Increasing Students' Time on Task in Calculus and General Physics Courses through WebAssign[1]

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1. Introduction

The purpose of this paper is to present an approach of using WebAssign, a web-based homework management and delivery system, as a tool to develop and deliver dynamic active-engagement assignments in Calculus and General Physics courses and to increase students' time on task outside the classroom. The pedagogical practice of incorporating web-based homework assignments to enhance students' time on task is part of academic curricular reform effort undertaken currently by the mathematics, physics and chemistry departments at North Carolina A&T State University under the NSF funded project "Talent-21: Gateway for Advancing Science and Mathematics Talents."

The development of dynamic active-engagement homework assignments involves the creation of well-designed and well-structured questions using HTML and Perl. Questions include features such as randomized content and Java applets. Various formats of questions were used including multiple choice, multiple select, numerical, fill-in-the-blank, symbolic, and essay questions. We will demonstrate how to use these techniques to write more intricate questions to actively engage students in the learning process, help them understand basic concepts, and improve their problem-solving skills. We will also illustrate how to use assignments delivered by WebAssign to create a learner-centered environment by promoting interactive, cooperative learning among students and increasing interaction between students and faculty.

Through using WebAssign to deliver, collect, and grade homework and quizzes, we have observed that students have increased the number of hours spent on academic tasks outside the classroom in Calculus and General Physics as well as interaction with their peers and faculty.

We also have observed that the use of WebAssign has enabled faculty to deliver assignments in increased frequencies and to use immediate feedback from students' responses to adjust their instruction focuses and maintain better communication with students, both individually and as a group.

The paper is organized as follows. Section 2 explains the need and motivation for using WebAssign as a lever to increase students' time on task and ensure that learning is occurring outside the classroom as well. Section 3 presents how to use various question modes to create more intricate questions. Section 4 describes the teaching methodology used in incorporating web-based homework assignments to generate appropriate learning activities outside of class. Section 5 discusses impact of using WebAssign homework and quiz assignments on student learning. Section 6 summarizes the paper.

2. Motivation

In their paper "Seven Principles for Good Practices in Undergraduate Education," Chickerling and Gamson stated that "Good practice emphasizes time on task" [5]. They went further as saying "Time plus energy equals learning. There is no substitute for time on task." It is widely agreed among U.S. university/college professors that adequate time on task is at least two hours of home study for each class hour. In reality, in the U.S. students actually spend only 0.3 to 1.0 hours for each hour in class [8], far below the expectation of their professors and significantly less than the two to three hours outside of class for each hour in class spent by their peers in the U.K. [11]. This raises real concerns. Part of the problem is related to the design of the course: "In most course descriptions what teachers do in class is described while what students do out of class is not—it is simply not planned in the same way or to the same extent." [9] Quite often students are given homework assignments without requiring them to submit their solutions for timely assessment. Even when solutions are collected, only small portions of submitted solutions are graded and feedback is not prompt. When a professor assigns homework regularly, but does not collect it because his/her load is too heavy to grade even portions of it regularly, many students take the opportunity to not do homework or to cram just before an exam. This hinders significant learning which requires regular disciplined work.

In an attempt to tackle this problem, a collaborative academic curricular reform effort among the mathematics, physics, and chemistry departments at North Carolina A&T State University is currently being implemented as a part of the National Science Foundation funded project "Talent-21: Gateway for Advancing Science and Mathematics Talents." One of the central themes of this curricular reform effort is to use WebAssign [17] as a lever to generate learning activities outside of the classroom and to increase students' time and effort on task for the enhancement of their learning. We choose WebAssign as a tool to enhance student learning because it has many distinguished features to promote interactive and collaborative learning, provide instant feedback to both students and instructors, and facilitate communication between students and instructors.

WebAssign is a large-scale web-based program that aids in creating, delivering, collecting, and grading assignments, tracking student performance, and facilitating student-instructor communication [13]. It was developed in the Department of Physics of North Carolina State

University. It allows an instructor to develop a question database with a variety of question types, such as multiple-choice, multiple-select, fill-in-the-blank, numerical, symbolic, poll, essay questions, and a mix of these question types known as multi-mode; all modes but essay and file-upload are graded automatically. One of the great features of WebAssign is that numbers, graphs, and text in a question can be randomized. WebAssign turns each instructor-created question into an HTML form. A set of selected questions is delivered by WebAssign as an assignment. Students listed on a class roster log in to WebAssign, view the assignment, work out solutions to the questions, and submit their responses. WebAssign collects, stores and grades all students' responses. Additionally, it allows multiple submissions by students, enables instructors to provide feedback to students after each submission, and delivers answer keys to students at an appropriate time. Instructors can view class grades, detailed student responses, and a summary of results at any time.

WebAssign fits the profile of an ideal Web-based testing and evaluation system [4, 10, 15, 16]. Features provided by WebAssign enable us to follow at least five principles of the "Seven Principles of Good Practices for Undergraduate Education": emphasizing time on task, encouraging contact between students and faculty, developing reciprocity and cooperation among students, encouraging active learning, and giving prompt feedback.

3. Creating well-structured questions

To effectively evaluate students' understanding of basic concepts and assess their problem-solving skills, well-structured content-oriented questions have to be created first by instructors. One concern for using a web-based homework management and delivery system is that many online questions only ask for the final answers to the questions, leaving out many solution steps. Another concern is that students sometimes get answers from each other without completing the work. The first concern can be alleviated by restructuring traditional textbook and test questions into several parts, each of which seeks a key step of a complete solution to the problem. The second concern can be addressed through randomization of numbers, graphs, and text of questions so that students have different versions of a given assignment. Breaking up a question into several parts means redesigning the question completely with attention to the solution process and using a variety of question modes. Randomizing contents of a question requires working out the problem symbolically and foreseeing possible traps that may invalidate certain answers. Obviously, creating well designed and well-structured questions is a challenging task and is time-consuming. On the other hand, it is a once-and-for-all investment in time and energy. Most importantly, well designed and well-structured questions can be used to engage students, help them enhance their understanding of basic concepts, and improve problem-solving skills. In the following paragraphs, we will demonstrate several examples.

First let us look at an example of finding the limit of a quotient of two functions whose solution requires the use of two fundamental limit evaluation techniques: rationalization of terms involving radicals and cancellation of the zero factor. The original question is to evaluate the limit $\lim\limits_{x \to 4} \dfrac{x-4}{\sqrt{x}-2}$. If this problem is assigned in a traditional paper and pencil fashion, students' understanding of the solution process will be assessed through their complete solution. However, if it is assigned online in its original form, then students must simply find the limit, regardless of

whether they understand the way the problem should be solved. A student knowing how to manipulate with a sophisticated graphing calculator or a computer algebra system can get the right without knowing what a limit means and how to find the limit of a function as x approaches a certain point. This shortcoming can be remedied by redesigning the problem as follows: First we randomize the problem by replacing the number 2 by an arbitrary positive integer k generated through using the WebAssign <EQN> tag with the **randnum** function and evaluating the limit $\lim\limits_{x \to k^2} \dfrac{x - k^2}{\sqrt{x} - k}$ instead, where k is a positive integer ranging from 1 to 30. Next we would like to assess students' understanding of solution procedure and computation skills by asking several questions closely related to the solution process. First the student is asked which of the two limit evaluation techniques should be used first. It is a multiple-choice question. Next the student is asked to identify the term to be rationalized. It is in the symbolic question mode. Then the student is asked to display the resulting function symbolically. That means the student has to carry out the rationalization of the denominator before answering this question. Next the student is asked to identify the zero factor term to be cancelled out from both the numerator and denominator. Then the student is asked once again to display the resulting function after cancellation. Finally, the student is asked for the value of the limit in the numerical question mode. This means the student needs to evaluate the limit of the resulting function as x approaches k. By inserting several questions before the final answer, the student has to demonstrate his/her work in detail. Randomization is used to prevent students from simply copying the answer from each other while at the same time enabling students to work together in small groups to help each other fully understand the solution process of this kind of problem. Figure 1 displays the captured image screen of the restructured problem for the case when $k = 12$.

Display: (a) (**Multiple-Choice**) To evaluate the limit
Versions

$$\lim_{x \to 144} \frac{x - 144}{\sqrt{x} - 12}$$

you have to use the cancellation and rationalization techniques, respectively. Which technique do you use first?
  ○ Rationalization technique - **Correct!**
  ○ Cancellation technique

(b) (**Symbolic**) If the rationalization technique is to be used first, what term do you multiply to both the numeritor and denominator?
[_____] ⊞? [sqrt(x)+12]

(c) (**Symbolic**) What is the resulting function after rationalization?
[_____] ⊞? [(x-144)*(sqrt(x)+12)/(x-144)]

(d) (**Symbolic**) Next you have to cancel the zero factor from both the numerator and denominator of the resulting expression. Identify the zero factor.
[_____] ⊞? [x-144]

(e) (**Symbolic**) What is the resulting function after cancellation?
[_____] ⊞? [sqrt(x)+12]

(f) (**Numerical**) Evaluate the limit of the function obtained in (e) as x approaches 144 to obtain the limit of the original function
[_____] [24]

Figure 1

The next example involves use of the integration by substitution technique to evaluate a definite integral $\int_0^2 x^2 e^{x^3+3}dx$. The problem is modified first through randomization of the integration limits, the power of x term, and the constant term in the exponent of e: $\int_a^{a+b} x^{n-1}e^{x^n+c}dx$, where a = -5,…,0, b = 1,…,5, c = 1,..,5, n = 3 or 5. Several questions related to the intermediate steps of the solution are posed as part of the restructuring of the problem. First the student is asked to specify a u-substitution. Next the student is asked to evaluate the differential of u as a function of x. It is worth pointing out that if a student omits the dx term in the expression of du as some of them usually do, the answer will be graded as incorrect. Hence they would have to consider what is wrong with their answer and put the dx term back. Next the student is asked to display the new integrand in terms of u. This makes sure that substitution and simplification are carried out. Then the student is asked to calculate the new integration limits with respect to u. This is a very important step in using integration by substitution for definite integrals. Then the student is asked to evaluate the indefinite integral of the new integrand. Finally, the student is asked to give the value of the original definite integral to complete the solution process. A randomized version of the problem for the case when a = -5, b = 1, c = 2, and n =5 is given in Figure 2.

Display:
Versions To evaluate the integral $\int_{-5}^{-4} x^4 e^{x^5+2}dx$ using substitution,

(a) (**Symbolic**) you first have to identify an approriate u-substitution:

$u =$ [   ] [+*?] [x^5+2],

(b) (**Symbolic**) you then have to compute the differential of u:

$du =$ [   ] [+*?] [5*x^4*dx],

(c) (**Symbolic**) after the substitution and simplification, the new integrand in terms of u is:

$f(u) =$ [   ] [+*?] [exp(u)/5],

(d) (**Numerical**) the new lower limit of integration in terms of u is: [   ] [-3123],

(e) (**Numerical**) the new upper limit of integration in terms of u is: [   ] [-1022],

(f) (**Symbolic**) the antiderivative of $f(u)$ is:

$F(u) =$ [   ] [+*?] [exp(u)/5+c],

(g) (**Symbolic**) finally evaluate $\int_{-5}^{-4} x^4 e^{x^5+2}dx$ =

[   ] [+*?] [(exp(-1022)-exp(-3123))/5].

Figure 2

We next demonstrate two Calculus II questions. The first one is to use the washer method to find the volume of the solid obtained by revolving the region enclosed by $y = 4 - x^2$ and the x-axis about the line $y = 7$. As usual, we first randomize the problem by introducing two numbers $-a^2$ in the place of 4 and $a^2 + b$ in the place of 7—and letting a vary from 1 to 10 and b vary from 0 to 10. So the problem becomes finding the volume of the solid generated by revolving the region bounded by $y = a^2 - x^2$ and x-axis about the line $y = a^2 + b$. The total number of variations of the problem is 110. Students are asked to answer several questions related to setting up and evaluating the integral. The student is first asked to find the limits of integration. Next the student is asked to find the outer radius and inner radius of the washer. Then the student is asked to specify the integrand. Finally the student is asked to evaluate the integral and find the volume of the solid of revolution. The following is a randomized version of the problem when $a = 5$ and $b = 1$.

Display: To use the washer method to find the volume of the solid created by rotating the region between $y = 25 - x^2$ and the
Versions x-axis about the line $y = 26$,

(a) (**Numerical**) first you need to determine the limits of integration

the lower limit is [_____] [-5]

the upper limit is [_____] [5]

(b) (**Symbolic**) next you need to identify the outer and inner radii

the outer radius $R =$ [_____] ⊞? [26]

the inner radius $r =$ [_____] ⊞? [1+x**2]

(c) (**Symbolic**) after simplication the integrand is

$A(x) =$ [_____] ⊞? [3.14159265358979*(675-2*x^2-x^4)]

(d) (**Symbolic**) the antiderivative of $A(x)$ is

$\int A(x)\, dx =$ [_____] ⊞?
[3.14159265358979*(675*x-2/3*x^3-1/5*x^5)+c]

(e) (**Numerical**) finally find the volume of the solid of revolution based on the results obtained so far

$V =$ [_____] [16755.1608191456]

Figure 3

The second example for Calculus II deals with determination of the interval of convergence of power series $\sum_{n=1}^{\infty}(-1)^n \frac{1}{3^n n}(x - 1)^n$. We randomize the problem by replacing 1 by a and 3 by b, letting a vary from 1 to 30, and letting b vary from 2 to 20: $\sum_{n=1}^{\infty}(-1)^n \frac{1}{b^n n} x(-a)^n$. First the student is asked to identify the nth term of the series. Next the student is asked to calculate the

absolute value of the quotient of the (n+1)th term over the nth term. Then the student is asked to compute the limit of the quotient as n approaches infinity. Next the student is asked to conclude the radius of convergence based on the limit of the quotient. Then the student is asked to identify the two endpoints of the interval of convergence. Next the student is asked to determine the convergence or divergence of the power series at each endpoint. Finally, the student is asked to come up with the interval of convergence. A randomized version of the problem for the case when $a = 4$ and $b = 11$ is displayed as follows.

Display:
Versions
For the power series $\sum_{n=1}^{\infty} (-1)^n \frac{(x-4)^n}{n11^n}$,

(a) (**Symbolic**) first specify the nth term of the series

$b_n = $ [_____] [⁎?] [(-1)^n*(x-4)^n/(11^n*n)]

(b) (**Symbolic**) next calculate the absolute value of the ratio of the (n+1)th term over the nth term

$|b_{n+1}/b_n| = $ [_____] [⁎?] [abs(x-4)*n/(11*(n+1))]

(c) (**Symbolic**) then evaluate the limit of the ratio obtained in (b)

[_____] [⁎?] [abs(x-4)/11]

(d) (**Numerical**) what is the radius of convergence?

$R = $ [_____] [11]

(e) (**Numerical**) what are the endpoints of the interval of convergence?

the left endpoint is [_____] [-7]

the right endpoit is [_____] [15]

(f) (**Multiple-Choice**) is the power series convergent at the left endpoint?
  ○ No - **Correct!**
  ○ Yes

(g) (**Multiple-Choice**) is the power series convergent at the right endpoint?
  ○ Yes - **Correct!**
  ○ No

(h) (**Fill-in-the-Blank**) determine the interval of convergence. [_____] [(-7,15]]

Figure 4

In the following examples, we demonstrate how WebAssign is being used to assess and facilitate learning in physics. Physlets® [12], small scriptable Java applets, are used to present an animation of a physical phenomenon [3, 6, 7]. The Physlet used in these examples is called Animator. JavaScript allows the question author to create objects, define their properties, and define their trajectories or forces on the objects.

The purpose of these questions is for students to make measurements and use conceptual reasoning in order to solve the problem. This radically differs from typical textbook problems where numbers needed to solve the problem are given in the text of the question. Novice problem solvers often use the numbers given in the question to find the "right" equation; little conceptual reasoning is used to analyze the situation before applying equations [14].

However, in these questions, few numbers are given in the question. Therefore, students must use a more expert-like approach to solving the problem by considering what principles are needed, what quantities must be calculated, and what data must be collected. It is akin to an open-ended laboratory experiment.

Consider the problem in Figure 8. Two billiard balls, albeit non-standard billiard balls, approach one another. Their positions and the clock reading are shown in the animation. In part(a), students are asked to find the mass of the red billiard ball. The student must first apply conservation of momentum, determine that the velocities of the balls before and after the collision must be calculated, and use the position and time data to calculate those velocities. The last step is to solve for the mass of the billiard ball. Thus, many characteristics of higher-order problem-solving skills are needed to solve the problem.
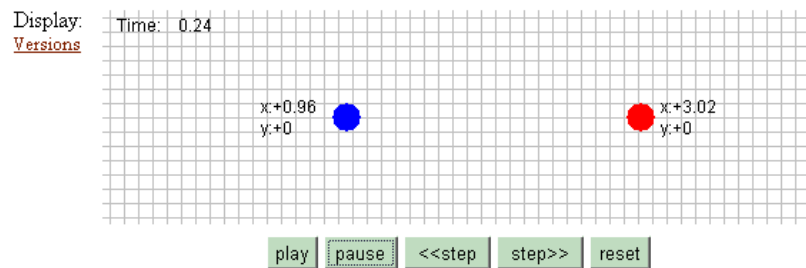

Figure 5

To motivate students to work together in solving problems, but not just share the final answers, WebAssign is used to randomize parameters of the animations and/or numbers in the text of the question. In Figure 6, the mass of the cart and also the position at which students must calculate the mechanical energy is randomized.

The question in Figure 7 demonstrates how multiple choice questions are sometimes combined with numerical problems to assess both conceptual understanding and problem solving. To calculate quantities such as the distance of the first child from the center of the merry-go-round, students can click on the child to measure her position.

In the past one and half years, over six hundred Calculus I and II questions have been created by the first author of this paper, many of which are randomized questions, and some of which require post-processing. More than seven hundred General Physics I and II questions have been created by the second author of this paper who was a co-developer of WebAssign. Most of these questions can be accessed by anyone using WebAssign. If you use WebAssign and would like to

include these questions on your assignments, please email us and we can give you information that will help you find the questions in the WebAssign database.

Display: Versions

Time: 1.15

x:+0.529
y:+0

play   pause   <<step   step>>   reset
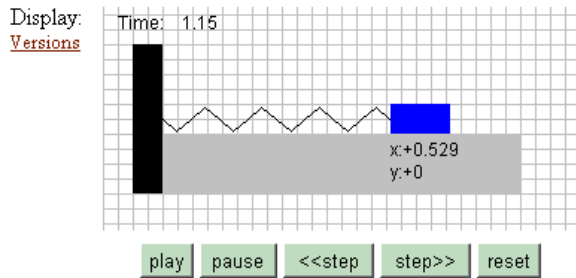
Start Animation(**Click here for help using the animation.**)

A spring is attached between the end of an air track and a 1.5 kg cart. The cart is pulled back from its equilibrium position (x=0) and released such that it oscillates as shown in the animation (position of the cart is in meters and time is in seconds; the equilibrium position of the spring is x=0).

a) What is the speed of the cart as it passes through the equilibrium position(hint)? [_____] [5.65] m/s

b) What is the kinetic energy of the cart at the equilibrium position? [_____] [24] J

c) What is the spring constant of the spring? [_____] [59.2] N/m

d) What is the total mechanical energy when the cart is at x=0.728 m? [_____] [24] J

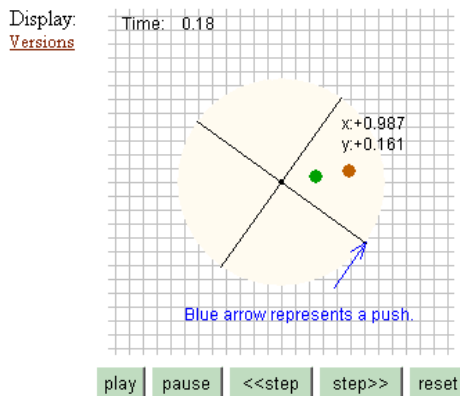e) What is the kinetic energy when the cart is at x=0.728 m? [_____] [8.29] J

Figure 6

4. Incorporating WebAssign into teaching and learning

WebAssign is used as an assessment tool to influence students' out of class learning behavior and generate appropriate learning activities. Currently, WebAssign is used for assigning both homework and quizzes. Weekly homework assignments and quizzes are designed to conduct both formative assessment and summative assessment, with homework leaning toward formative assessment and quizzes being more summative. Online homework assignments and quizzes are considered as formative assessment because both provide instant feedback to students on their progress. They are also regarded as summative assessment because both mark correctness of students' responses to summarize what has been learned. Both homework and quiz averages are used as part of the final grade. However, in homework assignments normally ten submissions are allowed-hence more feedback and opportunity for mastery is being provided−whereas for quizzes only three submissions are permitted. In addition, homework questions are gener ally not randomized, whereas all quiz questions are randomized and seek more detailed responses from students.

WebAssign has been used in Calculus I and II by the first author for three semesters. In the Fall semester of 2000, WebAssign was first used in two Calculus I classes to primarily assign bi-weekly quizzes while a question database for Calculus I was being developed. At that time the

symbolic question mode was not available. Thus the questions created at the time were mainly multiple-choice, fill-in-the-blank, and numerical types. Besides online quizzes, traditional take-home paper quizzes were also assigned every other week on Friday and collected on Tuesday. Paper quizzes were graded by a graduate teaching assistant using grading guidelines provided by the instructor. The combined quiz scores counted 15% of the course grade. Students' performance on online quizzes through WebAssign was slightly better than that on paper quizzes partly due to the fact that students got three submissions and prompt feedback after each submission on online quizzes. It was also noticed that students started to work together in groups and sought help from the instructor, tutors, and their peers. Increased interaction between students and the instructor, and among students themselves, and more time spent by students on homework and quiz problems were two preliminary findings in the experimental use of WebAssign to assign quizzes.

Display:
Versions

Time: 0.18

x:+0.987
y:+0.161

Blue arrow represents a push.

play   pause   <<step   step>>   reset

Start Animation(**Click here for help using the animation.**)

(a) Two children sit on a merry-go-round which is given an initial push as shown in the animation. Which child has a greater rotational kinetic energy after the push? The position of the outermost child is given in meters and time is in seconds. hint
  ○ neither, they have the same rotational kinetic energy
  ○ the child sitting toward the center
  ○ the child sitting toward the edge - **Correct!**
(b) If the mass of each child is 26 kg, what is the rotational kinetic energy of the child sitting toward the edge of the wheel?
  [ ] [57] J

(c) Compare the moment of inertia of the child sitting toward the center of the merry-go-round to that of the outermost child. It is
  ○ 8 $I_{outermost\ child}$
  ○ 1 $I_{outermost\ child}$
  ○ 1/8 $I_{outermost\ child}$
  ○ 4 $I_{outermost\ child}$
  ○ 1/4 $I_{outermost\ child}$ - **Correct!**
  ○ 2 $I_{outermost\ child}$
  ○ 1/2 $I_{outermost\ child}$
(d) If the mass of the merry-go-round is 250 kg, what is the rotational kinetic energy of the whole system (i.e. merry-go-round and children)? [ ] [688] J

(e) What was the work done on the merry-go-round by the person who originally pushed the merry-go-round?
  [ ] [688] J

Figure 7

In the Spring semester of 2001, WebAssign was used in a Calculus II class to assign online quizzes weekly while a question database for Calculus II was being created. The combined quiz scores counted 20% of the course grade this time. Additional question modes, such as symbolic, multi-select, and multi-mode, as well as randomization of numbers, graphs, and text content were used. A quiz was usually assigned on Friday and due by Tuesday night at 11:55 PM. Students were given three submissions with feedback being provided after each submission and answer keys being posted after the final submission. After each assignment was past the due date, the instructor reviewed students' scores, detailed responses, and the class summary and used this information to identify certain concepts and skills that needed to be stressed again in class. Students' performance on an assignment sometimes was used to adjust the pace and focus of lecture and to modify quiz questions. In addition, before each of the three hourly examinations and the final examination, a set of randomized review problems was posted on WebAssign as a quiz. After the final submission was done, a review session was conducted, and students were asked to share their solutions with each other. The complete solutions to the review problems were also provided by the instructor to students. After each hourly examination, randomized versions of test problems were again posted in WebAssign as an optional assignment so that students could work through the same types of test questions again and make extra credit points.

A total of thirteen quizzes were assigned in that semester. The instructor was told by many students that they typically spent six to eight hours each week to complete the weekly online quiz. A number of students worked together on Monday or Tuesday evening to go through problems similar to those on the quizzes and try to understand the solution procedures. The later was enforced by the structure and randomization of quiz questions so that an individual student had to work out his/her version of the problem set to come up with the right answers to the quiz questions. On the other hand, different versions of the quiz questions are of the same format so that collaborations can be forged. The instructor once again observed the increased visitation of students to his office during his office hours, especially on Monday and Tuesday. Sometimes he had to extend his office hours on those two days to accommodate students' needs for help. Additionally, a number of students sent e-mails to the instructor seeking clarification for certain questions or help for technical difficulties. Through his increased interaction with students during that semester, especially by repeatedly answering some routine problems students had and viewing students' responses to WebAssign quiz questions, he also noticed that even though homework was assigned almost daily, not many students completed assignments timely, and some of them even did not try them at all since homework was not collected and graded at the time. This made him realize that somehow homework assignments need to be assessed as well through WebAssign on a regular base.

Consequently, in the Fall semester of 2001, besides assigning weekly online quizzes in WebAssign, homework was assigned daily, and collected and graded once a week through WebAssign for a Calculus I class. To address students' unfamiliarity with WebAssign question mode, and syntax, a brief training session was conducted. A listserve was established for the class so that all course related matters can be discussed openly and promptly between students and the instructor and among students themselves. A non-credit quiz was assigned in the very beginning of the semester so that students had an opportunity to try out various question answering modes and syntaxes. Students were allowed to submit their answers five times. Regular online homework assignments and quizzes started in the second week after class

enrollment was stabilized. A weekly homework set was assigned on Monday, and due on Friday by 11:55 PM, while a weekly quiz was assigned on Friday and due on Tuesday by 11:55 PM. Each homework assignment contained an average of fifteen multiple-part non-randomized problems, and required an average student to spend three to four hours to complete the work. Each quiz had about ten multiple-part randomized problems, and expected an average student to spend four to six hours to complete the work. Pre-test review problem sets were given in the form of quizzes. Post-test extra credit problem sets also were given as optional assignments. The combined homework scores counted 15% of the course grade, weighted equivalently to one hourly exam. The combined quiz scored counted 20% of the course grade, weighted equivalently to the final exam. A total of twenty-seven assignments were given in that semester. A survey on the use of WebAssign was conducted near the end of the semester. It was found that an average student spent ten to twelve hours each week to complete online homework collections and quizzes. The most liked features of WebAssign are multiple submissions, instant feedback, and flexibility to view and submit assignments from anywhere at anytime. More detailed information about the survey will be discussed in the next section.

WebAssign has been used in General Physics I courses since 1998 when the second author joined the physics faculty. He was instrumental in introducing WebAssign to faculty on the A&T campus and has continually promoted the use of WebAssign and provided managerial and technical support to the users.

In General Physics I classes in the Fall semester of 2001, homework was given once per week and mostly covered one chapter. Each assignment had 10 possible submissions and usually included 7 to 10 multi-part questions. Mostly questions with numerical answers were used; occasionally conceptual multiple-choice questions were also included. The homework grade was 20% of the course grade, the equivalent weight of one exam.

Homework was generally due on the day after the instructor concluded lecturing on a certain chapter. Students often had questions about the homework on the day before it was due, and the instructor would generally help them where they were stuck but not give too much information. He was somewhat dissatisfied with this approach. Presently he is using WebAssign to provide a homework assignment for each class day that covers the content on that particular lecture. In this way, he hopes that students will get more practice applying the concepts and principles discussed during the lecture. In addition, it is hoped that students will make better connections and that assessment will more closely match objectives.

5. Impact on student learning

We have attempted to use WebAssign as a lever to engage students in the learning process and to redirect their learning effort in Calculus and General Physics courses in the last several years. We have observed that weekly homework assignments and quizzes−delivered, collected and graded through WebAssign−have
- increased students' time and effort
- generated appropriate learning activities such as interactive and cooperative learning
- increased contact between students and faculty
- increased reciprocity and cooperation among students

- provided prompt feedback to students

In addition, use of WebAssign enables the instructor to pay attention to what students do in order to learn, hence creating a learner-centered environment [1, 2].

These observations were supported by the results of a recent student opinion survey on the use of WebAssign. There were 23 students from a Calculus I class and 147 students from two General Physics I classes who participated in the survey. Eleven questions were asked on the survey, nine of which were multiple choice questions and two others were essay questions. The following is a summary of the survey results.

Question 1. How much time per week did you spend doing WebAssign homework? Include time at the computer and time solving homework problems off-line.

Time on Task

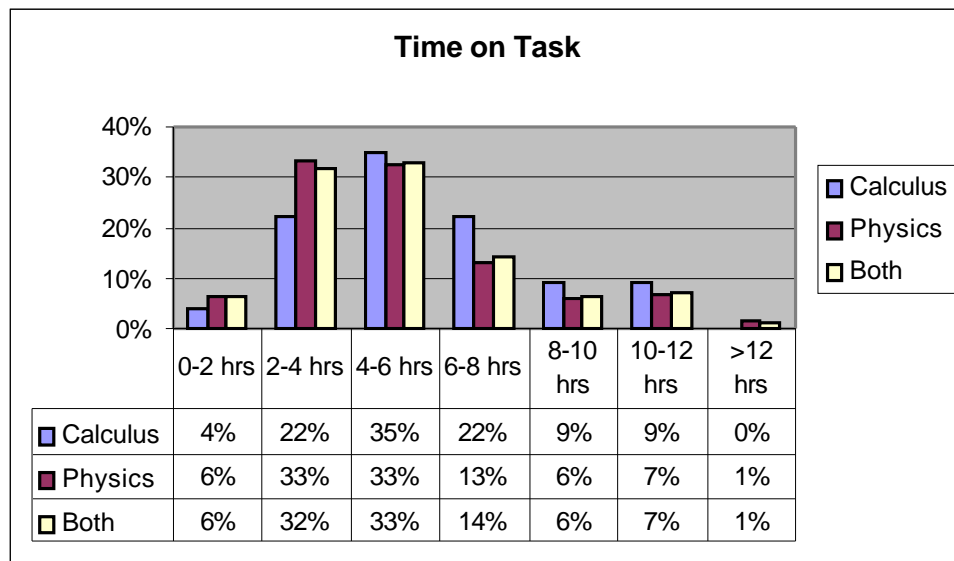|	0-2 hrs	2-4 hrs	4-6 hrs	6-8 hrs	8-10 hrs	10-12 hrs	>12 hrs
Calculus	4%	22%	35%	22%	9%	9%	0%
Physics	6%	33%	33%	13%	6%	7%	1%
Both	6%	32%	33%	14%	6%	7%	1%

Figure 8

It follows from the chart above that more than sixty percent of students in both Calculus and Physics classes spent 4-6 hours or more each week to complete WebAssign homework. In Calculus class, weekly quizzes were also given. It was reported by students and observed by the instructor that the Calculus students spent at least a similar amount of time each week doing WebAssign quizzes. Because of the importance of time on task, we are considering an increase in the amount of assigned homework−a decision dreaded by our classes to be sure.

Question 2. Please indicate your agreement with the following statement. *Doing homework using WebAssign enhanced my learning of the course content.*

Again more than sixty percent of students in both Calculus and physics reported that doing WebAssign homework enhanced their learning of the course content. Only 17% in Calculus, and 14% in Physics disagreed with this assessment. It is possible that paper-based homework might have a similar effect.
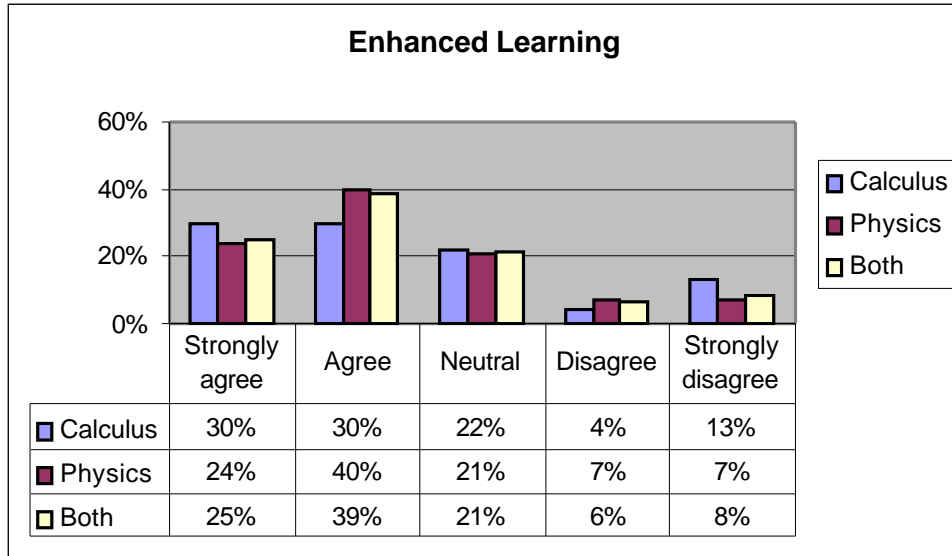
Enhanced Learning

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Calculus	30%	30%	22%	4%	13%
Physics	24%	40%	21%	7%	7%
Both	25%	39%	21%	6%	8%

Figure 9

Question 3. When doing homework did you work independently or collaboratively with one or more classmates?
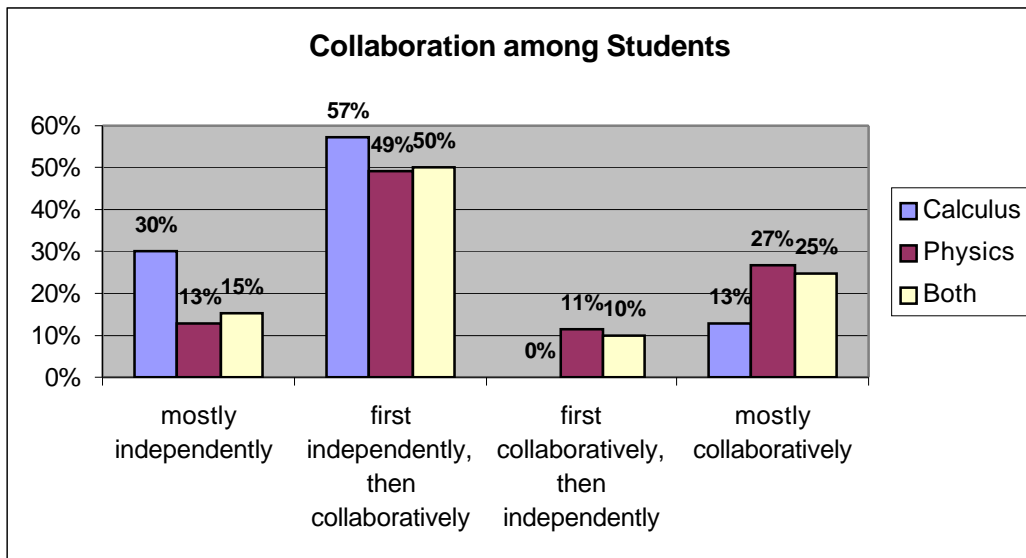
Collaboration among Students

Figure 10

More than 70% of Calculus students and 87% of Physics students reported that they collaborated more or less with other students to complete their WebAssign homework. Collaboration among students was really occurring. We believe that such collaboration was promoted by the use of WebAssign. It is interesting to note that half of students first work independently before seeking the help of classmates–a practice that we encourage.

Question 4. Consider the following two options for homework:

  (a). *Paper homework*: Submit homework on paper once per week, have it graded by hand (just right or wrong indicated with no partial credit), and returned within two days.

  (b). *Online homework*: Submit homework via WebAssign with ten submissions and right/wrong feedback.

Assume that the homework problems in the two cases are the same. Which do you prefer?

Homework Assignment Preference

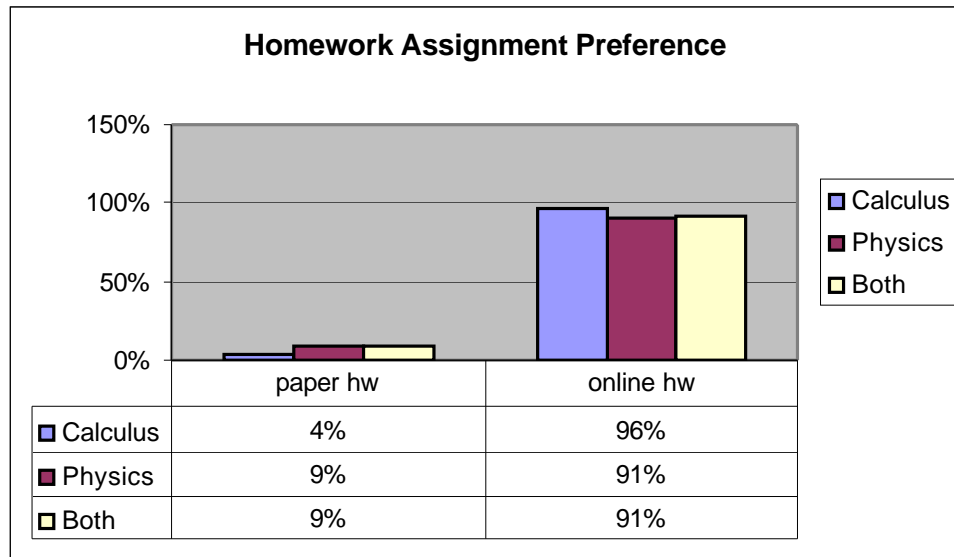|	paper hw	online hw
Calculus	4%	96%
Physics	9%	91%
Both	9%	91%

Figure 11

Given the same grading criteria, students who had used WebAssign overwhelmingly preferred WebAssign homework over paper homework. It is interesting to note that another Physics professor who had been collecting and grading paper homework weekly also conducted a survey on students' preference on the use of paper homework or online homework. In grading, he gives detailed feedback, pointing out students' errors and giving partial credit. He also returns homework by the end of the same day that it's due. In his case, students were evenly divided over which system they prefer. Therefore, it seems that hand-graded homework is at least equally preferred to WebAssign if it is well-graded with detailed feedback and partial credit. However, given similar grading criteria, WebAssign is overwhelmingly preferred, presumably mostly due to multiple submissions and immediate feedback. With large-lecture courses where the options are generally WebAssign, homework graded by a teaching assistant, or no homework assigned at all, WebAssign is a clear choice.

Question 5. Did having WebAssign homework increase your interaction with the professor in and outside of class?

It is interesting to note that the opinion on whether having WebAssign homework increased their interaction with the professor differed significantly between Calculus students and Physics students. We suspected that class size, question modes employed in assignments, and frequency of assignments may affect their opinion on this question. First, the Physics class size was much larger than the Calculus class. This may have an impact on each individual student's contact time with the instructor. Next, in Physics most WebAssign homework questions are of numerical or

multiple-choice types, whereas in Calculus most WebAssign homework questions are of symbolic or fill-in-the-blank types for which students are required to work out solutions in detail and enter their responses in precision. Hence more help or clarification may be needed from the instructor. In addition, Calculus students were also given weekly WebAssign quizzes. Increased frequency of assignments in Calculus may make students seek more help from the instructor. Overall, 43% of students in Calculus and Physics thought that doing WebAssign homework increased their contact with the professor.
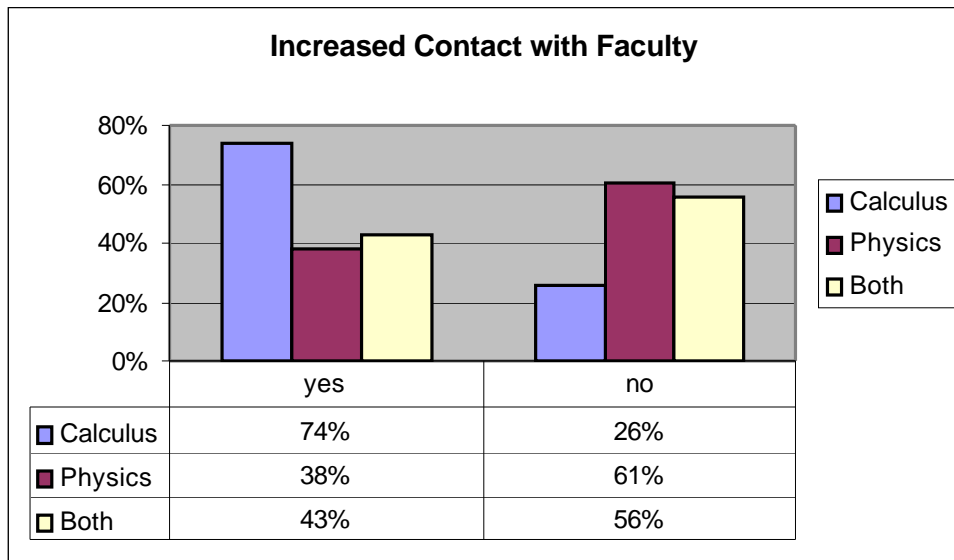
Increased Contact with Faculty

	yes	no
Calculus	74%	26%
Physics	38%	61%
Both	43%	56%

Figure 12

Question 6. Did having WebAssign homework motivate you to seek help from tutors, the professor, or classmates?

Seeking Help from Others

	yes	no
Calculus	91%	9%
Physics	85%	14%
Both	86%	13%

Figure 13

Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition
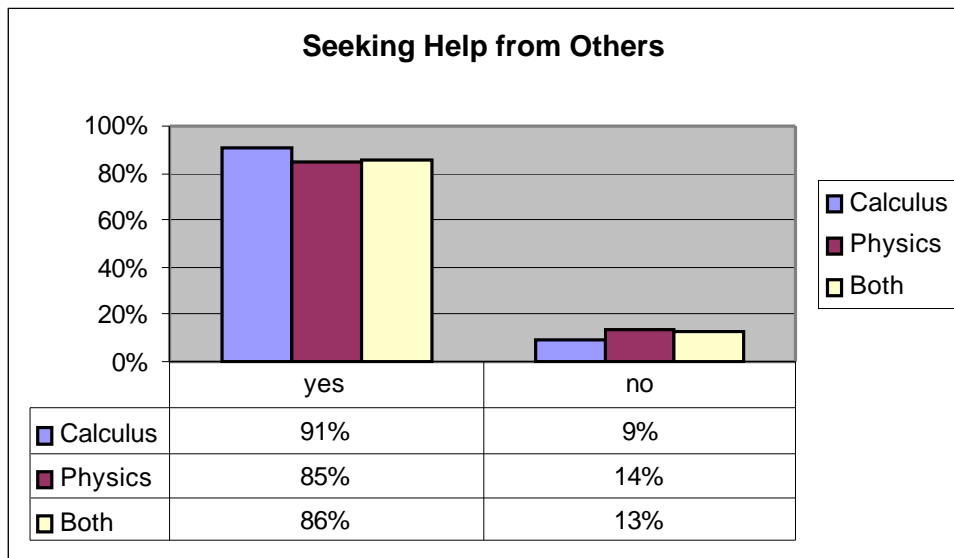*Copyright©2002, American Society for Engineering Education*

As illustrated in Figure 13, the majority of students (91% of students in Calculus and 85% of students in Physics) sought help from tutors, the professor, or classmates while doing WebAssign homework. Students' responses to Questions 3 and 6 clearly indicated that using WebAssign to assign homework actively promoted cooperative learning. It is possible that this is a general effect of any homework, paper or web-based. If homework is assigned and graded, students will likely seek help.

Question 7. Please indicate your level of agreement with the following statement. *Technical difficulties with WebAssign, computers, or networks significantly affected my performance and attitude toward homework in this course*.

This is the second question for which the opinion between Calculus students and Physics students differed significantly. From Figure 14, we notice that 43% of Calculus students reported that technical difficulties, network, or computers did affect their performance and attitude toward homework in the course, whereas only 21% of Physics students concurred with the opinion. We believe that a greater percentage of Calculus students reported technical difficulties because of the significant use of symbolic mode questions where students entered equations. A missing parenthesis or asterisk will cause an error just as it would with a graphing calculator, computer program, or computer algebra system such as Maple.
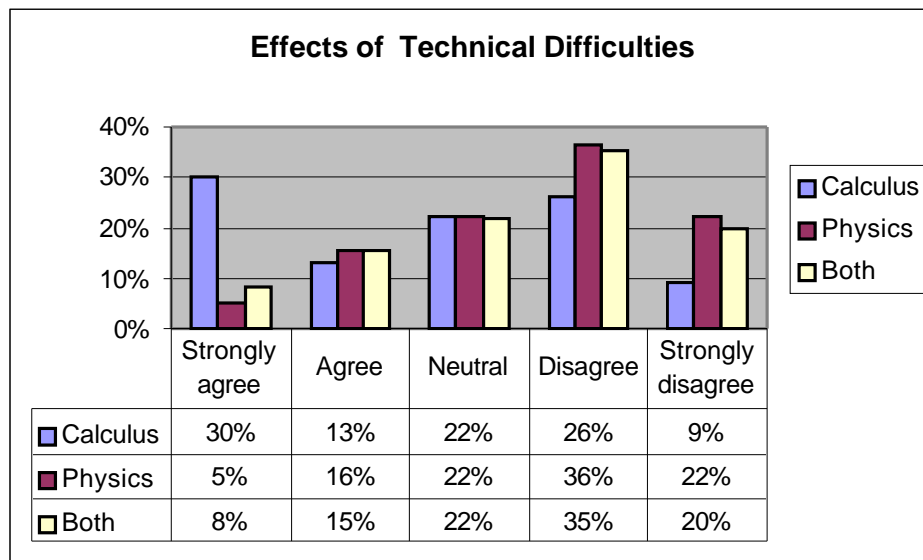
Effects of Technical Difficulties

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Calculus	30%	13%	22%	26%	9%
Physics	5%	16%	22%	36%	22%
Both	8%	15%	22%	35%	20%

Figure 14

Question 8. Please indicate your level of agreement with the following statement. *If homework was NOT collected and graded, I would spend less time solving problems and studying the content taught in this course.*

More than half of students (52% in Calculus and 59% in Physics) agreed that the use of WebAssign motivated them to spend more time on homework and studying.
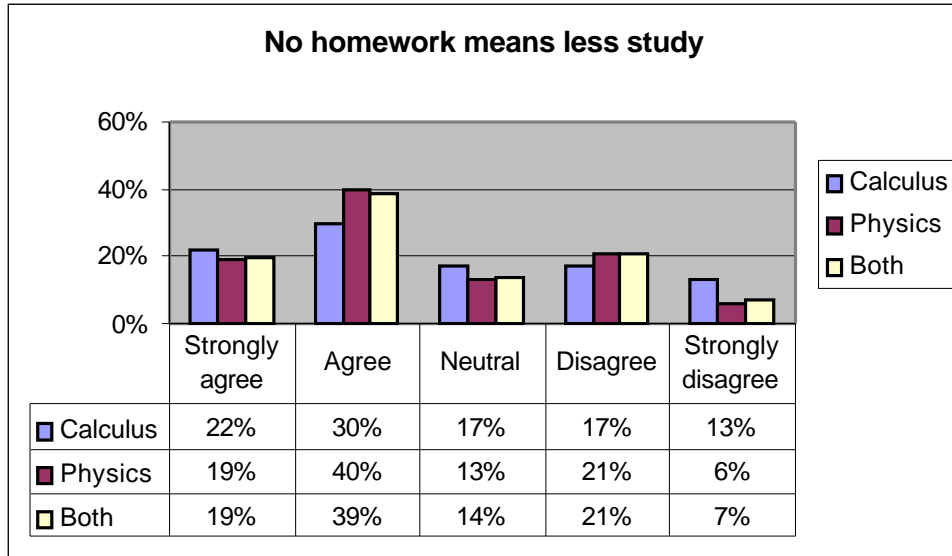
No homework means less study

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Calculus	22%	30%	17%	17%	13%
Physics	19%	40%	13%	21%	6%
Both	19%	39%	14%	21%	7%

Figure 15

Question 9. At what location did you most often access WebAssign?

Where to Access WebAssign

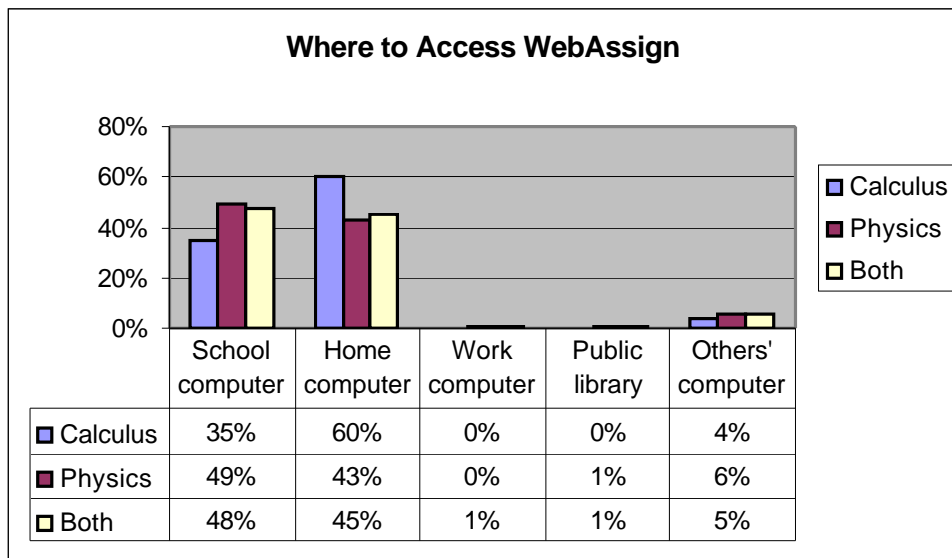|	School computer	Home computer	Work computer	Public library	Others' computer
Calculus	35%	60%	0%	0%	4%
Physics	49%	43%	0%	1%	6%
Both	48%	45%	1%	1%	5%

Figure 16

More than 90% of students used either school computer labs or home computers to access WebAssign. It is a comfort that computer and network accessibility is no longer a major concern in implementing Web-based evaluation and assessment.

Question 10. Compared to homework submitted and graded on paper, what was one advantage of WebAssign?

Based on students' responses, it is summarized that multiple submissions, instant feedback, spending more time and effort on homework, being able to learn from one's mistakes, easy

access to WebAssign anywhere at anytime, and precision in both submission and grading are some of the distinguished features of WebAssign that students liked most compared to paper homework collection and hand grading.

Question 11. Compared to homework submitted and graded on paper, what was one disadvantage of WebAssign?

On the other hand, students indicated that no partial credit given, network connectivity problems, no feedback on why an answer is incorrect, too many question modes, and easily making syntax errors in answering symbolic questions are some of the disadvantages of WebAssign. Modification and improvement may alleviate students' concerns in these areas.

6. Summary

In Calculus and General Physics I, we are attempting to use well-designed questions, distributed and graded via the web using WebAssign, to improve learning. Calculus questions use multiple steps to assess a student's process for solving problems. Physics questions use Physlets to require students to make measurements and use conceptual reasoning before applying a principle or equation. Although further research is needed to determine the effect on learning, students' responses to a survey indicate that homework indeed motivated them to spend more time studying and that homework promoted collaboration among students and communication between students and faculty. As reported by students, technical difficulties and access to computers was not a significant issue. Finally, students overwhelmingly prefer to use WebAssign due to a number of factors including immediate feedback and multiple submissions.

While many benefits of using WebAssign may also be true for paper-based homework, WebAssign has significant advantages for both teachers and students including the ability to assign and grade more homework, give problems with randomized content, and use animation to create innovative, more realistic problems. Therefore, in our opinion, well-designed problems delivered and graded via WebAssign is a clear choice.

In general, we believe that the attempt to increase students' time on task and collaboration was successful. However, we must now determine its impact on learning, and will turn our attention toward assessing students' understanding before and after completing the homework.

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