Electronic Submission, Grading & Return of Undergraduate Laboratory Reports - A Pilot Study & Outcomes Assessment

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Abstract

This paper describes a P.C. based system for electronic submission, grading and return of undergraduate laboratory reports. The system was implemented as a pilot study at the University of South Florida (USF) during the summer 1998, and proved to be very successful.

The system is based on an e-mail attachment approach, but this turned out to be by-no-means as trivial as might first be assumed. A variety of issues had to be addressed, such as: establishing e-mail accounts and connections; software requirements and acquisition; overcoming e-mail send size and faculty account size limitations; ensuring security/privacy; filtering and issuing electronic receipts; and deadline compliance through date/time stamps.

Electronic grading and return of annotated reports presented particular challenges. In order to approach the clarity and convenience of physically marking paper with a pen, faculty required annotation software and hardware in the form of a pen-pointer input device.

Many of the techniques discussed may be familiar to faculty who are cognizant of modern PC software. But for those who are not so "into" computers or who haven't got the time to develop their own system, this paper should prove to be an invaluable introduction into the advantages and convenience of electronic document handling.

Introduction

Undergraduate engineering degree programs across the country usually include at least one laboratory course, which invariably serves as a platform for teaching technical writing skills [1]. Undergraduate laboratory reports are a fertile ground for teaching engineers how to communicate through written documents, since they include such crucial elements as: an abstract, a nomenclature, graphs and tables, as well as conventional text and analysis. The mechanical engineering department at USF is no exception, and offers a course to undergraduates in their penultimate semester called "Mechanical Laboratory I", the details of which can be found in Refs [2, 3]. This course has traditionally required each student to write four reports a semester with each describing and reinforcing the engineering concepts introduced by hands-on experiments. These formal reports each run to 25 pages in length and have to be submitted according to a rigid hand-in schedule. Enforcing such a schedule teaches students the importance of meeting deadlines. The logistics of handling some 32 paper laboratory reports being submitted every 2 weeks has always presented a challenge and has required the cooperation and goodwill of departmental secretarial staff.

During the 1998 summer semester, a system for electronically submitting, grading, and returning laboratory reports was implemented as a pilot study to assess feasibility. Many problems had to be overcome, but the idea turned out to be very successful. The present paper describes how any faculty could adopt a similar approach to grading. Many of the techniques discussed may be familiar to faculty who are cognizant of modern PC software. But for those who are not so "into" computers or who haven't got the time to work out the "bugs", the paper should prove to be a "jump start" into the advantages and convenience of electronic document handling.

Why Electronically Submit?

Engineering students educated and trained in universities today are destined to enter an increasingly global market economy, and are likely to be employed by multi-national companies, or those that do business worldwide [4]. For such industries, rapid long distance communication is vital to competitiveness. The ready availability of relatively low cost, yet fast and powerful P.C.'s, together with the internet, has made such communication more flexible than ever. Now virtually all businesses and a large percentage of homes have P.C.'s with internet access.

Just as the telephone revolutionized voice communication, so the P.C. and internet have dramatically impacted the transfer of published material. Mail is generally slow, potentially unreliable, and expensive. FAX ties up telephone lines during transfer,

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blocking other incoming faxes, and can get expensive for large documents sent long distance. Fax also has a relatively poor print quality and most often accepts only single sided monochrome pages. Lost messages or a failed connection can occur if the receiving machine runs out of paper.

Digital document transfer using electronic mail (e-mail) attachments, working through servers, allows the delivery of large, superior quality, color documents worldwide at very little cost. The recipient does not have to have his P.C. active when the message is sent, but can access it from the server at any convenient time. The document must of course be available in purely electronic form before it can be sent, but once delivered its digital nature allows it to be archived using a variety of magnetic or optical storage media, where it can be searched and cataloged easily. If printed out, the quality is potentially always as good as the original (limited only by the printer used).

Students should therefore be encouraged to use electronic transfer methods, as this will equip them for their future careers. Without this requirement students tend to resort to paper "cut-n-paste" techniques to create documents, rather than learning how to assemble a single electronic document from a variety of individual software applications.

A number of prominent annual conferences are now accepting papers only when submitted electronically. The proceedings are invariably distributed in the form of a CD-ROM, with a hardcopy version only available on request and at additional cost. Once again this requires that the paper take the form of a single file, with photos, drawings, graphs etc., fully integrated into one application (usually a Postscript, Microsoft Word, Corel WordPerfect, or Adobe Acrobat file).

Aside from preparing students for the future, the idea of electronic submission of school assignments offers some attractive benefits to both faculty and students. For an average class of 32 students each submitting four 25 page reports, a purely electronic system stands to save some 3200 sheets of paper per semester, along with toner and printer hours. Students can submit their reports from the comfort of their own homes, while the faculty can access them from his/her office or home. Date stamps tell whether the report was received by the deadline, and automated receipts can be issued to allay student fears that their report didn't transfer properly. Secretaries are no longer required to physically accept paper reports, issue receipts, or deliver reports to a faculty mail box. Electronic reports are less likely to get lost, stolen or copied, as used to be the case when paper reports resided in faculty mail slots or on a secretary's desk.

With electronic reports faculty could potentially apply search routines to quickly discover any illegal similarities. If reports are required to be individual work such similarities might constitute cheating in the form of copying. Electronic grading and subsequent return of the annotated reports back to each individual student's e-mail account, completes the "paper-less" cycle.

Basic Methods

There are basically only two candidates when it comes to selecting an electronic transfer method, these being e-mail attachments or ftp (file transfer protocol). The latter is a powerful utility that facilitates the transfer of files between host and remote computers. Ftp is the common way that conference organizers use to gather submitted electronic papers. To use ftp the sender must have been provided with log-on information pertaining to the destination folder within the remote computer (which could also be a web site). Unfortunately, anyone with this log-on information is able to remotely view, copy, or even delete any file in the destination folder. So a different password protected ftp destination folder would have to be provided for each student in the class in order to avoid tampering. This tends to make secure ftp uploads to folders or web sites more difficult to implement for the submission of class assignments, than a simple e-mail approach.

E-mail allows messages to be sent to any person worldwide who has an active account issued by an internet service provider (ISP). USF (and most universities) issue an e-mail account to every registered student, and so it is not necessary for any student to purchase e-mail or internet services. E-mail generally permits the attachment of files to messages, and since each individual has a personal address and password, messages sent or received remain reasonably secure from third party tampering. For these reasons an e-mail attachment method was chosen for the pilot study. Universities and certain other volume providers do, however, tend to limit account size and message send size, so these limitations have to be actively addressed. Copyright issues should not present any difficulties [5], but students should be discouraged from scanning in too much published book material into their reports.

Hardware Requirements

Obviously to create and transmit electronic reports each student must have access to a P.C. USF has not yet instituted a P.C. ownership requirement for students, but many universities have [6]. Without this requirement colleges must provide access to P.C.'s in the form of computer labs. Such labs are expensive to create, maintain, keep up-to-date, supervise, and keep free of viruses. Universities are now more inclined to put their limited resources into modem pools that enable students and faculty who own P.C's

to have access to computer services from home. In the pilot study, all but 3 students already owned a P.C., and the remainder saw the class as a final good reason to buy one.

To run word processing, spreadsheet, and e-mail software does not require top-of-the-line hardware. A 486-based P.C. running at 66MHz could conceivably be used, although a Pentium running at 200MHz or faster with plenty of RAM and a good quality modem would obviously be preferred. Such machines are not particularly expensive, and many university credit unions offer low interest loans to students for the purchase of a P.C. For engineering students especially, P.C. ownership is rapidly becoming as much a necessity as a calculator. For the present application, students don't actually require a printer, but a flat bed scanner would be a useful addition.

The faculty in charge of the class will require, as a minimum, a good office P.C. preferably with Ethernet connection to the university server for fast downloads. To make the operation even smoother, a second computer located at home (preferably a notebook) would certainly make grading more convenient. Fitting both office and home computers with a Iomega Zip 100 or Imation LS-120 Super Disk drive would also help with the virus scanning, data transfer, and archiving functions. A pen-pointer input device was found to be more controllable than a mouse when circling text and placing other annotations on student reports during grading.

Software Requirements

Software can be expensive, and so the goal was to devise a system that used freeware, shareware or discounted applications where possible.

The first step for students was to establish a PPP (point-to-point protocol) connection between their home-based P.C. and the university server. This step uses only the Dial-Up-Networking utility included in the Windows® operating system (OS), and a set of step-by-step instructions usually available from university computer services, the book store, or off the university web site [7]. This connection is not necessary if a student already has an e-mail account through another ISP such as AOL. Some students preferred this alternative since the university modem pool available to them was often busy during peak times.

In order to write their lab reports each student needed desktop publishing software capable of word processing, creating tables and preparing graphs. To foster uniformity, students were told that laboratory reports would only be accepted if submitted as a single Microsoft Word® (.doc) or Corel WordPerfect® (.wpd) document. Either of the two basic word processors are best purchased when bundled with other necessary spreadsheet and useful presentation software in the form of Microsoft Office 97® or WordPerfect Suite 8® respectively. This software is normally quite expensive, but for registered students and faculty both are available from university book stores as an educational version. Such versions are sold at around 25% the price of the functionally identical publically distributed products, requiring just the production of a valid university I.D. The software costs then become similar to the purchase of a class text book.

Every student in the pilot class chose to use Microsoft Office 97, and so submitted their reports as Word documents. The reason for this is unclear given that WordPerfect is arguably easier to use, considerably cheaper, and less notoriously "buggy" than Office 97 [8]. Indeed, the major problems that surfaced during the semester invariably related to bugs and poor user friendliness of the Office 97 product. Microsoft has issued many patches and service releases pertaining to this product, and still a number of bugs remain unresolved (200, in fact according to Microsoft's online KnowledgeBase) [9]. The fact that Office 97 is sometimes bundled with a new P.C., or that students may have been required to use this software in prior classes, may account for its popularity.

The second major piece of software required was an e-mail client program. The students were asked to use Microsoft Outlook Express® as the client, as it has received excellent reviews [10,11] and is available free. Outlook Express is bundled with Microsoft Internet Explorer 4.0® (IE4.0) which is a free download from the Microsoft web site, and is now included in the new Windows 98® O.S.[12].

Finally, because of e-mail send size restrictions, it was suggested (but not required) that students use a compression software. Software such as WinZip® or PKZIP® can be downloaded from the web as free evaluation copies or as shareware. The user is not obligated to buy this software (although it is inexpensive and a good idea) if they use the product infrequently. Compressing just 4 reports in a whole semester could be construed as such. Students were required to keep the extracted (uncompressed) file size to a 3MByte maximum. This is ample for a typical report, provided that scanned images are used sparingly.

To read their returned and annotated reports, the students also required Acrobat Reader®, which is freely distributed via the Adobe Corporation web page.

Faculty software demands are obviously greater than for an individual student, since he/she would require both Office 97 and WordPerfect Suite 8 (if students were given the choice), the e-mail client (Outlook Express), compression software to extract files, and special software for grading. The latter requirement called for the use of Adobe Acrobat 3.0® (educational version) and an annotation plug-in called Ambia Re:mark®. As an alternative, software such as Cross All-Write® makes it possible to hand write annotations directly into documents using a pen pointing device.

Faculty Account Size Limitations

USF allows faculty an e-mail account size of only 10MBytes on the server. Should all the class of 32 students submit a 2MByte report at roughly the same time the faculty account would obviously be swamped. To avoid this problem, faculty need to designate a submission time window when students must submit their completed report. During this time the faculty must leave his/her office P.C. (with Ethernet connection) switched on and running the e-mail client in the background. Outlook Express includes a feature whereby the client will download to the P.C. all messages from the faculty account on the server every 5 minutes (say), and remove (delete) the server messages permanently. This puts the storage burden on the P.C. and keeps the server account space essentially free. The account size limitation is no longer a problem provided that no more than 10MBytes (5 reports) are submitted during any 5 minute period. The ethernet connection is important since its speed allows the download to be completed within the 5 minute cycle, further limiting the possibility of account swamping. To implement the above features in Outlook Express choose: **Tools - Options - General Tab**, check the box ***Check for new messages every ? minute(s),*** and scroll the interval box to 5 minutes. Also choose **Tools - Accounts - Mail Tab - Properties - Advanced Tab**, and ensure that the box labeled ***Leave a copy of messages on server*** in the *delivery* section is not checked.

E-Mail Send Size Limitations

USF limits the size of a single e-mail message (including any attachments) to 2MBytes maximum. Outlook Express can (when enabled) automatically break oversize messages into a series of smaller consecutively sent component messages. The recipient's client automatically gathers together the component messages and reassembles them back into the single oversize original form. This feature can be implemented by choosing: **Tools - Accounts - Mail Tab - Properties - Advanced Tab**, checking the box ***Break apart messages larger than ? KB*** and scrolling to 500 (say) in the size box.

Alternatively, compressing a file to a size where a single message can be sent provides for a much faster download time when sending e-mail from a home P.C. via telephone line. In reality the 2MByte size limit translates to a maximum attachment size of only around 1.7MByte, since the sent file is always larger than the attachment alone, even if no text message is included. If uncompressed this file size can be easily exceeded with a 25 page document especially if it contains scanned images. Students using PKZIP software were routinely realizing 60% to 90% size reduction by compressing their reports prior to attachment and sending.

Date & Time Stamps

Deadlines are very important in the corporate world, and students should be prepared for this aspect of their future careers by rigidly enforcing deadlines on student assignment submission. For the pilot class, the penalty for missing the submission deadline (assuming no server outages) was a zero grade for the report (a class F if a report is never submitted). Date and time stamps are automatically applied to e-mail, and show up on the recipient's e-mail client as "Sent" and "Received" information for each message received. However, the "Sent" information is placed on the message by the sender's P.C. and can be made to look falsely favorable by a student simply adjusting his system's clock. Therefore, students should be informed that judgement concerning deadline compliance will be based on the "Received" date and time stamp, which is issued by the server and not readily falsified.

Electronic Receipts & Sorting with Filters

Students are understandably leery about sending their hard work at the click-of-a-button, and hoping that it makes it to its destination by the deadline. These fears can be allayed to some extent by issuing a receipt via e-mail back to the sender if the report made it to the destination. Outlook Express can be set up to automatically reply to an author of a received message.

The first step is to make sure that student laboratory reports can be distinguished by the e-mail client from other unrelated mail. To this end, students were told to include the words "mech lab" in the subject field of the e-mail message containing the attachment. Outlook Express then uses its filtering capability to key in on messages with the designated subject. The filtering proved to be very robust, since it looks for letter strings and is thus unaffected by fonts, letter case, word spaces, additional words, or even the order of the key words. To implement the filter in Outlook Express choose: **Tools - Inbox Assistant - Add**, then fill in the properties table with the *criteria* and *action* information.

For the pilot class two *actions* were set when the *criteria* was "mech lab" in the subject field; these were first to *Move* the mail to a folder called "Mech Lab", and second to *Reply* to the mail's author with a receipt message. The "Mech Lab" folder was

created within Outlook Express by choosing: **File - Folder - New Folder**, and entering the name "Mech Lab". Any mail arriving with "mech lab" in the subject field was sorted and routed to the "Mech Lab" folder, thereby keeping the electronically submitted student laboratory reports separate from other unrelated mail which would end up in the "Inbox" folder. The reply receipt message was written using the **Compose** button without entering any information into the heading fields (To:, Cc:, Bcc:, Subject:), and then placed into any convenient C: drive directory using **File - Save As** in Outlook Express. The receipt mail is saved as a .eml file and its location is entered in the appropriate address box under *actions* described previously. Students could therefore expect to receive the receipt message via e-mail within 10 minutes of sending their report, automatically day or night, provided that their report was indeed received and they remembered to put "mech lab" in the subject field.

Viruses, Privacy & Security

An inescapable consequence of exchanging files between multiple users is the risk of P.C. virus infection. By restricting acceptable attachment file extensions to simple .doc, .wpd, or .zip minimizes the risk somewhat, although simple .doc files are now capable of carrying viruses [13]. As a faculty, do not accept (immediately delete) any Word Template file submitted (.dot) as such files are common carriers of destructive macro viruses. One such virus caused havoc for two students in the class, and one went so far as to inadvertently send an infected Word Template attachment to the faculty (which was happily deleted before being opened). Also do not accept any self extracting compressed files (.exe) for similar reasons. To be as safe as possible faculty should protect their P.C. with anti-virus programs such as: McAfee VirusScan®, Norton Anti-Virus®, Inoculan®, Dr. Solomon's® or Quarterdeck®. In doesn't hurt to have more than one of these programs, with engine upgrades and virus definition files always kept current through regular web downloads. As a further safety net, it is recommended that once the submission deadline has passed faculty save all of the attached files to an Iomega Zip 100 disc (or similar), and then delete all of the mail from the client's "Mech Lab" folder without ever opening an attachment (the regular messages can of course be read). The disc (most likely in the E: drive) can then be specifically scanned for viruses using an anti-virus program(s), being sure to scan "All Files" and "Compressed Files" rather than the default setting of just "Program Files".

Privacy, in the sense of whether one student can electronically access or tamper with another student's work, is reasonably assured by using e-mail. Obviously authorized university computer staff can access any e-mail account on the server even if password protected. But given that the student's laboratory report mail is not left on the server for longer than 5 minutes after arrival, this possible breach is not significant. Accessing and interrogating the faculty P.C. through the Ethernet connection would also be a significant challenge, and certainly not something easily achieved by a casual student user. However to be safe choose: **Start - Settings - Control Panel - Network - Configuration - File & Print Sharing** and make sure that the box labeled ***I Want to be Able to Give Others Access to My Files*** is not checked.

A more serious issue is that of security, in the sense of whether an unauthorized person could access the stored student laboratory reports by physically tampering with the P.C. hardware when left unattended overnight in the faculty office. The first line of defense is obviously a lock on the office door, but this could be compromised by cleaning staff or other faculty/graduate students who may share the room. For the pilot study, a P.C. was used which had a keyboard lock (requiring a physical key). When left running overnight during the submission window period the keyboard lock was set and a password protected screen-saver was run. This was set in Windows 95 using **Start - Settings - Control Panel - Display - Screen Saver**. To prevent compromise of the screen saver password by switching the main power off and back on, a Windows password was added using **Start - Settings - Control Panel - Passwords.** Such a password is easy to go around, but this it moot given that the keyboard lock prevents Windows from re-booting.

Final security steps involved switching off power to the monitor to give the impression of an inactive machine, and the addition of a battery back up power unit to keep the P.C. running during any brief power outages**.**

Electronic Grading

Once all of the submitted laboratory report attachments had been saved (to a Zip 100 disc, for archiving and easy transport to a home-based P.C.), the preparation for grading was begun. The annotation software used for grading in the pilot class was a plug-in for Adobe Acrobat Exchange (included with Adobe Acrobat). So each of the .doc or .wpd laboratory report files had to converted into Portable Document Format (PDF). When Adobe Acrobat is loaded, it places both PDF Writer and Adobe Distiller options into the print menu of the Word 97 and WordPerfect 8 word processing applications. Each laboratory report submission is opened in the appropriate word processing application and then "printed" (to a file) to convert it to the required PDF form. Generally Adobe Distiller works better than the PDF Writer when a document is graphics rich. Adobe Distiller was found to be much more

adept at correctly converting data symbols on imported Excel graphs in Word documents than the PDF Writer.

PDF documents are highly compressed (often smaller than a .zip file), are text searchable, but no longer editable. Several annotation software programs are available, such as Digidox Digitools® and Ambia Re:mark, with the latter used for the pilot class. When a PDF document is opened in Adobe Exchange the Re:mark plug-in provides a menu of annotation tools. These include a text over-writer (typed), high-lighter, underline, strikeout, freehand (best using a pen-pointing device), circle, rectangular box, pop up comment box, and rubber stamp. Many of these annotations are capable of taking on various line weight, font or color attributes. A sound comment is even available whereby a recorded audio message can be inserted at any location in the PDF document. These tools make it possible to correct, modify and make comments in red anywhere on the submitted laboratory reports, just as a grader would do with a red pen on printed paper.

Once a laboratory report was completely graded, the annotations were "rendered" into the PDF document. This ensured that all the annotations could be viewed without having the Re:mark software by just using Adobe Acrobat Reader, which is a free web download.

Certain software is available for use with pen-pointer input devices, such as Cross All-Writer, that enables annotations to be directly hand-written onto Word 97 and other documents, thereby eliminating the need for conversion to PDF. When compared to Re:mark such software lacks the variety of tools, password protection, and clarity of typed annotations. Hand writing with a pen pointing device, especially when lettering has to be small, requires some practice and is often harder to read and slower than typing.

For the pilot study, a pen-pointing device was used with the freehand tool in Re:mark for circling text, adding arrows, and correcting graphs and diagrams. The over-writer tool allowed for fast, clear, typed comments via the keyboard. Such a combination was not possible with the purely pen-based direct non-PDF annotation software.

Electronic Return of Graded Reports

Each annotated laboratory report can be electronically sent back to its author as an e-mail attached PDF file.

Collection of all the student e-mail addresses can also be automated in Outlook Express. Choose **Tool - Options - General Tab**, and put a check in the box labeled ***Automatically put people I reply to in my Address Book***. Since each student automatically receives a reply receipt if they include "mech lab" in the subject field, their e-mail address will be logged to the Address Book in Outlook Express.

Problems & Experiences

Generally the pilot program proved to be a great success. From the faculty point of view the worst aspect of the whole experience was the electronic grading. This required all grading to be performed while staring at a computer screen, which can be tiring on the eyes. Also, unless the faculty has access to a notebook computer he/she becomes "tied" to a desk top P.C. for many hours while grading, which is anti-social at home, and hard on the posture when occupying the same position in one chair for hours. A notebook computer should be regarded as a necessity for such activity since it comes close to the convenience and portability of simple paper grading, although such machines can exacerbate the eye strain problem.

Most students had no difficulty with the compressing or e-mailing aspect of the experience, but were dogged by difficulties in trying to create single file documents from multiple applications. Typically students used Word 97 for word processing, Excel® for tables and graphs, MathCAD® for analysis, and AutoCAD LT 97® for diagrams, together with various scanned images. Word 97 turned out not to be particularly user friendly when importing, placing, and anchoring output from other applications. Bugs associated with page numbering and extraneous blank pages were prevalent. Adding a "portrait" positioned page number on a page containing only a "landscape" oriented graph and title presented difficulties. Unless anchored, images tended to move around the Word document when e-mailed.

Overall the students did appreciate the educational benefits of electronic submission, as well as the convenience of instantly sending their finished report directly from home. However, a few students failed to see why they should have to spend countless hours wrestling with creating a single electronic document, when they could more easily "cut-n-paste" a hardcopy and hand it in manually. For this system to be viable it is vital not to allow hardcopy submission under any circumstances, otherwise most of the class will inevitably be tempted to take this easier option. Students are told to "pretend" that their report has to be submitted to someone in Australia (or some other far distant place), where physically hand delivering a hardcopy would be impossible and mailing it would be too slow.

The first round of laboratory reports submitted included all manner of mistakes, omissions, and e-mail induced formatting problems. However, by the second or third report the submissions were getting very "clean", and most grading corrections related

directly to the engineering content rather than presentation deficiencies.

No class time was devoted to teaching students how to use any specific software. Indeed today's software choice may well be tomorrow's "dinosaur". Rather, the climate is created where students have to choose, and teach themselves how to use, whatever software it takes to get the job done. Students are encouraged to use the resource represented by their fellow class mates, by networking outside the classroom with a view towards solving various software challenges. This equips students with the attitude and skills necessary to quickly become proficient at any software that they might in future encounter.

Conclusions

A system, based on e-mail attachments, has been developed that enables students to submit their laboratory reports for grading from the comfort of their own homes. Once graded, the responsible faculty is able to return a fully annotated version of the electronic report back to the student's account. Challenges and logistics had to be addressed before the system could be successfully implemented, but once established it proved to be very popular amongst the students. Students were obliged to become proficient in a variety of software packages, and to produce single file reports by importing graphs and technical drawings into a word processing application.

Apart from popularity, there are very few direct advantages of the system to faculty since electronic grading on a P.C. screen can be restrictive and tedious. The educational value to the students is however regarded as reason enough to implement such a system, even if this means some inconvenience to faculty.

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