Evaluation of Computer-Assisted Instruction in Principles of Economics

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Abstract

Despite increasing use, little is known about the effectiveness of web-based instructional supplements. This study assess the effectiveness of on-line materials in principles of economics courses. We have collected data on 66 students from three principles sections that describe demographic characteristics and performance and reflect the intensity of use of web-based material. We use this data to assess the effectiveness of the web-based material using a variety of empirical models.

Student utilization of web-based material was significant. Both on-line computer graded practice quizzes and posting to the class bulletin board are positively correlated with student performance, but use of web-based content is not. These results suggest that faculty should focus more on developing self-test quizzes and effective bulletin board discussion projects and less on generating on-line content.

Keywords: Effectiveness of web-based instructional supplements, Computer-assisted instruction

Introduction

The use of web-based instruction is increasingly common in many disciplines in higher education. Reserve materials are available on-line from libraries, class discussions are held via e-mail, textbook publishers provide WWW sites for their products, etc.; software developers are making programs available to colleges and universities that allow for on-line interactive instruction and testing. Although these materials are generally used as supplements in traditional lecture hall settings, they also serve as a substitute for class meetings in the rapidly growing area of distance education.

Little is known about the effectiveness of these web-based supplements to face-to-face instruction. How intensively will students utilize on-line course materials? Does access to on-line course materials increase comprehension and retention? Despite the paucity of answers to these and similar questions, the rush to make on-line technology an important component of higher education continues.

This study will assess the effectiveness of on-line materials in principles of economics courses. There are many advantages to this particular setting. ECON 101 - principles of microeconomics - and ECON 102 - principles of macroeconomics are offered by most institutions of higher education, from community colleges to small liberal arts colleges to comprehensive research universities. At many institutions of higher education, including our own, economics courses are taken by students from many different disciplines as part of the general distributional requirements. There will be, therefore, considerable heterogeneity among students participating in the study. Moreover, because similar courses are taught at a wide variety of schools, the evidence here will be of interest to a broad audience. Also, unlike many other disciplines, economics is not an important part of the secondary school curriculum; many students first exposure to economics comes in college-level principles courses. This will tend to reduce the effects of prior academic experience on outcomes. The same may not be true of math courses, for example; the quality and quantity of previous math instruction may have a large effect on student outcomes in introductory-level math courses.

Literature Review

Three distinct bodies of literature have bearing on this project. These bodies of literature are on homework, or out of class effort, computer assisted instruction, and economics education, respectively. We briefly review each of these literatures as they inform our choices of explanatory variables.

Homework

Some research on the effectiveness of homework on educational attainment has been performed on data from college students. We focus our discussion on evaluation of out of class effort on achievement of students in economics courses, but work on the relationship between homework and academic achievement exists for other disciplines as well. Examples of this are: Popovich (1996); Burman (1992); Frisbee (1984); Stephens (1977); and Miller (1996)

Studies focused on economics students are Polachek, Kniesner, and Harwood (1978), Leppel (1984), Borg, Mason, and Shapiro (1989), and Lopus and Maxwell (1995) each of which examined the effects of out of class work on performance. The first two of these found a positive relationship between time spent studying and student performance. Polachek, et al. (1978) measured performance by the percent correct on a multiple-choice midterm exam; Leppel's outcome measure was the student's grade for the course. In each case, the time spent studying was reported by the student. To what extent these self-reports are measured with error and, therefore, bias the coefficient estimates is unknown. Borg, Mason, and Shapiro (1989) did not find an effect of study time on student outcomes. They hypothesize that the reason for this is that the student data is aggregated. Lopus and Maxwell (1995) included a variable for hours spent studying, but it was not statistically significant in any of their regressions.

Student effort has been measured in ways other than time spent studying. Paul (1982) found that employed students do worse than non-employed students; Lopus and Maxwell (1995) did not find hours of work to be a significant determinant of performance on the Test of Understanding College Economics TUCE, a standardized test of economics knowledge. Raimondo, Esposito, and Gershenberg (1990) showed that part-time students did not do as well as full-time students in intermediate economic theory courses. Attendance has been found to matter for student outcomes. Arce, Formby, and Zheng (1996) and Durden and Ellis (1995) each found that those whose attendance is better did better than those students with poor attendance. Looking at the issue of effort from a positive perspective, Schmidt (1983) and Marlin and Niss (1982) each found that use of weekly quizzes appeared to raise student effort.

Computer Assisted Instruction

The use of computers in instruction has grown rapidly over the last decade. Evidence of this is the creation of several new journals, both print and electronic, dedicated to the topic. Among these are: Journal of Computer Assisted Learning, Journal of Computer-Based Instruction, the Journal of Educational Computing, and Educational Technology and Society. In addition, Education Technology has devoted many pages to computer assisted instruction.

Much of this published work is instructional in nature, comprised of how-to articles or papers extolling the possible virtues of one type or another of computer-assisted learning. Boldt, Gustafson and Johnson (1994), Berge (1994), Manning (1996), Bailey and Cotlar (1994), Kuehn (1994), and Wegner, Holloway, and Wegner (1999) are examples of this literature.

The Wegner, Holloway, and Wegner (1999) article is particularly relevant to this research because it evaluates different approaches to computer mediated communication. Specifically, they find that email and other web-based materials that are closely integrated, as in an instructional package, are used more than those same materials when they are separate tools connected only by hyperlinks. In our analysis, we evaluate the effectiveness of the use of bulletin boards and web-content. Taking the Wegner, Holloway, and Wegner results as given suggests that these tools may differ in their effectiveness depending on how the course materials are linked together.

Evaluations of the influence of online learning are becoming more common. Kearsley, Lynch, and Wizer (1995) examined the effectiveness of a series of courses in educational technology offered via satellite and online bulletin boards. Agarwal and Day (1998) evaluated the effects of online instruction in economics courses. A broad array of other studies evaluated the role of online learning [Bruce, Peyton, and Batson (1993); Berge and Collins (1995); Harasim (1989) (1993); Hiltz (1994); Mason and Kaye (1989); Waggoner, (1992)].

The general tenor of these studies is that student satisfaction is increased, there is greater interaction between students and between students and instructors, and critical thinking and problem-solving skills are frequently reported as improved. Moreover, GPA and other measures of student achievement are as high or higher under online teaching than in traditional classes. Indeed, a whole literature has developed on the "no significant difference" issue.

Kearsley, Lynch, and Wizer (1995) and Agarwal and Day (1998) span the range of sophistication in the studies of effectiveness of online instruction. Kearsley, et al. reported survey responses from 14 students who had graduated or nearly completed the George Washington University program in Educational Technology Leadership. The survey asked such questions as "To what extent has your ability to initiate technology-based projects improved as a consequence of being in this program?" and "Do you feel more confident or competent in your current job as a result of skills and knowledge you have acquired in this program?" Students perceived themselves to be more knowledgeable after being in the program than before. Of course, whether this is different from how the students would have felt after completing a traditionally-taught program is not assessable. Neither is it possible to determine whether actual knowledge has improved more as a consequence of the online learning than would have occurred with traditional methods.

Agarwal and Day (1998) raised the sophistication of the analysis substantially. First, they use survey information, course grades and results on the TUCE as measures of student outcomes. Second, the study involved both a control group, which did not have access to the Internet materials, and an experimental group which did. The same instructor taught both groups using the same text, tests, instructional style and similar homeworks. The experimental group made use of E-mail and discussion lists for communication and the World Wide Web for information retrieval and access.

In regressions explaining the students' scores on the TUCE or the students' course grades, those students from the class which used the Internet performed better than those who did not in the sense that their average score was a statistically significant 1.15 points higher. It is difficult to interpret this result precisely, however, because the authors do not report the mean score on the exam for the students in their sample. However, Phillip Saunders (1991) reported a mean score of 31.82 (29.67) on the combined micro and macroeconomics tests, which appears to be what Agarwal and Day used. Using these values, then use of the Internet methods raised the average score of Agarwal and Day's students by about 3.6% (3.9%). This is probably an overestimate of the value of the Internet because Saunders' sample is limited to students who have just completed principles of economics courses, overwhelmingly undergraduates and predominantly freshmen and sophomores but about 39% of the Agarwal and Day sample was graduate students. To the extent that graduate students would have higher average scores than freshmen and sophomores, the mean in Saunders is too low a basis of comparison. Consequently, the impact of the Internet is probably less, possibly substantially so, than a 3.6% (3.9%) improvement in TUCE scores.

Education in Economics

Economists have exerted substantial effort in evaluating teaching and learning in economics courses. For example, research on the teaching of college economics has addressed issues of student effort, study time and attendance, as described above, as well as the role of learning and teaching styles, gender, maturity, aptitude and preparation. John Siegfried and William Walstad (1998) summarized the extensive literature in this area. This literature also informs our research, but for space considerations we do not review it. Suffice it to say that this literature is closely related to the extensive literature on education production functions surveys of which include papers by Eric Hanushek (1986), (1996) and recent volumes by Helen Ladd (1996) and Gary Burtless (1996).

Data Description and Analysis

The data used in this paper were collected from three principles-level economics classes at a mid-sized state university during the academic year 1998-1999. Two sections were principles of macroeconomics classes and one was principles of microeconomics. Each section had password protected access to course-related material using the WebCT courseware program. The web-based material included course-related content (including supplemental readings), practice quizzes that students could take up to five times, graded multiple choice quizzes, hyper links to course-related material on the internet, access to a threaded bulletin board for asynchronous discussion of course material, access to a chat room for synchronous discussion, e-mail and access to an on-line grade book where students could check their grades for the classes.

66 students enrolled in the three sections, 38 in the macro sections and 28 in the micro section. Six students dropped, leaving 60 students that completed the courses through the final exam. Prior to the first day in class, there was no indication that web-based material, including quizzing, would be used in the classes. Student participation in the asynchronous discussion that took place on the bulletin board was a determinant of the final grade, as were scores from the on-line quizzes.

Demographic Data

Demographic data on the students were collected by using on-line surveys. 14 students (21%) did not complete these surveys, the following statistics are based on data from the 52 students who completed the demographic surveys. The sample was 77% male and 96% white. 96% were full-time students. 69% reported being involved in extra curricular activities. Additional sample information is presented in Table 1.

These students were fairly typical of the student body, except that the majority of the students here do not live on campus; that is, this is predominantly a commuter campus. The information in Table 1 reveals a skew toward resident students in our data. This was probably because the classes were introductory level and the students taking them are more likely than other students to live on campus.

Class Standing	%	Primary Internet Access	%
Freshman	0.21	Home/Dorm	0.61
Sophomore	0.42	Library/Lab	0.35
Junior	0.21	Other	0.04
Senior	0.15		
Hours Spent Working	%	Commute Time	%
Did Not Work	0.38	Lived On Campus	0.63
$<$ 10 hours per week	0.23	$<$ 10 minute drive	0.08
10-20 hours per week	0.15	10-20 minute drive	0.12
20-30 hours per week	0.12	20-30 minute drive	0.10
$>$ 30 hours per week	0.12	$<$ 30 minute drive	0.08

Table 1: Demographic Data

Internet Use

How intensely do students utilize web-based instructional resources? Answering this question is an important step in evaluating the effectiveness of these resources. If students are reluctant to use web-based resources, then no matter how effective these materials are at enhancing comprehension, they will ultimately have little value.

Our personal teaching experience suggests that simply making supplemental material available to students does not guarantee that students will utilize these materials. Copies of past exams and solutions to problem sets placed on reserve at the library are often neglected by students. However, these materials may be neglected because the total cost of accessing them (including time, shoe leather and copying costs) exceeds the expected benefit. Proponents of computer-assisted instructional material often argue that these materials have a lower cost of access, which will lead to increased use and, consequently, comprehension and mastery of the material.

The computer-assisted instructional material used in this study can be grouped into two general categories: material that enhances the student's interaction with the course material, which includes the practice quizzes and the supplemental web-based content, and material that enhances the student's interaction with other students and the instructor, primarily through the course bulletin board and, to a lesser extent, through e-mail. We examine each in turn.

Utilization of Practice Quizzes

Students in all three classes had access to practice quizzes. These quizzes were composed of multiple choice, true-false and matching questions and organized by broad topic (markets, consumer theory, macroeconomic policy, etc.) Each quiz consisted of a small set of five to ten questions drawn randomly from a large pool of potential questions. Each quiz could be taken up to five times, and the pool of potential questions was large enough that the probability of drawing the same question in multiple quizzes was small. The quizzes were also graded by the computer as soon as the quiz was submitted, and students could immediately see their

score and the correct answer to each question.

The two macro classes used five quizzes and an online portion of the final exam, and the micro class used five quizzes. Because each quiz could be taken up to five times, there were a total of 1,840 student quiz-opportunities for the 66 students. There were 1,195 actual student quiz-attempts, a 65% utilization rate by the students, suggesting that the students made considerable use of the practice quizzes. Clearly, from Table 2, a majority of the students who attempted any given practice quiz took that quiz the maximum number of times allowed, suggesting that students perceived some benefit from multiple attempts at the quizzes.

# of Attempts		%	High Score		%
0	65	0.18	0-59	19	0.06
1	29	0.08	60-69	13	0.04
2	34	0.09	70-79	29	0.10
3	32	0.09	80-89	64	0.21
4	38	0.10	90-100	178	0.59
5	170	0.46			
Total	368			303	

Table 2: Frequency Distributions - Practice Quizzes

The right panel of Table 2 shows the frequency distribution of the highest score on a quiz for the 303 instances where a student took a quiz one or more times. In 80% of these cases the high score was a B or an A. The mode of this variable is 100%, which occurred in 103 cases, probably because the quizzes were relatively short (5-10 questions each).

A natural question is to examine the possibility of a statistical relationship between the high score on a quiz and the number of times that quiz was attempted. Since quizzes were taken outside of class, one could interpret more attempts as greater student effort or more time spent studying for the course. A statistically significant relationship between these variables would be evidence that some sort of learning took place when students exerted more effort by taking a quiz multiple times. If these variables were statistically independent, then no learning took place and performance is unrelated to outside effort. The Pearson χ^2 statistic with 12 degrees of freedom for this sample was 41.25, which has a P-value of 0. The null hypothesis of no relationship between high score and attempts per quiz is rejected, suggesting the presence of some relationship between these variables. All scores below 69 were placed in the same category for this test in order to obtain enough cells with a predicted value of more than 5% to make the χ^2 test valid. A likelihood-ratio χ^2 test similarly suggested a relationship between the variables.

Utilization of Asynchronous Communication Tools

Students were also provided with other on-line resources. These additional resources were designed to increase student interaction with the material by providing web-based content or to increase student interaction with other students. The latter category included e-mail,

a bulletin board, and chat rooms. Some measures of student use of these resources are summarized on Table 3.

The on-line content consists of original html pages that reinforce the course content by explaining material in different ways, some using animated gif's and other material uniquely suited to the web as well as links to other material on the internet. This type of material is not available for every topic in the courses, but the major topics are covered.

The variable "Hits" on Table 3 is the total number of content pages accessed by each student over the course of the semester. This variable reflects general student use of the on-line material. In general, it is not a very good measure of intensity of use of the on-line content for two reasons. First, the internal hits counter is incremented every time a page is displayed in the student's web browser. Thus each page that the student must pass through before reaching a particular page of content is counted as a hit, even though the page may contain no course content. Second, this variable does not take into account how much time a student spends on a page or the intensity with which a student focuses on the content displayed on a page. Glancing at a graph for a few seconds and closely reading a passage are given the same weight in this metric.

Keeping this caveat in mind, the frequency distribution of "Hits" on Table 3 suggests that there was relatively little variation in the students' access of the on-line content. The total hits for a majority of the students fall in the 101-500 range. A likely explanation for this grouping of hits is that navigating through the content to visit the last page in a particular "thread" of linked pages one or two times would generate a total number of hits in this range. A small group of about 10% of the students either utilized, or surfed through this material much more frequently. The "Hits" measure of usage does not allow us to distinguish these alternative uses of the material.

Page Hits		%	BB Posts		%	BB Posts Read		%
0-100	4	6.1	0-10	34	51.5	0-190	33	50.0
101-500	36	54.6	11-20	8	12.1	191-380	14	21.2
501-1000	11	16.7	21-30	7	10.6	381-570	2	3.0
1001-1500	7	10.6	31-40	10	15.1	571-760	3	4.6
1501-2000	7	10.6	41-50	3	4.6	761-950	4	6.1
2001-2527	1	1.5	51-60	4	6.1	951-1116	10	15.2
Total	66	100.0		66	100.0		66	100.0

Table 3: Frequency Distributions - Page Hits, BB Posts, BB Postings Read

We did not have access to a summary statistic for the number of e-mails sent or for use of the chat rooms. We did have access to the total number of bulletin board messages posted and read by each student. In order to provide students with an incentive to use the bulletin board, a small part of each student's final grade depended on the number of postings read and written. The instructors also monitored the bulletin boards for the purpose of answering questions and, in some instances, initiating threads.

Like "Hits", posts and postings read are clearly imperfect measures of a student's use of this resource. A two word post ("Me too!") and a carefully thought out answer to a question posed by the instructor are both given the same weight in the "posts" variable.

Careful reading of all the posts in a thread and skimming through 50 posts in five minutes are also indistinguishable. Still, these variables can provide an approximate indicator of student use of the bulletin board.

The right two columns of Table 3 show the frequency distributions for the total number of bulletin board articles posted and read for each student. The general pattern that emerges from these distributions is one where a majority of students post relatively infrequently (the modal number of posts in the sample was 1, the total number of posts made by 1 in 5 students) but a smaller but important group of students (the slightly less than 40% in the next three groups) posted considerably more often. The frequency distribution on "Read" suggests that even those students who posted infrequently looked at a majority of the threads on the bulletin board.

The number of students with "read" totals above 761 is interesting. Given that there were about 1500 posts, these students read, or at least surfed through, about half to three-quarters of the total postings. At the other end of the distribution, the median and modal number of posts read is 190 or less. This translates into only about 13% of the postings. Combining the lowest two categories, over 75% of the students read a quarter or less of the postings. In other words, participation in the bulletin board discussions is characterized as great participation by a small number of students, very disappointing participation by the vast majority of students, and moderate participation by a small number of students.

Alternatively, these small number of very high "Read" totals could represent strategic behavior on the part of a few students trying to get extra points for bulletin board participation by rapidly surfing through a large number of posts in a short amount of time. However, in each class, students were explicitly told that the number of messages posted, not the number of messages read, would determine their grade.

We have decided not to use survey data on student attitudes about web-based material in this study. Several factors affected this choice. Data on student's attitudes about web-based material have been extensively analyzed in the distance education literature and the overwhelming conclusion emerging from this literature is that students feel that web-based material is useful and beneficial. Rather than contribute another stanza to this hymn of praise, we feel that an examination of the relationship between use of web-based material and performance, if done correctly, can increase our understanding of the appropriate role for these materials. We were also concerned that, in the case of principles level students, the novelty of web-based material might lead students to report that this material was useful and beneficial no matter what the true effect.

Statistical Analysis of the Data

The assessment of student's use of web-based material above is informative. However, learning takes place in a complex environment and an examination of usage statistics may not reflect the full story. In order to separately account for the different factors that affect student performance, statistical models must be used. In this section we describe our empirical models for estimating the effects of participation in online discussions and multiple attempts at practice and other quizzes on student performance. Performance is measured in several different ways including scores on the quizzes, the mid-semester exams, and the final exam.

We begin by describing the basic empirical model and then turn to a discussion of the results.

Statistical Model

Our empirical model relates student performance on some graded material to a variety of socio-demographic characteristics and measures of effort and background. The basic model seeks to address the question of whether or not a) participation in the online bulletin board discussions predicts performance and b) whether or not the ability to take quizzes multiple times provides benefits for learning in the course as evaluated by outcomes on the quizzes, and on the final exam. The basic equation is:

$$Y_{i,t} = \alpha_0 + \alpha_2 W_i + \alpha_3 C_i + \alpha_4 Z_t + \epsilon_{i,t}$$

Where i indexes students $(1 \ldots \mathrm{N})$ and t indexes quizzes $(1 \ldots \mathrm{T})$, the α_j's are vectors of parameters to be estimated and the variables are defined as

$Y_{i,t}$	Outcome of student i on quiz (or exam or course grade) t
Z_t	A course indicator
W_i	List of variables reflecting student i's use of web-based material
C_i	List of variables reflecting measurable factors specific to student i
$\epsilon_{i,t}$	Mean zero, normally distributed error term

A somewhat different version of the model relates the score on a quiz to the demographic characteristics, which try at the quiz the score is for, and the score on the previous attempt. The intuition of this model is straightforward. The more previous tries at the quiz the student has taken, the more time engaged with the material and, therefore, the better performance on the current attempt. Moreover, the better one performed on earlier attempts, the better one will perform on the current attempt, suggesting that there may be correlation between the regressors and the error term. We discuss this issue below.

Included in the $W_{i,t}$ are variables measuring the number of attempts a student made at a given quiz as well as variables reflecting experience with the internet and participation in the online bulletin board discussions. $C_{i,t}$ contains attributes of the student such as race, gender, and involvement in extracurricular activities or work. Z_t is a dummy variable indicating a student from the micro course rather than the macroeconomics course.

We have no particular expectations about gender and race, but we do have expectations on the other characteristics. We expect transfer students and those who are working or involved in extracurricular activities to perform worse, on average, than non-transfer students and those who neither work nor participate in extracurricular activities. These hypotheses are, of course, holding all other things constant.

The hypothesis about transfer students perhaps bears more explanation. It is largely a function of the particular situation at this institution whereby the school must accept anyone who has completed two years at a state-run community college. Such students enter without having to take the SAT, and are generally thought by the faculty to be weaker students.

We also expect that those students who take each quiz more times are likely to perform worse than students taking them few times. The reason for this is that students who do

well the first time will be less likely to take the quiz additional times. Students taking the quizzes multiple times will have a lower average than those taking them few times because it is those students who perform poorly on the first, second, or nth attempt who have the most to gain from taking the quiz again.

If the student is simply taking practice quizzes, as is the case in the micro section, then there is no reason not to take the quiz additional times. However, students in the macro sections can improve their score which counts toward their grade, because only the high score counts in grade determination. Those students who score well, on the other hand, have less likelihood of raising their score and greater likelihood of scoring below their already high score. What this suggests is that the average score on the quizzes and the number of attempts at them are simultaneously determined. The error term from the equation explaining the student's average score on a quiz is correlated with that student's number of attempts. Indeed, the error in the average score can also capture motivation and inherent interest in the subject, and students that are more motivated and more interested are likely to take more attempts. We address this endogeneity problem below.

There is another issue related to repeated attempts at the quizzes. Taking the quizzes multiple times increases student's interaction with the material. We are all familiar with the self-tests that are included in study guides. These repeated attempts at the quizzes are simply an electronic means of taking these self tests. We hypothesize that those students that take more attempts of the quizzes will perform better on the midterm and final exams, and in the course, than students who take few attempts at the quizzes.

An important statistical issue is the endogeneity of the number of attempts at a given quiz mentioned above. We have attempted to address this possibility with an instrumental variable technique, using two different methods to obtain an instrument. In our first approach, we predict the number of attempts on any given quiz with the number of attempts at the previous quiz and the list of student characteristics. In the second, we use the average score on the first quiz as an instrument for future attempts. The idea is that the score on this first quiz reflects both background and inherent interest in the subject. The first quiz in both the micro and the macro sections covers common introductory material. This material is common to both courses because it is particularly important as core knowledge of economics and because students may take either of the courses first. The topics for this first quiz include the definition of economics, scarcity, the production possibilities frontier, opportunity cost, and supply and demand. In the results section below we comment on the effectiveness of each of these approaches.

Empirical Results

We begin by looking at the regressions in which the average score on repeated attempts at a given quiz is the dependent variable. The variables used in the empirical analysis are described on Table 4. These results are shown on Table 5. In this instance, the data are a panel, with observations on each student for each of five quizzes and an online portion of the final exam (for the macro classes). We relate the average score on all the student's attempts on a quiz to the number of attempts of that quiz, and demographic variables. Because of the panel nature of the data, we estimate the model using random effects.

When we do not treat the number of attempts as endogenous, it is never statistically

read	Bulletin Board Posts Read
posted	Bulletin Board Posts
hits	Number of class web pages visited
male	Gender Dummy = 1 if Male
white	Race Dummy = 1 if White
aid	Student received financial aid
ec101	Student was enrolled in ECON 101
noecon	Student had not taken a previous economics class
job	Student worked during the semester
athlete	Student was a scholarship athlete
extra	Student was involved in extra curricular activity
busy	job + athlete + extra
tran	Student transfered to UMBC
quizatt	Number of practice quizzes attempted
q1	Score on first graded on-line quiz
midexam	Score on Midterm exam

Table 4: Variable Definitions

significant, even when it is the only regressor, and its sign flips from positive to negative as the model expands to include other explanatory variables beyond it and an intercept. Indeed, the only variable that is statistically significant generally is the variable indicating which class the student was in. The dummy variable indicating the student is white is significant at the 10% level in one equation and indicated that white students scored about a half of one point higher on average than non-whites.

	Model 1		Model 2		Model 3	
Variable	Coefficient	Stand. Err.	Coefficient	Stand. Err.	Coefficient	Stand. Err.
C	5.50	0.37	5.96	9.92	6.32	.61
attempts	0.053	0.08	0.02	0.27	-0.03	0.08
job			0.27	0.76	0.31	0.35
aid			-0.02	0.35	-0.14	0.34
transfer			-0.34	0.35	-0.39	0.34
extra			0.37	0.34	0.31	0.36
male			-0.14	0.32	-0.10	0.32
white			0.65	0.35	0.48	0.36
ec101			-2.33	0.34	-1.95	0.63
noecon			0.24	0.69	0.05	0.68
hits					0.001	0.0008
read					-0.0007	0.001
posted					-0.03	0.02
$Wald\ \chi^2$	0.45		58.34		66.98	

Table 5: Random Effects Regression Results: Average Quiz Scores

Two approaches to controlling for the possible endogeneity of the number of attempts were followed. In the first of these, we simply replaced attempts on this quiz with the number of attempts on the previous quiz. We also introduced the score on the first quiz as a regressor

in this model. These results are shown on Table 6. As is clear from the table, only this score on the first quiz is a significant explanatory variable. We also used a first stage regression to predict the number of attempts on a given quiz. The key instrument in this equation is the lagged number of quiz attempts. The results from this approach are not meaningfully different from those obtained using the lagged attempts directly.

	Model 1		Model 2		Model 3	
Variable	Coefficient	Stand. Err.	Coefficient	Stand. Err.	Coefficient	Stand. Err.
C	2.50	0.57	2.37	1.26	3.97	2.39
lagged attempts	-0.05	0.93	-0.10	0.10		
job			0.10	0.32	0.23	0.33
aid			-0.04	0.31	0.03	0.32
transfer			-0.17	0.36	-0.21	0.36
extra			0.09	0.39	-0.27	0.60
male			0.16	0.32	0.07	0.34
white			0.14	0.35	-0.02	0.39
ec101			-0.52	0.88	-0.62	0.89
noecon			0.44	0.62	0.31	0.64
hits			0.0002	0.001	0.001	0.001
read			0.001	0.001	0.0007	0.002
posted			-0.02	0.02	-0.03	0.02
q1	0.52	0.06	0.51	0.12	0.57	0.14
predicted attempts					-0.56	0.55
$Wald\ \chi^2$	77.5		79.61		79.61	

Table 6: IV Random Effects Regression Results: Average Quiz Scores

Examining the relationship between the score on the current attempt at a quiz and which attempt it is reveals a strong positive correlation. An additional attempt at the quiz raises the score on the quiz by .37 points, in column 1 of Table 7. The effect is statistically significant with a p-value well below .01. Similarly, if one uses the score from the previous attempt at this quiz as a regressor, that variable is strongly statistically significant with a coefficient of about .49. In other words, an additional point on the previous attempt translates into an additional half point on the current attempt. Including both the number of the attempt and the lagged score as explanatory variables results in both being significant at the 5% level or better. Each is also positive. The lesson from these results is that additional attempts at the quizzes translate into higher scores on the quizzes.

In each of the regressions reported in Table 7 both the microeconomics indicator and the quiz 5 dummy are statistically significant. In the third model, job and transfer are significant at the 10% level. The former indicates that students with jobs score about a quarter point better than non-working students, the latter that transfer students score about a quarter point worse than non-transfer students.

Switching to an examination of the determinants of the score on the final examination, some additional information is revealed. Of course, the sample size falls dramatically, down to just 40 observations. Nonetheless, there are some interesting results, which are shown on Table 8.

First, the most important determinant of the score on the final exam is the score on the

	Model 1		Model 2		Model 3	
Variable	Coefficient	Stand. Err.	Coefficient	Stand. Err.	Coefficient	Stand. Err.
C	4.96	.44	3.52	0.30	3.17	0.33
lagged score			0.49	0.03	0.47	0.03
attempt number	.37	.04			0.13	0.05
job	.41	.29	0.22	0.15	0.24	0.15
aid	-.15	.29	-0.12	0.14	-0.13	0.14
transfer	-.27	.28	-0.23	0.14	-0.24	0.14
extra	.39	.29	0.16	0.14	0.18	0.14
male	-.07	.27	-0.05	0.13	-0.05	0.13
white	.35	.29	0.11	0.15	0.11	0.15
ec101	-2.07	.29	-1.35	0.15	-1.37	0.15
athlete	.09	.36	0.002	0.18	0.005	0.18
quiz2	-.23	.16	0.04	0.18	0.04	0.18
quiz3	-.30	.17	0.12	0.18	0.12	0.18
quiz4	-.23	.17	0.01	0.18	0.01	0.18
quiz5	1.27	.17	0.85	0.19	0.88	0.18
$Wald\ \chi^2$	285.1		712.1		722.7	

Table 7: Random Effects Regression Results: Quiz Score on Each Attempt

midterm. One additional point on the midterm raises the score on the final exam by .38 points.

Second, race and whether or not the student has a job are each statistically significant at the 10% level. The average score on the final exam is 54. Whites score 7.6 points higher than do non-whites, about 14% of the mean. Those with jobs score about 7 points higher, 13% of the mean, than those who do not have jobs. In addition, whether or not the student transferred carries a positive coefficient, with a t-statistic about 1.6.

Of the internet variables, only the number of postings to the bulletin board is statistically significant at the 5% level or better. This coefficient is .51, so it would take about 15 postings to match the effect of race. The number of articles read is clearly not relevant as its t statistic is well below 1 in absolute value. The number of attempts at quizzes throughout the course of the semester carries a positive coefficient, with a t-statistic around 1.5.

A potential problem with these results is that the score on the midterm may be correlated with the unobservable in the regression. Thinking of the unobservable as ability that has not been controlled for by the other variables, particularly the demographic variables, then this unobserved ability is certainly a determinant of the midterm score as well as the final score. In this event, the coefficients reported above are potentially biased. Unfortunately, we have no way to instrument for this endogenous variable.

We have, however, re-estimated the model while omitting the midterm score. These results are shown on Table 9 The general conclusions are basically unchanged. Race and having a job each exert a positive influence on the score on the final exam, though now the t-statistics have risen such that the variables are significant at the 5% level. In addition, whether or not the student is an athlete, meaning a member of one of the university's intercollegiate sports teams, is signficant at the 10% level and negative. Interestingly, the standard error has not changed much, but the estimated coefficient has. It now suggests

	(1)		(2)		(3)	
Variable	Coefficient	t-Stat.	Coefficient	t-Stat	Coefficient	t-Stat
c	-9.87	-.78	-15.85	-1.09	-19.23	-1.38
read	-.004	-.43	-.009	-.84	-.007	-.74
posted	.379	1.61	.505	2.24	.443	1.92
male	.05	.02	.445	.13	1.02	.31
white	5.38	1.27	7.63	1.86	6.64	1.58
ec101	14.84	1.53	15.67	1.67	17.62	1.84
job			7.03	1.92		
busy					1.70	.73
athlete			-4.89	-1.18		
extra			3.99	.99		
tran			5.70	1.55	6.92	1.95
quizatt	.73	1.55	.677	1.41	.723	1.52
midexam	.41	4.21	.383	3.94	.443	4.63
R^2	.76		.82		.79	

Table 8: Dependent Variable: Score on Final (OLS)

that a student athlete scores 8.8 points lower than other students, all else constant. This translates into over a 16% lower score than otherwise. Finally, the t-statistic on the number of quiz attempts and on the transfer variable have each fallen substantially. The variables were not significant at conventional levels before, but they did have t-statistics well over 1. Now the t on each is below 1.

Conclusions

We set out to describe and analyze student use of web-based materials in principles of economics classes. Students in three sections of principles of macroeconomics and microeconomics were provided with an array of web-based material, including content, computer graded quizzes that could be taken multiple times, and synchronous and asynchronous communications tools.

Students made extensive use of the on-line quizzes, completing about 2/3 of the total available quizzes. The distribution of the total number of "hits" on pages in the course suggests that students did not ignore the web-based content, but that a majority of the students probably did not return to this material multiple times. A majority of students were somewhat reluctant to make posts to the class bulletin board, although a small but significant fraction posted frequently. A majority of students read the bulletin board postings.

Student's utilization of the web-based material was significant, especially when the fact that these students were primarily freshmen and sophomores and campus residents is taken into account. Much of the research on student's use of web-based material comes from classes taught at a distance and composed of adult learners who are working full time while attending school. These adult learners have higher opportunity costs of going to the library to access reserve materials, coming to office hours, or forming study groups and thus would be expected to utilize flexible web-based material more often. However, younger campus residents have

	(1)		(2)		(3)	
Variable	Coefficient	Stand. Err.	Coefficient	Stand. Err.	Coefficient	Stand. Err.
C	12.01	.08	12.35	.79	17.06	1.29
read	.001	.41	.005	.41	.006	.52
posted	.584	2.14	.49	1.68	.45	1.58
male	1.30	.31	2.94	.70	2.30	.57
white	11.65	2.4	11.16	2.13	10.12	2.02
ec101	5.34	.48	6.35	.54	5.09	.44
job	10.07	2.31				
busy			1.21	.69		
athlete	-8.83	-1.79				
extra	4.22	.87				
tran	2.44	.56	4.04	.37		
quizatt	.57	.78	.66	.28	.66	1.14
R^2	.71		.64		.63	

Table 9: Dependent Variable: Score on Final (OLS)

lower opportunity costs and might be expected to make use of reserve materials, office hours and study groups instead of web based material if these resources are substitutes. The observed utilization in our sections suggests that web based materials can be useful even for resident undergraduate economics students.

Much of the evidence suggests that on-line practice quizzes can be an effective tool. Taking multiple quizzes on a topic increased the high score on that topic significantly and there is some evidence that more attempts at the practice quizzes were positively correlated with the student's score on the final exam. Posting to the class bulletin board also appears to be positively correlated with performance, although passive reading of posts made by others is not correlated with performance. Use of on-line content, as measured by the number of "hits" on class web pages, was not correlated with performance.

Posting to the bulletin board was a good predictor of performance, but reading and not posting (or "lurking") was not. If this correlation between posting and performance reflects learning, then instructors using bulletin boards to enhance their principles courses should focus on developing interesting discussion topics and designing discussion exercises that draw more students into the on-line discussion.

Many publishers are rushing to provide on-line content related to texts. Faculty often think that making their notes or lecture slides available will help students. But our data suggest that the on-line content was not used extensively and our measure of use of on-line content was not a good predictor of student's performance. Before more effort goes into making on-line content available, we need to know more about the use and effectiveness of such material.

Finally, we note that these conclusions and observations are based on a relatively small sample of students. More data collection and analysis needs to be done in this area before definitive conclusions can be reached. We view this as an ongoing research project, and plan to continue to collect data. We strongly encourage other faculty who use web based material in their classes to take the time to undertake similar studies.

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