cooperative learning, and enables self-constructed meaning, yet are driven by the pressure of external expectations to do something that is often quite different from that which we value philosophically. This schism between theory and practice leaves mathematics education in a state that some have compared to schizophrenia (Gadanidis, 1994). While many of us claim to value constructivist learning, the majority of mathematics teachers seldom provide opportunities for it in the classroom.

Critique of Pure Constructivism

Pure constructivists like Iran-Nejad (1995) would disapprove of any compromise involving the blending of traditional and constructivist methods arguing that "constructivism must not be some kind of program added to the curriculum, a revision of direct teaching, or merely a way of teaching higher-order thinking skills"(26). Others, such as Airasian and Walsh (1997), would disagree with this type of all-or-nothing rhetoric. They would assert that constructivist instructional techniques are powerful tools in the educator's repertoire, but they are not and should not be the only tools. In their article, "Constructivist Cautions", Airasian and Walsh (1997) state "Do not fall into the trap of believing that constructivist instructional techniques provide the sole means by which students construct meanings… Thus no single teaching method ought to be used exclusively… One's task is to find the right balance between the activities of constructing and receiving knowledge, given that not all aspects of a subject can or should be taught in the same way or be acquired solely through 'hands-on' or student-centered means" (p. 449). The key word here is "balance". As David Ausubel (cited in Gadanidis, 1994) suggests, all learning that is discovered is not meaningful and all learning that is received is not rote. In their critique of constructivism, Baines and Stanley (2000) also attack the all-or-nothing rhetoric when they state that "Teaching is one of the most demanding and dynamic occupations on earth. With that in mind, the pronouncement that one method of teaching is best seems dubious. In a constantly changing environment, a teacher must be eclectic, spontaneous, and highly adaptable" (p. 330). The constructivist approach is only one in an array of possible instructional strategies. No one approach is effective for all learning styles and all populations of students. By offering multiple modes of instruction, the teacher is best able to reach all learners in a meaningful way.

Some would say that some constructivists like Iran-Nejad also go too far in dismissing content area knowledge as only a means to an intellectual end. While developing thinking skills may indeed be the primary goal, one should not diminish the power of the mathematical ideas being studied. The curriculum is valuable in and of itself as a body of knowledge. Mikasa emphasizes the point that the constructivist teaching methods should be used as stepping-stones to accomplishing existing curricular goals. As such, attempting to choose between student-centered and content-centered instruction is a false choice. The two should not be exclusive but should be intertwined. Both process and product are valuable parts of the learning experience.

Refections on the Literature

Recognizing that constructivism is not an educational cure-all, but rather is one possible tool of many, is not to diminish the impact of these instructional techniques on student learning. They are not the only way to teach, but they are indeed a tremendously powerful way and one that is underutilized. I believe that today, through resources like the internet, the opportunities for the integration of student-centered learning via discovery, hands-on, and interdisciplinary learning experiences as a part of a balanced instructional approach are better than they have ever been. Fleshing out how the web can be used to achieve this goal is the focus of the remainder of this synthesis.

CHAPTER 3:

INTRODUCTION TO THE WEBSITE AS AN INSTRUCTIONAL TOOL

www.quincypublicschools.com/mathwebsite

In the past, taking advantage of the internet as an instructional resource has been difficult since many students did not have a computer at home. This is becoming less and less of an issue with each passing year. U.S. Census Bureau statistics show that in 1997, only 18% of households had internet access, in 2000 the number had already climbed to 41.5%, and a survey of my Algebra 2 and Precalculus classes in May of 2004 showed that 90% of my students had an internet connection at home, 74% of which were high-speed connections. With such a high percentage of my students possessing the resources necessary to access a website at home and the school library making it possible for all others to access it from school, I felt that the time was right to experiment with the usefulness of a class website as an instructional resource.

While a classroom website is not a new idea, it is definitely an underused and under-developed one. A brief survey of existing teacher websites in the Quincy Public Schools as well as other school systems in the greater-Boston area, indicates that the large majority tend to be static in their content and focused primarily on communicating general information such as the course syllabus and the grading policy. In contrast to sites such as those mentioned above, the classroom website described in this synthesis is intended to go beyond the communication of only general information. It is also designed to be a springboard for student-centered learning, independent research, and enrichment.

In this chapter, I will lay out the goals of my website and provide a general overview of its content. I will then introduce the reader to a series of exemplars that will better illustrate some of the unique ways in which the web is able to enrich the learning experience.

Website Goals

There are three primary goals around which this website has been designed. They are as follows:

> Goal #1: To effectively communicate expectations, grading policies, assignments, and other important information to students and their parents.
>
> Goal #2: To improve attitudes about math class.
>
> Goal #3: To encourage and foster problem solving and higher-order thinking skills.

Overview of Website Content

To provide a snapshot of the website's content and features, in the list below I have provided examples of specific ways in which the site addresses each of the three stated goals.

<u>Goal #1: Communication</u>

The website features:

- Student expectations & grading policy
- A course description
- A school calendar

- A daily homework schedule
- Chapter syllabi and review sheets
- Class notes, PowerPoint presentations, & handouts
- The teacher's email address
- Essential information translated into simplified Chinese

Goal #2: Improving Attitudes About Math Class

The website features:

- A hall of fame for top achievers
- Photos of award winning students from years past
- Interesting statistics and quotes
- A Chinese "word of the week"
- Links to helpful, interesting, and fun websites
- Displays of exceptional student work
- A gallery of student artwork including visual art, music, and creative computer programs

Goal #3: Problem Solving and Higher-Order Thinking

The website features:

- Non-routine challenge questions and logic puzzles
- Individual and group projects
- Links to virtual hands-on activities
- Web research and interdisciplinary activities
- Interactive tutorials for MCAS open response questions

- Interactive review games for the midyear and final exams as well as for the MCAS exam
- Thought-provoking statistics and quotes

The remainder of this chapter serves to guide the reader through a series of exemplars. I have chosen a handful of specific features of the website to highlight in hopes that through them, the reader will begin to glimpse the potential benefits that the website as an instructional tool affords.

Communication Exemplar:

Most of the features listed under the "Communication" subheading are relatively self-explanatory. I would, however, like to expand further on one particular component that I think is a particularly helpful application of the website, namely communicating with ESL Chinese learners and their parents.

Depending upon the year, 30-50% of the students in my Algebra 2 and Precalculus classes are Chinese immigrants, many of whom enter my class for the first time at various points during the school year. The majority of these students arrive possessing little-to-no fluency in the English language.

I have found communication with these students to be difficult and my means of communication inadequate. In the past, when a new student has arrived, I have asked the student as well as another Chinese speaking student to stay and speak with me after class. I give the new student a textbook and a series of three papers that they and their parents are expected to read and/or fill out (class expectations & grading policy, a textbook accountability form, and a personal information questionnaire). All of these forms are written in English and I can sense how intimidated the students feel when confronted with this large body of information that they can sense is important, but cannot understand. As a result, despite my best efforts to accommodate them, it often takes a few weeks for the student to acclimate and to understand what is expected of them in my class. In response to this communication problem, I enlisted the help of a student web team consisting of both Chinese and American students. Together, these students and I were able to achieve the following goals:

1. Translation of key classroom documents into Chinese (Simplified).
    a. Course Expectations
    b. Grading Policy
    c. Course Description
    d. Course Outline
2. Creation of a Chinese "word of the week" component.
3. Compilation of links (math-related or otherwise) that might prove helpful to a Chinese immigrant.

The website format has enabled my Chinese students and their parents to access this essential information in a way far more effective than that which I was able to provide previously.

Problem-Solving and Higher-Order Thinking Exemplars:

I would also like to provide a more detailed description of some of the ways in which the website can achieve what I feel is its most significant aim: to encourage and foster problem solving and higher-order thinking skills.

1. Non-Routine Challenge Problems

Each week, the website features a different "Challenge Problem" that the students can complete for homework or extra credit. These problems have been selected from a variety of sources and consist of both logic puzzles and non-routine mathematics problems. They are considered non-routine problems because there is generally not a clearly evident solution process. The challenge lies in deciding how to best apply their prior knowledge and strategies in solving a problem that is removed from the highly structured and predictable context of the textbook. Students are encouraged to experiment, test multiple ideas, and apply a variety of problem solving strategies.

2. Links to Virtual Hands-On Activities

I have provided links within my website to a tremendous resource for educators created by The University of Utah. Their "Library of Virtual Manipulatives" features activities that allow students to experience "hands-on" learning via their computer. For example, to illustrate the concept of an equation as a balance, there is an activity that allows the student to see an actual balance with colored boxes representing quantities on each side. They can then add or subtract quantities from either side of the equation by clicking and dragging different colored blocks onto or off of each side. The site also has an activity that can be used to teach set operations using Venn diagrams. This activity provides a Venn diagram for three sets and asks the user to click on the graphical regions that have been represented symbolically. The program will tell whether the given answer is correct or not and will provide the user with the correct answer if they are unable to successfully locate it. This allows for experimentation and individual discovery on the part of the student.

3. Individual and Group Projects: "The Birthday Problem"

The website also includes opportunities for students to complete projects either individually or within the context of a group. Using the website as the starting place for a project allows for the integration of a variety of technological tools including the web and Microsoft Excel or PowerPoint. To better illustrate, I will describe a project that I give in my Algebra 2 classes involving probability and the famous "birthday problem".

The "birthday problem" project asks the students to use Microsoft Excel and their knowledge of the multiplication rule of probabilities to calculate the probability that at least two people in the class share a birthday. To begin, the students print out a worksheet that provides instructions and space for their work and answers. The website also allows them to download a pre-formatted Excel spreadsheet that will accompany their work and facilitate their calculations. By using Excel to complete a burdensome number of calculations quickly, the students are able to see patterns and draw conclusions from the table that would have been difficult to discover when done by hand or with a calculator.

Since the majority of my students are not experienced with Excel, This project is usually completed in the computer lab in pairs with the teacher acting as facilitator. A more experienced class could conceivably complete the activity individually at home.

4. Web Research and Interdisciplinary Activities: "The Electoral College"

A classroom website allows the teacher to effectively draw upon the tremendous resources available on the World Wide Web when creating activities. This opens the door to true interdisciplinary learning where the student is asked to apply mathematical problem solving skills in the context of an issue in science or social studies. This type of activity goes a long way toward establishing the relevance of mathematics to other disciplines and to the real world.

One activity in this vein that I have created for use in all my classes relates to the Electoral College and how Americans elect our president. This activity takes the form of an individual web-exploration. I begin with a mock newspaper headline proclaiming that one candidate lost the popular vote by ten million votes, yet won the election "fair and square". This controversial statement is designed to create a sense of disequilibrium and to motivate student exploration. The challenge for the students is first to understand the process by which this is possible, and then to calculate and explain the mathematical reasoning behind a theoretical "worst-case scenario" for a popular loss that results in an electoral win.

To provide the necessary background information, the website's initial "roadmap" page contains links to other websites that provide: 1. Information on the what, how, and why of the Electoral College. 2. An interactive map that allows students to view the popular and electoral results of any election in U.S. history. 3. A table of population and electoral data from the U.S. Census Bureau. In addition, there is a printable "exploration journal" where students are asked to answer certain questions and record their thoughts and conclusions as they go through the activity. The activity also asks students to conduct their own research, finding and summarizing an article in favor of the Electoral College and another in opposition to it. Lastly, students are asked to synthesize and reflect upon all of the information they have been exposed to, drawing personal conclusions and stating related topics they would like to learn more about in the future.

After the students have completed this project individually at their home computers or at the school library, class time is provided for a group discussion about our individual findings. During class, the students first discuss their findings and conclusions in small groups of three or four. Then, the teacher facilitates a group dialogue where students can share and debate.

This activity requires approximately fifteen minutes of class time to introduce and another 45 minutes of class time in which to hold the final discussion. By drawing upon the resources of the web, an interdisciplinary activity of this magnitude can be completed with an investment of only one hour of class time.

5. <u>Interactive Tutorials for MCAS Open Response Questions</u>

The state-mandated MCAS mathematics exam asks students to complete six open response questions. These questions generally involve multiple steps and the careful communication of the solution process. These types of problems have historically been the most difficult for students in Quincy. Practicing them in class requires a substantial investment of time which often results in a sacrifice of curriculum. In an effort to provide students with resources for improving their performance without sacrificing an inordinate amount of time in class, a team of five Quincy math teachers including myself worked together to create a series of interactive tutorials. These tutorials can be completed individually at home allowing the student to work at his or her own pace.

The tutorials begin by offering general advice regarding how to answer open response questions. They then feature actual MCAS questions for the students to answer. These multi-step problems are broken down and completed one step at a time. As the student proceeds through the problem, they have the opportunity to access helpful hints along the way. Once the student has completed the problem, they are shown examples of work done by other students who have earned each of the possible scores ranging from zero to four. They are then encouraged to grade themselves and to look for ways to improve their performance on this problem and in the future.

In writing this chapter, it has been my goal to provide the reader with some concrete examples to better illustrate my vision of what an effective course website looks like and to introduce some of the unique applications of this technology. With the website established, in the following chapter I will discuss the ways in which I have assessed and will continue to assess the effectiveness of the site.

CHAPTER 4:

EVALUATING THE IMPACT

Setting/Population:

This website is presently used to supplement the curriculum in all of my classes throughout the academic spectrum, but for the purpose of this project, I will be limiting my study to three college-preparatory mathematics classes in Algebra 2 and Precalculus. These are students from grades 10-12 at Quincy High School in Quincy, Massachusetts. Quincy is a racially and socio-economically diverse urban community on the south shore of Boston. Racially, our school is made up of 21.6% Asian, 5.7% African American, 4.8% Hispanic, 0.5% Native American, and 67.4% White students. Many of our approximately 1400 students come from immigrant families, with the largest numbers being from China, Vietnam, and Albania. Approximately 21.2% of our student population speaks a language other than English as their first language.

Academically, Quincy High School performs near the state average on the state-mandated MCAS Mathematics Exam with 22% of our students scoring Advanced, 32% Proficient, 33% Needs Improvement, and 14% Warning/Failing. 82% of our students go on to two or four-year colleges, with 53% in four-year colleges. The particular students that will be interacting with my website for the purpose of this study are, as previously stated, college-bound students.

Assessment:

To informally assess how effectively my class website is achieving its three primary goals, I have collected a variety of data from my students and their parents. To collect this data, I have distributed a student survey to each of my Algebra 2 and Precalculus students and a parent survey to each of their parents.

To establish a relative baseline for this data, I administered these surveys in the spring of 2004 before the addition of the bilingual content and the newer problem-solving and higher-order thinking activities. These surveys were used to collect data regarding students' comfort level, understanding of class expectations, and general opinions regarding the availability and helpfulness of the website as a resource. I organized the responses by primary language (Chinese or English) and analyzed the results. The 2004 surveys yielded the following information.

- 95% of the students surveyed had a computer at home.
- 90% had internet access and 74% of those connections were high-speed.
- Most students visit the site every week or once every two weeks.
- The site worked well on nearly all of the students' platforms with a few exceptions involving file downloads.
- Using this website throughout the year produced only modest gains in their level of confidence in using computers and the internet.
- Most students agreed that the site is a valuable resource, is easy to navigate, and is attractive.
- Only 10% of parents had visited the website prior to the administration of the parent survey.

To evaluate the effects of the new content, I will re-administer the surveys yearly to determine if there have been significant gains made as a result of the bilingual content and increased number of higher-order thinking activities. In addition to the questions asked on the initial survey which were primarily focused on the communication goal of my website, I plan to add another section focusing more on the latter goals of improving motivation and promoting problem solving skills. These goals are a bit more difficult to assess with a quantitative measure, so I will be relying more on short answer responses.

As an additional source of data relative to this desired change and in response to the fact that only 10% of parents have visited the site, I composed and administered a parent survey in the spring of 2004. This survey was available in both English and Chinese. This survey asked the parent to evaluate their familiarity with their son/daughter's math course before visiting the website and after visiting. Administering the survey to parents provided me with some insights and served to encourage a larger number of parents to access the website as a helpful resource (71% of parents visited the site as a result of the parent survey). "Education experts say that the more parents are involved in their children's education, the better the children will perform in school. One of the best ways to foster involvement is to keep communication flowing from school to home."(Morris, G9) I hold that the website could be a valuable source of information for parents and could help to open up avenues for communication between the parents and myself. Through this parent survey, I have been able to gather data from a different set of stakeholders (parents) regarding the degree to which the website has facilitated the communication of important classroom information. The parent surveys yielded the following information:

- 87% of parents agreed that the website was a valuable resource for parents.

- 70% of parents agreed that they understood the classroom policies better now than they would have without the website.
- 75% of parents agreed that they understood what topics would be covered in class after visiting the site.

Process for Revision & Improvement:

To evaluate the effects of the new content, I will re-administer the surveys yearly to determine if there have been significant gains made as a result of the bilingual content and increased number of higher-order thinking activities.

In addition to the surveys, in an effort to get a more in-depth assessment of student opinions, I will collect and analyze student work as well as conduct informal student interviews throughout the year. As the students work through some of the activities, I will ask them to journal and reflect on their experiences as they go in response to some general prompts. I hope that through this journaling, they will be able to demonstrate the process of their learning in addition to the product. Articulating this process will enable them to learn about their own learning and to value the significance of their role in this type of learning.

The written reflections, along with individual student interviews, should allow me to gather more meaningful feedback regarding the website's impact on students' learning as well as their attitudes toward constructivist learning. I will also ask my colleagues, drawing from multiple disciplines, to provide ongoing feedback concerning the website in a more general sense. By analyzing these responses, I will look for ways to improve the existing content as well as expand the functionality of the site to address perceived needs on the part of the students and their parents. This process of evaluation and revision will be repeated annually as the site develops.

In addition to continuing the assessment of the website's effectiveness, there are several other directions that I can foresee this project taking in the near future. These future directions are the topic of the last chapter.

CHAPTER 5:

FUTURE DIRECTIONS

Now that the essential structure and content of the website is completed and has been informally assessed, I can foresee several related avenues for future exploration. A few of these that I feel merit a brief discussion are: 1. Expanding the library of online activities. 2. Motivating student use. 3. Getting other teachers involved.

Expanding the Library of Online Activities

It has been my goal to design the website as a basic structure into which future activities could easily be integrated. The higher-order thinking activities described in prior chapters are only a beginning. I hope to see continued growth in the website's library of resources and activities. This growth can come from a variety of sources:

1. Activities from the web

There are many resources for the mathematics classroom presently available online, but sorting through them can be imposing. The students can serve as a helpful resource in this process. At times, I have asked my students to research and choose one website that they thought might be interesting or useful to other students in their class. This is an efficient way to locate a variety of interesting resources, and this process also helps to create a sense of ownership on the part of the students. I hope to continue this process each year, gradually improving the quantity and quality of resources available through the website.

2. Teacher-generated activities

I hope to create more web-based activities of my own with a particular focus on constructivist learning. However, creating experiences such as these can be a time-consuming endeavor. As such, I also hope to take advantage of the work of other teachers. As more teachers begin to use the web for their course activities, collaboration between teachers and the sharing of resources becomes easier than ever before. With tens of thousands of math teachers in the U.S., if each teacher were to create even two or three web-based activities and publish them online, the resulting quantity of available resources would be astounding.

3. Student-generated activities

The students themselves can also play a role in the creation of these activities. One of the central ideas of constructivism is that when students generate questions of their own, they are more motivated to find their own answers. This process of directing their own exploration fosters a sense of ownership and increased investment in the ideas being discussed. The teacher can ask the students to work in groups to determine a problem, issue, or question that they would like to explore further. They can then break the problem down, brainstorming related questions and developing strategies for answering those questions. Based on these discussions and their follow-up research, each group can then be given the assignment of designing their own web-based exploration activity. This process would allow students to see their work published online, further encouraging their sense of investment in the course website. It would also serve to generate a large number of possible activities in a short period of time.

Motivating Student Use

Once the structure and basic content of the website are in place, motivating the students to use the site becomes the central challenge. While the website holds tremendous potential for student learning, this is no guarantee that the students will take advantage of the opportunities that this resource affords them. The teacher must set clear expectations and hold the students accountable for their participation in the activities.

Initially, student familiarity with the site's offerings should be an objective. This can be done individually at home with a handout directing them to specific destinations within the site. It may also be worth the investment early in the year to spend one class period in small groups in a computer lab exploring the site and interacting with its content, activities, and hyperlinks. This time set aside for exploration would help to provide an improved level of familiarity and should validate the importance of the website to the course.

In order for students to perceive the website as necessary and relevant, there must be a pressing reason for them to visit the site. This can take on many forms such as posting class homework schedules, class notes, and review sheets online. The students can be asked to retrieve these documents from the site prior to class. This application alone will encourage students to access the website several times per chapter. Also, while many web activities can be useful as stand-alone experiences, the ideal is to integrate the web content into the curriculum and connect it to the material being discussed in class. This requires some pre-planning on the part of the teacher, but the assigning of specific website activities at specific moments in the curriculum will help to insure that these activities serve to enrich and deepen the existing curriculum.

Beyond my Classroom: Getting Other Teachers Involved

If enough teachers in a school created websites to accompany their classes, the school's main website could become a virtual schoolhouse where students and parents could go to access information from all of their teachers. Motivating student use would be a much less significant issue if several teachers were requiring that they access the website on a regular basis. There are several hurdles to overcome before this type of widespread teacher use could be achieved. One of these is teacher motivation. Convincing teachers that this is a worthwhile investment of their time and energy is the first step. To that end, I plan to present my work and the results of my assessment to the other math teachers in my department. It is my hope that, once fully developed, this website can serve as a model for other teachers to emulate and will enable others to see that the rewards in student learning are worth the initial investment on their part. If the teachers in the math department are receptive, I will then bring this idea to the larger school community, encouraging all teachers to consider implementing similar changes. After successfully implementing the change on the department level, it is my hope that my colleagues in the math department will act as advocates to the teachers in other departments.

Another significant hurdle is technical in nature. Many teachers are interested in developing a website but do not feel comfortable using the necessary technology. Overcoming this obstacle requires some administrative support. The department of information technology and media services in our school system has been very supportive of this effort and has purchased a software package for our district that greatly simplifies the website creation process, creating automatically formatted pages that prompt the teacher to enter specific types of information. Using this software, it is possible to create an attractive and useful website with very little effort. After the software is in place, teachers will need professional development time in which to become familiar with its use. Scheduling this time requires the support of the department head and the principal.

In an effort to address some of these obstacles, I have been working with a group of three colleagues who are interested in seeing this change occur. Together with our school system's department of information technology we will develop a professional development plan for familiarizing the faculty with this software and demonstrating the ways in which it can be useful. It is my hope that, given sufficient teacher training and time to gain momentum, this initiative could have a significant impact on both student learning and communication with our students and their parents.

Concluding Remarks:

Throughout the past two years, the website has continued to grow and evolve, and it is my expectation that it will continue to do so. I feel that I have only just begun to tap into the potential benefits to student learning that this resource affords. Technological resources such as the graphing calculator and Microsoft PowerPoint have already had an enormous impact on the way mathematics is taught. The internet holds the potential to be one of the most significant technological resources yet. The versatility of the web opens doors to critical thinking and connected knowing that were inconceivable even fifteen years ago. Authentic constructivist learning experiences are more readily available and easily designed than ever before. By housing these experiences on a website, the educator is able to successfully shift the bulk of the necessary time investment from the classroom to the home or library thereby making the integration of these types of activities a more viable option for the time-conscious educator. This student-centered approach places greater responsibility on the students for their own learning. It is this responsibility and freedom to explore that ultimately will foster the habits of mind and problem solving skills that educators so desire our students to have, but find so difficult to teach. These are skills that cannot be written down on a chalkboard. They must be discovered by each learner on their own in their own time. The website that I have proposed in this synthesis can function as a powerful tool for facilitating that discovery.

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