

Web-Assisted Learning via On-Line Course Supplements

Gregory L. Plett, Mark A. Wickert
University of Colorado at Colorado Springs

Abstract

In many courses, supplemental materials might be made available to the student to assist learning. These include, but are not limited to: printed lecture notes, audio and video files of lectures, homework hints, homework solutions, worked example problems, sample tests and computer code to implement or demonstrate some theory learned. An efficient means to distribute these materials to the students is via the world-wide-web.

Our premise is that these documents are dynamic in nature—they are developed and modified as the semester progresses. Therefore, it is not ideal to simply keep a repository of dozens of files at an internet site. A mechanism must be in place to track the dynamic nature of the documents.

This paper describes an internet-based course-supplement management system that we have developed. Each student may log into the system by providing his or her student ID and password. The site keeps a data-base to annotate files with a description and to log all download activity for each student. (The student access log also enables assessment: “Which students are downloading files?”, “Are they doing so in a timely manner?”, “Is it helping test scores?”) When the student logs on, the system labels each file as being “not yet downloaded”, “updated since last download” or “unchanged since last download” with respect to the student querying the site. In this paper, we describe the system’s operation from both the student and instructor point of view, including securely adding and validating new users, logging in, retrieving files, adding files to the data-base and modifying files already present.

We have found this system to be very convenient for students and very easy to use for the instructor. Supplements that might not otherwise be made available to the student (for security purposes or because the instructor is unwilling or unable to generate the required html code) assist learning and provide additional insight through extra examples and clarifications.

I. Project Objectives

It is our premise that students in any class might benefit from electronic course supplements such as: printed lecture notes, audio or video files of lectures, homework hints, homework solutions, worked example problems, sample tests and computer code to implement or demonstrate some theory learned. An efficient means to distribute these supplements is via the internet. The innovation described in this paper is the result of a project with three main objectives:

1. Develop standards of style and format for on-line course supplements and for the parts of the course web-site documenting the supplements;

2. Develop simple implementation means whereby the instructor may add supplemental materials to the course web-site (without compromising security or utility); and
3. Develop automatic evaluation means to determine if the on-line course supplements assist student learning.

These three aspects are described in the following sections.

I-A. Standards

To make the content of the supplements as accessible as possible to the student, we believe that the instructor should standardize file formats and style. Issues of style might include: a constant template for homework assignments and solutions, and consistent documentation standards for code segments. Consistency allows a student to decode the content more quickly as she* knows what format to expect.

More fundamentally, we strongly recommend that only open-standard file formats be used for supplement materials. This provides universal access and eliminates economic prejudice from the system. For example, we use Adobe Portable Document Format (PDF) files in preference to proprietary document formats such as Microsoft Word or Corel Word Perfect. The PDF file format is an open *de facto* standard that preserves all the fonts, formatting, graphics and color of the source document regardless of the application and platform used to create it. Handwritten documents, such as homework solutions, may be scanned directly into PDF format using popular software, and computer-generated documents may be converted to PDF using Adobe Acrobat on Windows and Macintosh platforms, and Ghostscript on Unix platforms. PDF files avoid certain problems: With a proprietary format, not all recipients can open files because they do not have the application used to create the document; documents don't print correctly because of software or printer driver limitations. PDF files always print correctly on any printing device.[†] Where PDF files are not appropriate, we use standard ASCII text files where possible, as these may be easily read on any computing platform.

I-B. Supplement Dissemination

The internet is an obvious choice for disseminating electronic media. Certainly, there are other options, such as a posting board or a folder in the library. However, there are significant advantages to using the internet: it is more convenient for students who can access it from anywhere at any time; it is more convenient for the instructor, who does not need to make frequent trips to the library to update the folder and to replace lost or stolen items; it is a better medium to transmit programs or code segments, which must be re-typed if delivered in paper media; it is able to inform the student which files have been updated since that particular student last visited—impossible with a generic paper format; and it is the only reasonable way to make audio, video and data files available to large numbers of students.

* To avoid gender bias without the text of this paper being too stilted, we use a feminine pronoun for the student and a masculine pronoun for the instructor. Clearly, student and instructor may be either male or female.

[†] See <http://www.adobe.com/products/acrobat/adobepdf.html>. Accessed 4 December 2002.

A simple method to make files available via the internet is to have a repository of files in a web-accessible directory. However, as the number of files gets large, this becomes an untenable solution. Students lose track of which files they have downloaded, and there is no apparent organization to the dozens of supplements.

Furthermore, course materials are dynamic documents. They are developed and are modified as the semester progresses. The student needs to know when a file has been updated. For this, a repository of dozens of files on an internet site is not sufficient. In Section II, we describe a system we have developed where a student logs on to a course web site by giving her student ID and name. The site keeps a data-base of all download activity for each student and can then mark supplement-material files as being “not yet downloaded”, “updated since last download” or “unchanged since last download” with respect to the student querying the site. The file listing also contains sufficient annotation for the student to discern the content. The system is designed to be as easy as possible for both the instructor and student to use. It also protects the intellectual property of the instructor / university by using an authenticated logon procedure.

I-C. Evaluation Means

Finally, we have developed evaluation means to determine whether or not the supplements are aiding learning. We have written scripts to parse the log file of supplement downloads and correlate them with student grades. We have also created surveys to gather student’s opinions as to whether the supplements were useful. Both evaluation means are described in Section III.

II. The EduFile Course Supplement Management System

In this section we discuss the web-based software created to meet the aforementioned needs. We call this program the “EduFile Course Supplement Management System” or simply *EduFile*.[‡] First, we describe the students’ perspective and then the faculty / instructor perspective.

II-A. The Student Perspective

At the beginning of each semester we give each class the URL to the *EduFile* login for their particular course. Students may browse to this location using Internet Explorer, Netscape, Mozilla, or any other fully-featured web browser. The page that appears is reproduced in the screenshot of Figure 1.

The first time a student uses the system, she must click on the word “register”, which redirects to a form where she can type in her contact information. Specifically, for each student we collect a name, student ID, password, phone number and email address. (The password is stored in an encrypted form so that not even the course instructor can view it in plaintext, although he may reset it to a known value if necessary).

The student does not automatically have access to the course supplements. When she submits the form, *EduFile* sends an email message to the course instructor:

[‡] Technical details: *EduFile* is written in PERL and uses a mysql database to manage information on students, supplements, courses and so forth. We use a Linux-based platform with an Apache web server.

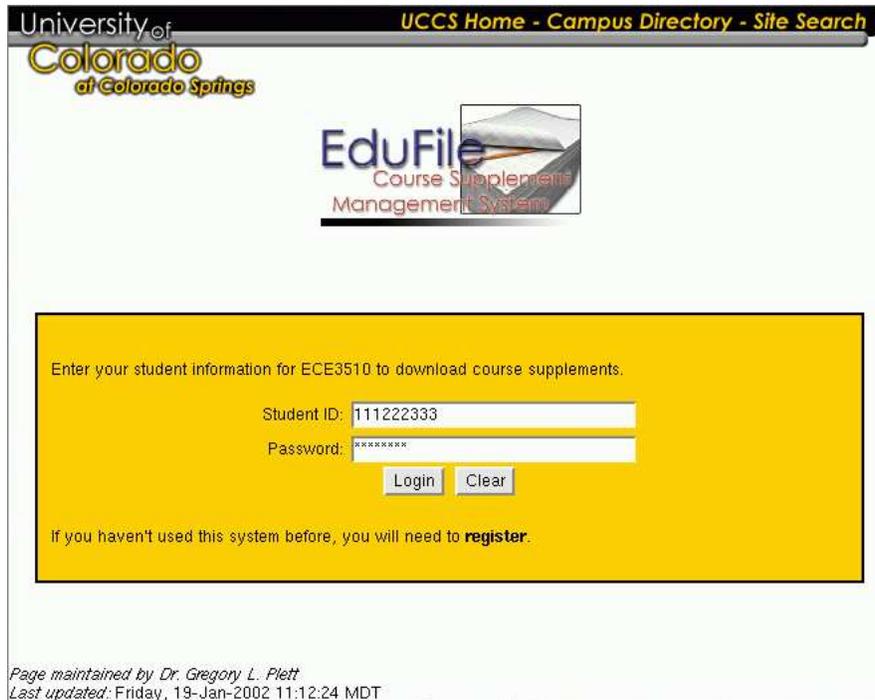


Figure 1. Screenshot of student login screen.

Student user 111222333 has requested to download supplements for course ECE3510. Go to <http://edufile.uccs.edu/facultyadmin/> to log in and enable this user.

The instructor must manually “enable” access for each student, as described in Section II-B. When the student has been enabled she will receive an email message from *EduFile*:

Student user account for 111222333 has been enabled. Go to http://edufile.uccs.edu/?course_id=ECE3510/ to log in.

Only then may she access the supplements.

Although somewhat cumbersome, this procedure is only done once per semester so is not onerous. It protects course materials from getting into the wrong hands—such as parties from off campus whose intent is to pirate proprietary course content. (In our server access logs, we have noticed daily attempts to gain unauthorized access). We understand that not everyone will agree with us regarding our desire for course-content security. M.I.T., for example, has a radically different approach to “proprietary information” in which they make their course material available to the internet public for free (cf. <http://web.mit.edu/ocw/>). Our position, however, is that we wish to maintain tighter personal control over those not registered for the course who receive our lecture notes/ videos and so forth, and how they use them. With regard to homework and exam solutions, we understand that hand-me-down solutions are unavoidable, so ask our own students different questions each semester, minimizing the need for security with

University of Colorado of Colorado Springs UCCS Home - Campus Directory - Site Search



Welcome to EduFile

Course Info	
Instructor Name:	Dr. Gregory Plett (glp@eas.uccs.edu)
Course Name:	Linear System Theory
Course Description:	Characterization of linear systems by impulse response, convolution, transfer function. Linear differential equations and linear difference equations as models. Applications to circuits, electromechanical systems, etc. Transform methods include: Fourier series, Fourier transforms, and Laplace transforms. Introduction to state variables and the state transition matrix. Use of a variety of models in design. <i>Prer., ECE2220 and Math 340.</i>

Click on the Filename to download the file you need.

Update Since Last Download?	Downloaded	Filename	File Description
ANNOUNCEMENTS			
Yes	Yes	syllabus.pdf	Revised syllabus including course objectives.
--	No	TutoringSchedule.pdf	HKN Tutoring Schedule
CHAPTER 1			
No	Yes	ch01.pdf	Chapter 1 lecture notes. Fixes typos on page 1-5.
--	No	classes.m	Example .m file.
--	No	cospulse.m	Example .m file.

Figure 2. Screenshot of main course supplement page.

respect to on-campus access. However the site security does have the advantage that our materials do not contribute to the temptation of some students from other campuses—who are studying a similar course with the same textbook—to download problem solutions and copy them.

Once a student has been enabled, she may log on to the system by browsing to the *EduFile* logon page where she enters her username and password. She will be directed to the page shown in the screenshot of Figure 2. Access to the system is on a course-by-course basis.

At the top of the page, the course name, course description and instructor are listed. By clicking on the instructor email address, the student may send an email message directly from her web browser to the instructor. Below the course description is a listing of supplements that she may download. These are divided into categories (*e.g.*, ANNOUNCEMENTS, CHAPTER 1...) as assigned by the instructor.

In the figure, we see that this student has downloaded the syllabus and the first chapter of the lecture notes. Furthermore, she is assured that she has the most recent copy of the lecture notes since the flag “Update Since Last Download” says “No”. However, the syllabus has been updated since the last time she downloaded it, so she should retrieve the newer version. This student has not downloaded the tutoring schedule or the example Matlab simulation files, which she might want for extra help and understanding of the material. Not shown, because it falls at the bottom of the page, is a button allowing the student to modify her personal information (name, password, and so forth).

II-B. The Faculty Perspective

We have designed *EduFile* to be as easy for the student to use as possible. We have also tried to make instructor usage simple. All instructor tasks are accomplished using a web-based interface.

To log on to *EduFile*, the instructor must browse to the faculty administration URL. The dialog of Figure 3 is displayed. After the instructor enters his username and password, he is redirected to the page shown in the screenshot of Figure 4. Here, he is given the options of creating a new course (which involves entering the course number, name, description, and the course instructor), editing an existing course, or viewing the student activity log of downloaded course supplements.



Figure 3. Screenshot of the instructor logon dialog.

If the instructor chooses to edit a course, he is asked to select the course from a list of courses managed by the system and is then directed to the “manage course data” page. The content of this page is broken into three parts, shown in Figures 5 through 7.

The top part, Figure 5, allows the instructor to modify the course description. The middle part, Figure 6, allows the instructor to add course supplement files to the database, delete them, or to edit their description. The bottom part, Figure 7, allows the instructor to view student contact data and to either enable or disable their access to the system.[§]

Once a course is set up, the instructor has two main tasks. The first is to enable or disable student access, and the second is to add supplements to the system. When a student registers for the course, as described in Section II-A, *EduFile* sends an email message to the instructor to notify

[§] In this figure, we have erased personal data from the screenshot image using a paint program to protect student privacy. Names have also been altered. Typically, the Student ID, Phone Number and Email Address fields would be filled in.



Figure 4. Screenshot of faculty welcome page.

him that someone is requesting access. He then browses to the faculty administration page, to the bottom of the page (Figure 7). He enables the student by clicking in the checkbox to the right of her name. Should a student choose to drop the class, the instructor may un-check this box, and disable further access.

To add a supplement to the system, the instructor may either “drag” the file to the directory of files for that course (outside of *EduFile*), or may choose to upload the file with the upload file button (not shown in the figure). In either case, the filename is added to the table of files in Figure 6. The instructor may then click on “Edit” next to the filename to add a file description and category.

III. Evaluating Benefit to Teaching and Student Learning

Before starting this project, our hypothesis was that benefit to student learning would be significant. By keeping up-to-date and accurate information available to the student, she does not need to be confused by typographical errors in lecture notes and solutions. It follows that the teaching will be clearer as well when all such errors are removed. By providing homework hints, worked example problems and sample tests, the students may go beyond the minimal requirements of the course and study the material in greater detail. Office visits for simple questions can hopefully be minimized as well. By providing code segments (we have developed many hundreds in order to illustrate lecture notes alone) the students can see how problems are solved in a methodical manner. Simulation code producing graphical output can be used by students to experiment with problems and help them to immediately visualize solutions. In short, we believe that any student who invests the time to examine and understand the course supplements will increase her learning and will improve her classroom performance.

We have used *EduFile* in three courses thus far. The majority of the data presented here is for the

University of Colorado of Colorado Springs

UCCS Home - Campus Directory - Site Search

EduFile Course Supplement Management System

Manage Course Data

The course information below for course **ECE3510** can be updated. Just make a change to the value and click update.

Course ID : ECE3510

Course Name:

Course Description :

Instructor: [Add Instructor](#)

Edit/Delete Instructors

Delete?

Figure 5. First screenshot of course management page.

ece3510-sol8.pdf	Homework #8 solutions	HOMEWORK	Edit	Delete
hw10.pdf	Hw 10. Due Monday 2 December 2002.	HOMEWORK	Edit	Delete
ece3510-sol9.pdf	Homework #9 solutions	HOMEWORK	Edit	Delete
imp3.m	Example .m file	CHAPTER 1	Edit	Delete
randsig.m	Example .m file	CHAPTER 1	Edit	Delete
imp1.m	Example .m file.	CHAPTER 1	Edit	Delete
ex2.m	Example .m file.	CHAPTER 1	Edit	Delete

Figure 6. Second screenshot of course management page.

Students				
Student Name	Student ID	Phone Number	Email Address	Enabled
Bip				<input checked="" type="checkbox"/>
Brad				<input checked="" type="checkbox"/>
Chris				<input type="checkbox"/>
Christin				<input checked="" type="checkbox"/>
Daniel				<input checked="" type="checkbox"/>
Darren				<input checked="" type="checkbox"/>

Figure 7. Third screenshot of course management page.

core Electrical Engineering course *ECE 3610: Engineering Probability and Statistics*. This course has traditionally been considered difficult by the students so we believe that the additional supplements may be especially important to assist student learning. However, the mechanisms proposed are generic, so may be just as easily applied to any of the courses that we teach and, we believe, to any other course.

Our evaluation of *EduFile* is twofold. First, we analyze the access log and perform correlation with student grades. Secondly, we discuss the results of a survey we conducted.

III-A. Statistical Analysis of Student Access

From the *EduFile* database tables, information about student file retrieval activity can be obtained. In this section we consider a brief statistical analysis of this data to better understand how often and when students use the system. We also performed a correlation analysis of retrieval activity against student scores on a midterm exam and the final course average. From an assessment standpoint it would be encouraging if student use of course supplements had a positive correlation with their true learning, or at least learning as measured by performance on exams and homework assignments.

For the ECE 3610 course, Spring 2002, we first consider overall student access versus time. The time interval analyzed is the start of semester January 26, 2002, until March 13, 2002. Issues with the prototype software prevented complete capture of access data for the entire semester. How students used the system on a daily basis can be seen from the histogram of Figure 8(a). The date tic marks are at the start of each week, Sunday. Note in particular that each week the activity level peaks on Thursday, which is the day weekly homework assignments were posted. In Figure 8(b) the histogram bins are set to a width of one week, with the bin centers placed at Wednesday.

It is interesting to note from the plot that a peak in activity occurs in the week proceeding the first midterm exam. It is not surprising that the students felt the need to gather more inputs when preparing for the first course exam of the semester.

Next we consider when students made their visits by time-of-day. In Figure 9(a) the access data is histogrammed with respect too time of day, with all days considered being aggregated. One might

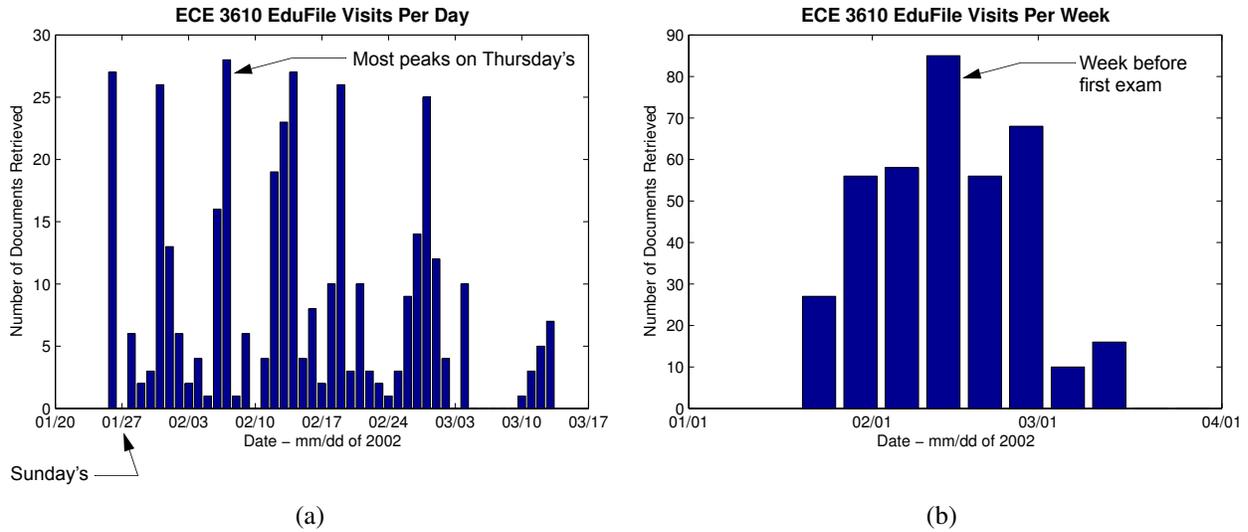


Figure 8. Histograms of student access (a) per day; and (b) per week, to *EduFile* for ECE 3610 during Spring 2002.

think that students put off getting assignments and solutions until late at night, but from this figure we see that this is not the case. Most file retrieval activity occurs between 6:00 AM and 6:00 PM.

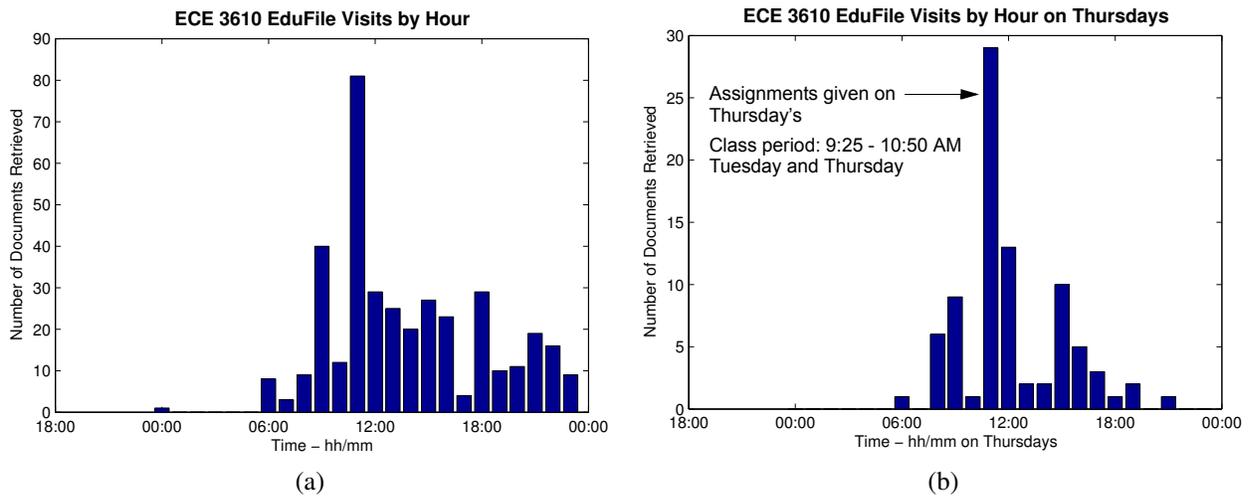


Figure 9. Histograms of student access (a) by hour and (b) by hour on Thursday's to *EduFile* Spring 2002.

Since course assignments are made on Thursdays, with class meeting from 9:25 AM–10:40 AM, the data was further parsed to see what in particular happens on just these days. In Figure 9(b) a Thursday-only activity histogram is given. From this plot it is clear that most students visit the *EduFile* Web site immediately following class to download the latest homework assignment. Indeed, the primary student use appears to be as a source of information about assignments.

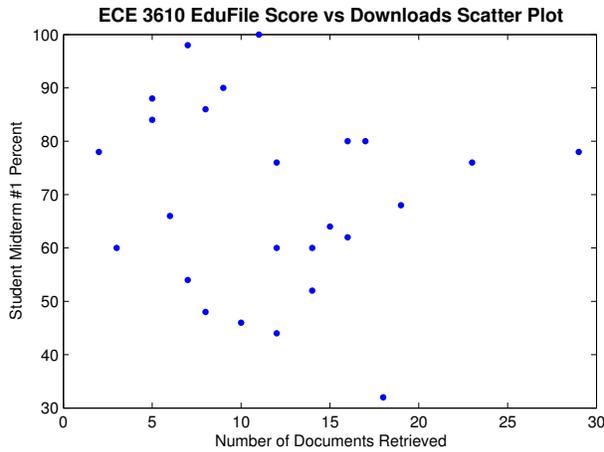
For assessment purposes we now consider how *EduFile* document retrieval correlates with

student course grades. In this analysis we consider the first midterm, given on February 19, 2002, and the final course average, which was used to determine the course letter grade. To best correlate with the midterm scores, the access data was parsed to remove retrieval of files placed on the system following the exam. For correlation with the final average the entire time interval available was utilized. A secondary form of parsing was used to remove assignments postings, which are essential for all students, and to consider just retrieval of homework solutions and old exam samples. We recognize that some students might print copies of supplements for their friends, so this analysis lacks some rigor. However, based on the log files, which show that each student made regular and consistent downloads, we feel that this was not a common occurrence, so the bias should be slight. The number of observations in all cases is 25 students.

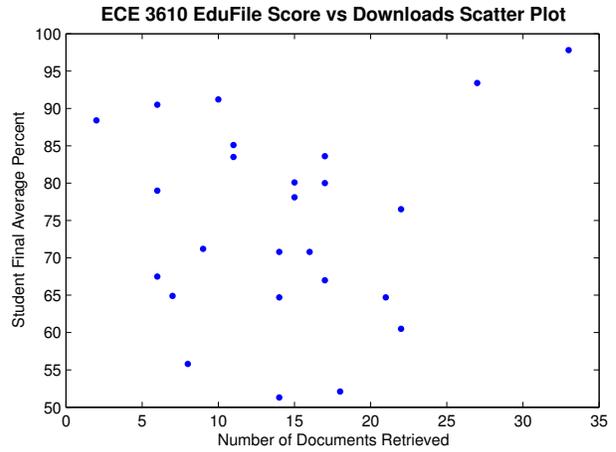
Shown in Figure 10(a) is a scatter plot of midterm exam scores versus the number of files retrieved. Is there a statistical relationship between file downloads and midterm score? When linear regression analysis of this data is attempted, several observations result. First of all the coefficient of determination, r^2 , is only 0.0146, meaning that in the context of linear regression modeling, only 1.46% of the variation in midterm grades can be explained/attributed to file downloads. Also an hypothesis test to determine with 95% confidence that the slope is zero passes, thus in that sense there is no correlation. Secondly, below the linear regression line in the right side of scatter plot, there is a void. The two data points sitting above the void would seem to indicate that more downloads correlate to a passing grade. This is only true for the two largest download data points. Linear regression modeling may not even be reasonable for the range of downloads considered. From an assessment standpoint, we were hoping for some indication of correlation, but with the exception of two students, no correlation is all that can be said. Additional parsing of the data yields scatter plot variations. In Figure 10(b) a scatter plot of the midterm exam scores is again plotted, but this time the homework assignment file retrievals are removed. Again, there is no evidence to suggest correlation. Figure 10(c) is a scatter plot of the midterm exam scores versus the number of homework solutions and old exam files retrieved. No correlation. Just because students download solutions does not mean they actually take the time to read and understand every detail. The fact that they have retrieved them is encouraging, as it indicates a desire to better understand difficult course topics.

Finally, we consider the correlation between final course average and the number of files retrieved over the time span of the access data set. Shown in Figure 10(d) is a scatter plot of midterm exam scores versus the number of files retrieved. Regression analysis similar to that used for the midterm scores is employed. The results are basically the same. There is no strong evidence to suggest correlation exists. The one exception is the two students that have downloaded in excess of 25 documents. The void in the lower right corner of the scatter plot suggests the possibility of positive correlation for these two students. In Figure 10(e) a scatter plot of the midterm exam scores is again plotted, but this time the homework assignment file retrievals are removed. Again there is no correlation. In Figure 10(f) a scatter plot of the midterm exam scores versus the number of homework solutions and old exam files retrieved.

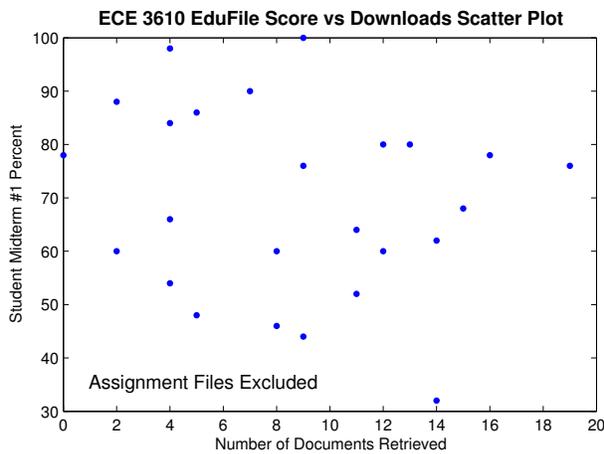
In summary, for the limited data set available, regression analysis indicates that with high confidence there is no correlation between the number of downloads and receiving a high grade in the course. This is not that encouraging, but as was stated earlier, simply retrieving documents



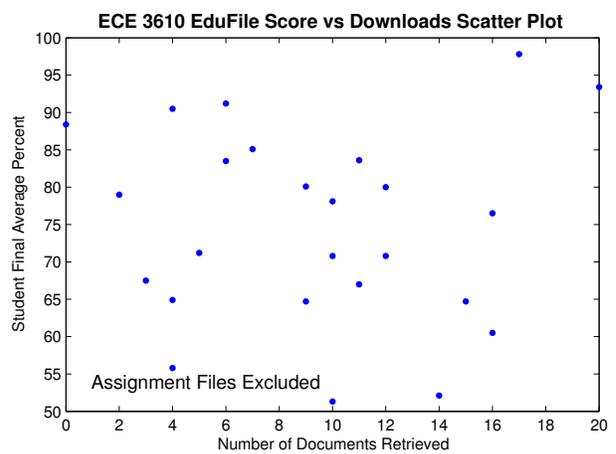
(a)



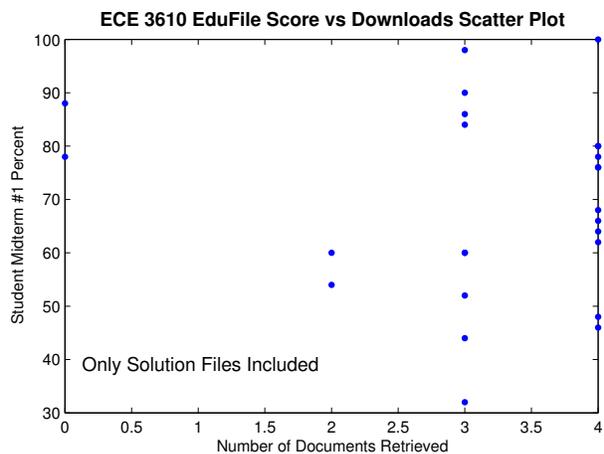
(d)



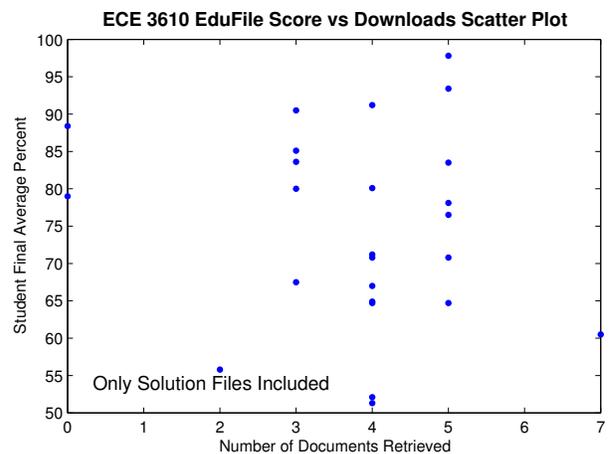
(b)



(e)



(c)



(f)

Figure 10. Scatter plots of grades versus downloads. Plots (a)–(c) show midterm #1 score versus student access to *EduFile* during Spring 2002; plots (d)–(f) show final course grade versus access. In (b) and (e), homework assignment retrieval was not considered; in (c) and (f), only homework solutions and old exams were considered.

does not guarantee that the information contained in the documents is fully digested by the student. We feel that having supplements readily available via the Web is a step in the right direction to improving student learning.

III-B. Survey responses

To complement the quantitative results from the log file, we conducted a survey of two subsequent classes.[¶] The survey is reproduced in Figure 11, and numeric results are entered in Table I. Overall, students indicated that they frequently downloaded homework assignments, homework solutions, and sample exams. They downloaded simulation files and updated lecture notes less frequently. The utility of the supplements was judged to be very high, especially for homeworks, homework solutions and practice exams. Students were very pleased with the convenience and were not concerned with any “invasion” of privacy (by logging accesses).

The most frequent comments in the write-in section were “please add more practice exams”, “please add worked problems” and “please add solutions to practice exams”. Other comments indicated that ‘night-owls’ were very appreciative of the convenience of being able to download supplements at any time. Some students wanted the supplements displayed in a different organization on the internet site, and we are planning to do so next course offering.

IV. Conclusion and Future Plans

We have described an internet-based course supplement management system that we have designed and implemented. We hypothesized that benefit to student learning would be significant. Our findings from the access log show that every student used the system, but were statistically inconclusive as to whether or not grades were improved by the availability of the supplements. On the other hand, responses to our survey indicate that the students themselves believed the supplements to be very helpful, and the internet system to be very convenient.

Our plan is to incrementally add courses to the *EduFile* system, as we teach them. For each course, we intend to increase the quantity and quality of supplements available to the students. This task will be aided by the analysis of access log data as it is created, which can help determine which supplements are most useful.

ACKNOWLEDGMENT

This work was supported in part by a grant from the University of Colorado at Colorado Springs’ Teaching and Learning Center. Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of the University of Colorado at Colorado Springs, or of the Teaching and Learning Center.

The majority of the code in *EduFile* was written under subcontract by Matthew Long of Matthew Long Enterprises, <http://www.matthew-long.com>.

[¶] The log data was lost for these classes, so could not be included in the previous section.

**Department of Electrical and Computer Engineering
Evaluation of the *EduFile* Course Supplement Management System**

Please evaluate by filling in the circled numbers.
(1 = strong disagreement, 5 = strong agreement)

Your usage of *EduFile*

- | | ☹ | ... | ☺ |
|---|---|-----|-------|
| 1. I download homework assignments from the class web site. | ① | ② | ③ ④ ⑤ |
| 2. I download homework and exam solutions from the class web site. | ① | ② | ③ ④ ⑤ |
| 3. I download sample exams from the class web site. | ① | ② | ③ ④ ⑤ |
| 4. I download sample Matlab simulation files from the class web site. | ① | ② | ③ ④ ⑤ |
| 5. I download lecture note corrections from the class web site. | ① | ② | ③ ④ ⑤ |

The utility of course supplements to your learning

- | | ☹ | ... | ☺ |
|--|---|-----|-------|
| 1. I find homework assignments useful to understand course content. | ① | ② | ③ ④ ⑤ |
| 2. I find homework solutions useful to understand course content. | ① | ② | ③ ④ ⑤ |
| 3. I find sample exams useful to understand course content. | ① | ② | ③ ④ ⑤ |
| 4. I find sample Matlab simulations useful to understand course content. | ① | ② | ③ ④ ⑤ |
| 5. I find corrected lecture notes useful to understand course content. | ① | ② | ③ ④ ⑤ |

Convenience and privacy issues

- | | ☹ | ... | ☺ |
|--|---|-----|-------|
| 1. I find it convenient to have supplements available 24/7 on the internet. | ① | ② | ③ ④ ⑤ |
| 2. I do not mind the “extra step” of needing to log on to <i>EduFile</i> with username and password. | ① | ② | ③ ④ ⑤ |
| 3. I find it useful that the system tells me which files have changed since I last downloaded them. | ① | ② | ③ ④ ⑤ |
| 4. I do not feel that my privacy is being compromised by the system tracking which files I (personally) have downloaded. | ① | ② | ③ ④ ⑤ |

Feedback

Do you have any additional comments—positive or negative—about the system?

Can we improve any feature to make *EduFile* easier to use or work better in some way? (How?)

Can we add some features to *EduFile* to make it more useful to you? (What?)

Can we add additional course supplements to assist learning? (What?)

Figure 11. Survey used to evaluate *EduFile*.

TABLE I

Raw data resulting from survey shown in Figure 11. Note that the number '6' in row ECE3510 #19 was handwritten on the survey form by that student—it is otherwise an impossible score on a 1–5 scale.

Student	Usage					Utility					Convenience			
	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4
ECE5540 #01	5	5	5	5	5	5	5	5	4	4	5	5	5	5
ECE5540 #02	5	5	5	4	4	5	5	5	4	4	5	5	5	5
ECE5540 #03	5	5	5	5	5	5	5	5	5	5	5	4	4	4
ECE5540 #04	5	5	5	5	5	5	5	5	5	5	5	5	5	5
ECE5540 #05	5	5	5	4	4	5	4	5	3	4	5	3	5	4
ECE5540 #06	4	4	4	3	4	5	5	5	5	5	5	4	4	3
ECE3510 #01	5	5	5	3	4	5	4	5	3	3	5	2	3	4
ECE3510 #02	5	1	5	5	1	5	1	5	5	1	5	5	5	5
ECE3510 #03	5	5	4	2	2	5	5	4	3	3	5	5	3	5
ECE3510 #04	5	5	5	5	5	5	5	5	5	5	5	5	5	5
ECE3510 #05	5	5	5	5	1	3	3	3	3	3	4	4	3	4
ECE3510 #06	5	5	5	3	1	3	4	4	4	2	5	5	5	5
ECE3510 #07	5	5	5	5	5	5	4	5	5	5	5	5	5	5
ECE3510 #08	5	5	4	4	5	4	5	4	5	5	5	3	4	3
ECE3510 #09	5	5	5	3	2	5	5	5	3	3	5	5	5	2
ECE3510 #10	5	5	5	5	5	5	5	5	2	5	5	5	5	5
ECE3510 #11	5	5	4	1	1	2	3	3	3	2	5	5	4	2
ECE3510 #12	5	5	5	5	3	5	5	5	5	5	5	5	5	5
ECE3510 #13	5	5	5	3	5	5	5	5	4	5	3	4	4	4
ECE3510 #14	5	5	5	3	5	4	5	4	3	4	5	5	5	5
ECE3510 #15	5	5	5	3	3	5	5	5	4	5	5	4	5	3
ECE3510 #16	5	5	5	5	3	4	5	4	5	3	5	3	5	3
ECE3510 #17	5	5	5	5	4	4	3	3	4	4	5	5	5	5
ECE3510 #18	3	1	5	2	1	2	4	3	1	3	5	3	5	5
ECE3510 #19	5	5	5	3	5	5	5	5	2	5	6	5	5	5
ECE3510 #20	5	5	5	5	3	5	2	3	5	3	5	5	5	5
ECE5540 mean	4.8	4.8	4.8	4.3	4.5	5.0	4.8	5.0	4.3	4.5	5.0	4.3	4.7	4.3
ECE5540 sigma	0.4	0.4	0.4	0.8	0.6	0.0	0.4	0.0	0.8	0.6	0.0	0.8	0.5	0.8
ECE3510 mean	4.9	4.6	4.9	3.7	3.2	4.3	4.2	4.3	3.7	3.7	4.9	4.4	4.6	4.3
ECE3510 sigma	0.5	1.2	0.4	1.3	1.6	1.0	1.2	0.9	1.2	1.3	0.6	0.9	0.8	1.1
Overall mean	4.9	4.7	4.9	3.9	3.5	4.5	4.3	4.4	3.9	3.9	4.9	4.4	4.6	4.3
Overall sigma	0.4	1.1	0.4	1.2	1.6	0.9	1.1	0.8	1.2	1.2	0.5	0.9	0.7	1.0

GREGORY L. PLETT

Gregory Plett was born in Ottawa Canada in 1968. He received the B.Eng. degree (with high distinction) in Computer Systems Engineering from Carleton University in 1990. He received the M.S. and Ph.D. degrees in Electrical Engineering from Stanford University in 1992 and 1998. Since 1998, he has been an Assistant Professor in the Department of Electrical and Computer Engineering at the University of Colorado at Colorado Springs. He can be reached by email at glp@eas.uccs.edu.

MARK A. WICKERT

Mark Wickert received the B.S. and M.S. degrees in electrical engineering from Michigan Technological University in 1977 and 1978, respectively, and the Ph.D. degree in electrical engineering from the University of Missouri-Rolla in 1983. In June of 1984, he joined the University of Colorado, Colorado Springs, where he is currently Professor of Electrical Engineering. His research interests include communication systems and signal processing. He can be reached by email at wickert@eas.uccs.edu.