AC 2009-586: USING WEB-BASED TECHNOLOGIES TO REACH AND ENGAGE MILLENNIAL STUDENTS IN CALCULUS

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Using Web-based Technologies to Reach and Engage Millennial Students in Calculus

Abstract

Today's college-aged students are classified as millennials (born between the years of 1974 and 1994). Several characteristics of this population make web-based technologies attractive tools for reaching and engaging students. Millennials are classified as both digital natives and experiential learners. Moreover, in the area of personality, these students are more warm, outgoing and socially bold than their predecessors. Using these characteristics as a guide, there are a variety of web-based technologies which can be used to more effectively reach millennial students and engage them in learning mathematics. This paper will review use of online homework, e-mail and online tutoring, as well as Web 2.0 technologies such as blogs, wikis and podcasts which focus on social interaction. Practical strategies for implementing these technologies in a college-level mathematics course will be discussed, along with both student and instructor feedback from their use in calculus.

Background

Today's traditional college-aged students, born between the years of 1974 and 1994, belong to the millennial generation. These students display a number of characteristics which differentiate them from their predecessors. According to Richard Sweeney[1], University Librarian at the New Jersey Institute of Technology, millennials want to personalize the products and services they are offered. And they want those goods and services now - they are impatient. They like constant feedback and they want that instantly, too. They learn best by doing (hands-on, active and cooperative, interactive learning) and largely find traditional lecture-style courses uninteresting. But they do want teachers who interact with them face-to-face. They just expect the digital services, too (with speed, convenience and flexibility) and will mix and merge the two to their own satisfaction. While research shows that millennials are not readers, they are major communicators and expect to be able to communicate on the go, whenever and wherever they are. They expect services that can be "time and place shifted" to meet their schedules and needs. Millennials, in the area of personality, are more warm, outgoing and socially bold than their predecessors. These differences suggest that traditional static, non-interactive, text-based approaches to presenting information to these students are not likely to be the most effective way to reach and engage this generation. Web-based technologies, however, are attractive tools for reaching and engaging students. Many web-based products and approaches have the capability to personalize learning, to offer services around the clock and around the globe, and to provide immediate feedback. Consequently, using web-based technologies in conjunction with a traditional calculus course provides opportunities to provide personalized, interactive learning that is available 24-7 and gives students instant feedback. The goal of this project was to incorporate several web-based services into a standard calculus course and determine which, if any, of these technologies students were willing to use, which they found most helpful and why.

Reviews of literature on the use of educational technology and mathematical learning over several decades show that use of technology is associated with gains in student achievement on standardized tests and, in many cases, student attitude. It is most effective if the technology use

is focused and has clear objectives and goals[2,3]. Educational software has been shown to be useful for self-study and have a positive association with student achievement in mathematics[4]. Research also shows that there is strong evidence to support the theory that technology complements traditional classroom instruction[5]. Moreover, there is some evidence from distance education studies to support the notion that use of personalized software tools in combination with traditional classroom instruction is an effective strategy[8]. Regarding use of Web 2.0 technologies in college-level calculus courses, there are studies which suggest that such approaches can capitalize on millennial students' characteristics and successfully increase faculty and student interaction[9].

Our first foray into the use of web-based technology began in 2002 when the Mathematics and Statistics Program at Louisiana Tech University began using a web-based tutorial program, ALEKS[2], marketed by McGraw-Hill, in an effort to provide a more effective mathematics tutoring program for students. The goals in using a web-based program were to increase student retention and success in freshman and sophomore-level mathematics courses (such as calculus) and increase the willingness of students to utilize the available tutorial services. Data on student performance indicated both a strong correlation between student usage of online tutoring and retention/success and that students usage was far greater than for traditional tutoring programs (approximately 1500 students per term for all mathematics courses at the level of calculus and below) than any other tutorial program we have ever had at our university, including come-and go tutoring sessions and the more formal Supplemental Instruction program (both of which averaged 10 – 20 students per day *total* from all lower-level mathematics courses, including calculus).

Spurred by both the personalization afforded by such web-based tools and the overwhelming willingness of students to use a web-based program, Program faculty began to explore other web-based technologies for reaching and engaging students.

An Overview of Web-Based Technologies

There are a variety of web-based technologies available to assist with homework, communication and social interaction, tutoring, and demonstrations both in and outside of the classroom. Some of these technologies are linked with particular texts whereas others are not. Some programs are fee-based, whereas others are open-source. In addition, there are course management systems which are web-based and offer other options for interaction. Here we provide an overview of several of these web-based technologies.

Tutoring: We have used a web-based tutorial program marketed by McGraw-Hill entitled ALEKS[10] (Assessment and LEarning in Knowledge Spaces) since 2002 in an effort to provide a more effective mathematics tutoring program for students. The goals in using a web-based program were to increase student retention and success in freshman and sophomore-level mathematics courses (such as calculus) and increase the willingness of students to utilize the available tutorial services. Based on the student's performance an initial assessment (which measures mastery of prerequisite material and course content for the course in which the student is enrolled), ALEKS provides personalized online tutorial instruction and associated practice problems work toward student mastery of the course syllabus. This feature speaks to the desire

of millennial students for customized services. ALEKS is a mandatory component of the course for every student who enrolls in our Calculus I and II courses and students are asked to spend at least 3 hours *and* make at least 6% progress on ALEKS outside of class each week. Data on student performance indicated that strong student use of ALEKS in Calculus I does highly correlate with both student retention and success, not only in Calculus I and Calculus II, but throughout the entire freshman sophomore calculus and differential equations sequence[11,12,13]. Data also indicates that students use ALEKS in far greater numbers (approximately 1500 students per term for all mathematics courses at the level of calculus and below) than any other tutorial program we have ever had at our university, including come-and-go tutoring sessions and the more formal Supplemental Instruction program (both of which averaged 10 – 20 students per day *total* from all lower-level mathematics courses, including calculus).

Homework/E-Mail: In the Fall of 2006 the Mathematics and Statistics Program at Louisiana Tech University began piloting a web-based homework system in an effort to increase student mastery of course content and increase individual student accountability on out-of-class assignments. They chose a program called WeBWorK[14], developed in the mid-1990's at University of Rochester by Arnold Pizer and Michael Gage. Two of the primary goals of this project were: 1) to increase student mastery of course content, and 2) to increase individual student accountability on out-of-class assignments. Students receive individually parametrized assignments. The fact that no two students are likely to receive the exact same problem decreases the odds of cheating or copying answers from other students, both of which are widespread issues when assigning problems from the textbook. WeBWorK allows students to attempt problems multiple times and provides immediate feedback. This provides immediate feedback that millennial students find attractive and appears to motivate them to stick with a problem until they get the correct answer. It also means that students receive feedback on every homework problem they work (versus a small subset of problems graded asynchronously by a grader). Consequently, students have a much better sense of which type of problem they understand and which they do not. WeBWorK allows students to e-mail their instructor from *inside* a particular problem in their WeBWorK assignment. Again, this gives students the ability to contact the instructor wherever and whenever they might be doing their homework, versus the confines of set office hours. The instructor receives not only the e-mail message from the student, detailing their question(s), but also a direct link to the student's problem inside WeBWorK. The instructor can see the most recent answer the student has submitted (if any), the number of times the student has attempted the problem, the correct answer for the problem, as well as a link to the computer code for the problem. This generally provides the instructor with sufficient information, when paired with the student e-mail message, to provide meaningful feedback (versus just telling them the answer). That is, it is fairly easy to distinguish between conceptual errors, syntax errors, potential programming errors in the problem, etc. Using standard e-mail alone to provide virtual assistance to students affords none of these niceties and is generally unsatisfactory when used for this purpose. It has been our experience that the ease of e-mailing the instructor encourages students to contact their instructor more often than they would if they had to come to office hours the next day[15].

Wikis: Wikis[16] are web pages designed to host documents that can be written, viewed and edited by a group of participants. They can be thought of as the simplest type of database and support hyperlinks. Around since 1995, there are now free wiki programs available (such as PBWiki)

that require minimal training to use. Given that our calculus classes utilize ALEKS for web-based tutoring, WeBWorK for web-based homework, as well as a web-based course management system, Blackboard, students began to request a central listing of information. A free math course wiki was created for this purpose. Students could remember one web url for the wiki and have access to all web-based course tools. Links to all web-based tools were listed, along with current assignments and due dates. The wiki was updated after each class and also listed upcoming exams and projects for the course, along with other course announcements.

Podcasts and Blogs: Podcasts[17] are recorded audio programs that are posted on websites and available for download on computers or mobile devices, such as iPods. Podcasts can be recorded using a computer, several free software programs and a microphone. Music can be overlaid behind the audio program. Podcasts provide an interesting forum for providing short previews or summaries of topics or sections in a textbook, as well as interviews with faculty, students or even famous personalities in a particular field. This is particularly important given the fact that millennials are not readers and consequently not likely to read their textbook before class. Blogs[18] or web-logs are another Web 2.0 technology and are designed as a forum to post web-based journals, logs, news or resources, such as podcasts. Because blogs are intended to be shared with other interested readers, they can be distributed using a content distribution tool, such as RSS. Users can subscribe to the blog information and receive automatic notifications of new postings.

Course Management Software: Course management software[19] has become standard at most universities and provides a course website template for all courses which is customizable by the instructor. Such a course site can be used to communicate with students, from simple announcements to posting of course documents and grades to administering quizzes and uploading homework. Videos, podcasts, web links, etc., can all be posted to a course site which is accessible to all students enrolled in the corresponding course. Other options such as e-mail, virtual classroom, group sub-sites, etc., make course management software a major resource in communicating with millennial students using a variety of Web 2.0-type technologies in one convenient location. Course management software has matured rapidly in the last few years and its popularity has soared. Most universities provide or even require course management software for all courses taught through their system, so while it is a considerable cost for the university, there is no cost to either the faculty or student. During this project, upgrades to the course management software, Blackboard[20] , used at Louisiana Tech University have made it more attractive as a platform to engage students using a variety of Web 2.0-type applications.

Strategies for Implementation

Practical strategies for implementing each of these technologies in a college-level mathematics course are summarized, below. Note that the strategies presented here are not specific to a Calculus I course and could be used in almost any college-level mathematics course.

The web-based tutoring program ALEKS is used outside of class and focuses on prerequisite content which students should know to be successful in Calculus I. Students are asked to log-on to ALEKS and take an initial assessment (covering pre-requisite algebra and trig content needs for Calculus I) during the first week of the term. Students then spend time working on only

those topics which they have not mastered. ALEKS prompts students to take periodic assessments to assist ALEKS in accurately assessing their content mastery. Students are expected to spend at least 3 hours and make at least 6% progress each week of the term in order to receive credit for ALEKS usage. Some instructors check progress on a weekly basis, some prior to each exam, and others only at the end of the term. ALEKS usage counts for at most 4% of the overall course grade in Calculus I and II courses.

Faculty have successfully used the online homework system WeBWorK in a variety of ways in their calculus classes. Some use WeBWorK exclusively to assign and grade out-of-class homework assignments. Others continue to assign (but not collect or grade) homework assignments from the textbook, while assigning a small sample of problems to be completed (and graded) on WeBWorK. There are faculty who assign and grade homework using WeBWorK on a daily basis, just as they would if they were assigning problems from the textbook, while others make weekly assignments. Some only require that all assigned WeBWorK problems be completed by the end of the term. As with ALEKS, usage of a web-based tool such as WeBWorK allows individual faculty the flexibility to incorporate the program in a variety of ways.

All faculty at Louisiana Tech University are now required to utilize course management software (Blackboard) to maintain sufficient material, information and resources on the course site to allow the faculty member to continue to teach the course in the event of a major disaster or other disruption during the term. Specifically what constitutes "sufficient material, information and resources" is still not clearly defined, but left up to the judgment of the Dean. The University has assembled a task-force to provide more guidance on this issue. Ongoing faculty development training is being conducted to assist faculty in obtaining the necessary skills to successfully utilize the course management software. Faculty are increasingly using Blackboard to post grades. Given that students have unique login and password protection for their courses on Blackboard and that the university has disabled guest access to course Blackboard sites, the issue of security of posted grades is considered to be satisfactorily addressed.

Wikis are designed for group document development, although they were used in Calculus I to assist students with keeping up with the range of web tools and corresponding assignments. A course management system can be used to communicate the same information, but not necessarily in as simple a format. While Blackboard contains areas specifically for link information, announcements and assignments, the areas are distinct and buried at least one level into the system, along with a host of other information. The wiki provided a forum for listing all of this information in the same location in a simple, clean format that can be quickly updated and maintained.

Podcasts summarizing course content were recorded and posted online prior to class. Students were encouraged to listen to the podcast prior to attending class to get a quick overview of the day's material. Once posted, podcasts were not removed from the blog site until after the exam. This provided students with the opportunity to listen to them for a quick review of the exam content. Once recorded and saved, podcasts can be reused each time the course is taught or new podcasts recorded and posted, as the instructor desires.

Student and Instructor Feedback from Use in Calculus

With multiple web-based tools being using in a single calculus class, a survey was conducted at the end of the Calculus I course to determine frequency of student use and benefits of each tool. In addition, feedback on how to make the tools more useful was sought. Instructor feedback was collected on each of these topics, as well. Blackboard usage (which is mandated by the university) was included in the survey to compare with the other methods of web-based communication, particularly given upgrades to the software which occurred during this project that have made it a more attractive option for implementing some of the goals of this project.

The survey consisted of 4 questions:

1) Which of the web-based resources have you used for this class?
2) For those that you used, how often did you use them? (Once every 2/3 weeks, Once a week, Twice a week, Three times a week, Daily)
3) What did you like best about the site(s)?
4) What recommendations do you have about the sites?

Figures 1 – 3, below, summarize the student responses:

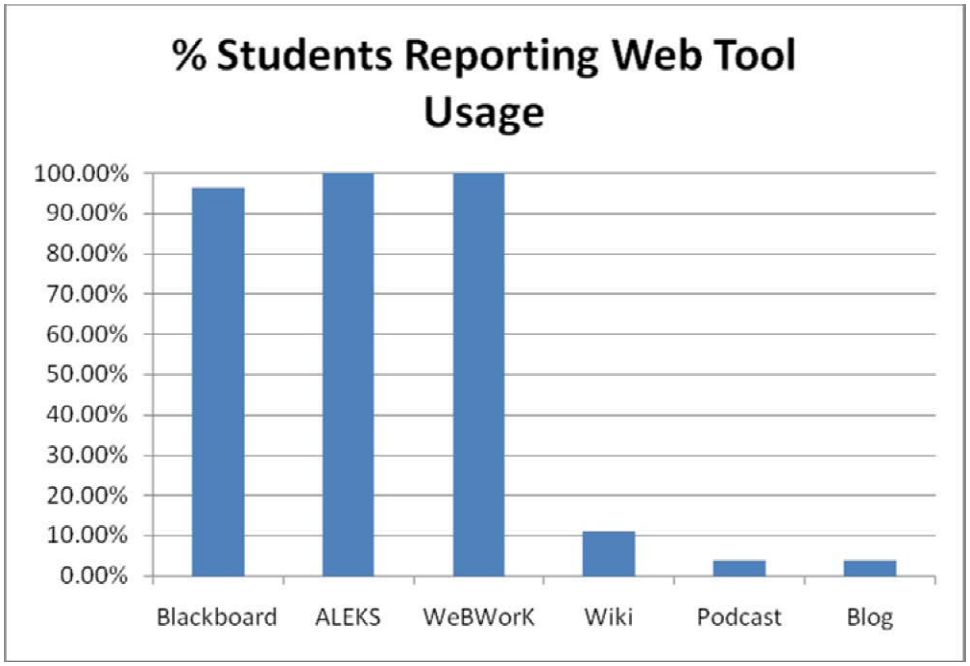

Figure 1 - % Students Reporting Usage of Web Tools during term

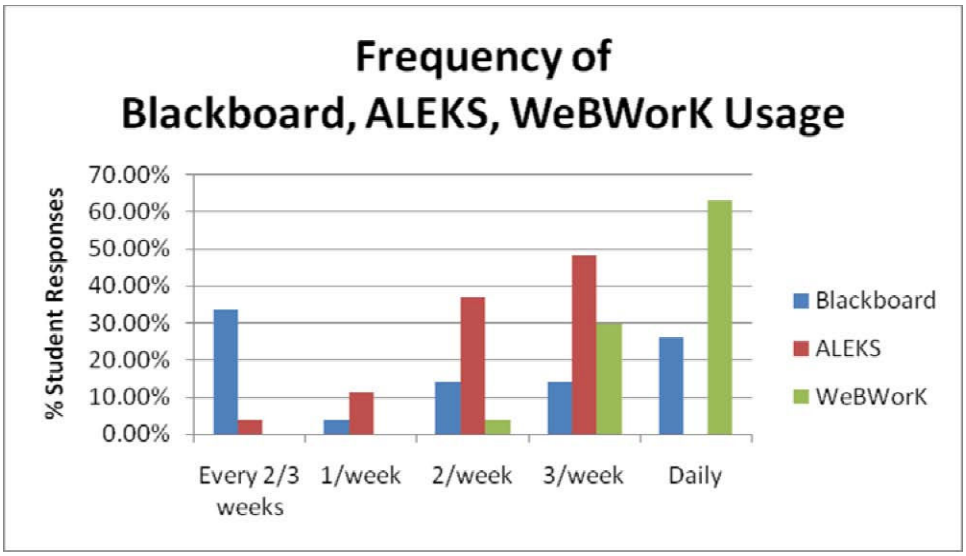

Figure 2 – Self-Reported Frequency of Blackboard, ALEKS, WeBWorK Usage

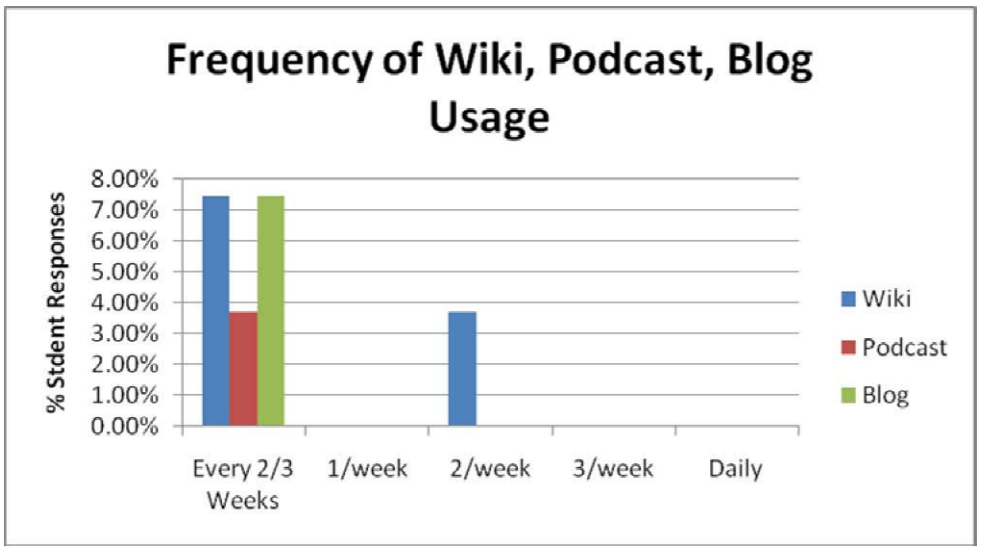

Figure 3 – Self-Reported Frequency of Student Usage of Wiki, Podcast and Blog

Students reported using required tools most frequently (ALEKS for tutoring, WeBWorK for homework and Blackboard for review sheets and handouts). Optional web-based tools, such as the course wiki, podcasts and blog, not surprisingly, reported much less frequent usage. Instructor feedback indicates that with recent campus upgrades to the Blackboard course management software, some features, such as podcasts, could be posted on the course Blackboard site. Use of the Blackboard "Announcement" page could replace the course wiki. Given the frequency of student usage of Blackboard in all classes, the podcasts and wiki information might receive more student attention in that format.

Student comments about what they liked best about each web tool are given, below:

Blackboard

keeps me up-to-date, review sheets
Announcements about upcoming tests and things
being able to get review sheets
class notes, study guides & grades
review sheets
seeing my grades for every class except this one
see grades and schedule
it lets me see announcements for the class
the reviews posted here
Dr. Carpenter could put review sheets on there
announcements, examples, grades
review sheets posted here
provide study guides for upcoming test
like seeing my grades, but this class didn't use that. I logged on when there was a review over an assignment posted
it is great for learning the requirements of the course and communication between the teacher and the class
organized announcements
information for the tests really helped me out
up-to-date easy to download review sheets
the availability of the material and the fact that it is constantly being updated
posted reviews and announcements
everything was there
helpful for students

ALEKS

practice concepts I was rusty on
Feedback that is available
the extra practice with trouble spots
review old skills
helped my math background
helped with reviewing for class
I hate ALEKS
improved my math background
gave instant feedback on problems and always available when needed
review of material
really helped me learn the material
it was effective
learned the stuff I memorized to pass the tests in high school
good help with the basics
helped review basic pre-calculus, easy to use
taught basic algebra skills

rebuilt my algebra foundation & along with webwork, kept my brain active enough that I wouldn't start forgetting concepts
It is great review for past material
helped with patching up holes
amazing algebra practice, wish I could have used this before I took the ACT
good built-in calculator
it helps us to learn by learning form us
excellent basic review
easy grade
shows how to work out problems

WeBWorK

no paper homework I love web-based homework
Multiple attempts allowed for correction of simple typos and mistakes
help on current work & you get to see if you are correct automatically
being able to e-mail the teacher about a problem
easy way to do homework
can go back & find correct answers, can e-mail teacher
Webwork was ok
can instantly see if answer is right or wrong
gave instant feedback on homework
online homework assignments
reinforced material learned in class
not too hard. It was good practice for the material I was learning
unlimited chances to answer a question correctly
emailing the instructor
homework
provide homework and examples for work done previously in class
instant feedback helps you know if you're working the problems right instantly
It is a great reinforcer of learned materials
allows us to easily see past grades
tells you when you get an answer correct
easy to see when work is due and check answers
a new method of teaching and learning that helps to recognize what we need help with
good method of going over recent material
could go back and rework problems to help study
able to rework problems before tests
good practice

Wiki

easy way to find assignments
Wiki was very useful because it was just one site to remember

Podcasts

I went but didn't' find it helpful it just had old stuff

Blog

assignments posted here
I went but didn't find it helpful it just had old stuff

Students seem to favor the course management software, Blackboard, for communication of announcements and are very interested in having grades posted on the course site. Students were generally very positive about their experiences with the online tutorial software, ALEKS, and felt it was very helpful for personalized reviewing of prerequisite content for the course. Similarly, they enjoyed the online homework system, WeBWorK, and particularly liked the ability to receive instant feedback on their work, rework problems they missed and resubmit them for full credit, and e-mail their instructor to receive online assistance. Given that very few students reported having used the wiki, podcasts or blogs, feedback on those tools was sparse and mixed.

Recommendations

Students were asked what changes they recommended with regard to the various web tools. Their responses are given below:

Blackboard

more teachers should post grades via this site
grades be posted & weighted so you can keep up with average better
show and calculate weighted average
post grades
post grades
it would be nice to have grades posted
post grades on blackboard
post grades up please
put class notes on it
post grades
more updates

ALEKS

Great program!
don't require it
easier ways to plug in number
just require percentage, not hours
3 hours and 6% progress is a lot of time spent just doing math, Penalties for missing a question are too high
wished the assessments counted towards progress
typing complex math terms and formulas is very frustrating, especially when one type means another 20 minutes of work

have the info we are going over in class to be practiced
would make start all over if made simple mistakes

WEBWorK

Little more clarity on graphs seems like a lot of students have problems deciding what the scales and things are
check the problems more because they often have errors
constantly changing input for different values such as minf, -I and -∞
less
more consistent questions
show how to do the problem after missing several times
be able to graph on webwork
show how to work problems you can't figure out
show hints for working problems like ALEKS
the notation needs to be the standard notation
better interface
weekend (eliminated or due Sunday night) assignments killed me I go to _____ city on weekends and have no access to internet sometimes
typing complex math terms and formulas is very frustrating, especially when one type means another 20 minutes of work
follow along with the book
fewer bugs/issues
wouldn't give partial credit if only mess up one part of problem like a negative

Wiki

good like it is
update more

Podcast/Blog

update

The primary recommendation was to use the Blackboard course site to post grades for the course. Upgrades to the Blackboard software made during this project have made posting grades an easier task, whereas prior versions of the software made this a tedious task. Judging from student comments, teachers are widely utilizing course Blackboard sites to post grades, perhaps in partial response to the mandate to maintain adequate material on the site to continue the course in the event of disaster or other disruption.

With respect to the online tutoring program, ALEKS, students reported some frustration with errors typing in answers and a desire to reduce the requirement and/or weight of the ALEKS score on their course grade.

The open source online homework system (WeBWorK) generated comments about the quality of the graphing feature, errors in problems from the problem bank, and a desire for sample worked

problems. Another recommendation is to avoid requiring students to complete online homework assignments during the weekend. Some students do not have internet access off campus or may travel out of town on the weekend, making such assignments challenging to complete. For the purposes of this study, assignments due during the weekend (Friday or Saturday night) were assigned early enough to permit students to complete them prior to leaving campus. Still, it would be prudent to make weekend assignments due on Sunday evening so that commuting students or those who leave campus for the weekend are not penalized for lack of access to the internet.

The wiki, podcasts and blog again generated only a few, mixed comments, reflecting minimal student use.

Based on this feedback, it appears that shifting the podcasts and assignment information to Blackboard, along with posting of grades on Blackboard, would be a smarter strategy for attempting to reach students with these tools. Additional investigations with this arrangement should yield information on whether the podcasts and assignment information are worthwhile tools for engaging students in Calculus I.

Conclusion

This paper looks at utilizing web-based tools to reach and engage students today's millennial students in a college-level calculus course. This paper reviewed the use of required tools, such as online homework, e-mail and online tutoring, course management software, as well as optional Web 2.0 technologies such as blogs, wikis and podcasts which focus on social interaction. Practical strategies for implementing these technologies in a college-level mathematics course were discussed, along with both student and instructor feedback from their use in calculus. Survey data shows that students overwhelmingly use and like online homework, tutoring and course management software. While there was some positive feedback with regard to the optional Web 2.0 tools such as blogs, wikis and podcasts, students rarely used them. Utilizing the course management software to accomplish some of the tasks previously relegated to wikis and podcasts has the potential to increase student usage by placing those on a site that students are clearly using frequently. It would be helpful to gather data on student usage with this type of arrangement to determine if these strategies might be successful.

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