"Paperless Grading" of Handwritten Homework:
Electronic Process and Assessment

Susan C. Schneider
Marquette University
Electrical and Computer Engineering Department
P.O. Box 1881
Milwaukee, WI 53201-1881
susan.schneider@marquette.edu

Abstract

The typical engineering homework assignment may involve sketches, formulas with special symbols, as well as calculation steps. The most time efficient way for students to do this work is by hand, on paper. In terms of grading such assignments, it is faster and easier for instructors to handwrite comments than to add typewritten comments via text box, sticky note, etc. The computer and printing technologies available to instructors and students have progressed to the point where the use of electronic submission and grading for assigned work is viable, both in terms of ease of use and the benefits accrued – even for handwritten assignments.

The goal for this project is to implement and assess a "paperless grading" process for handwritten homework assignments which allows for both electronic submission and return of the assignments. This process also allows the grader to "mark-up" the papers with handwritten comments.

In spring 2013, the 33 students in the "Engineering Systems" class participated in a semester long trial of a paperless grading process for their homework assignments. An iPad was used as the homework grading platform coupled with the university's course management system. At the end of the semester, the students completed a survey with questions which asked them to compare the paperless process with the process associated with the more traditional homework submission and grading process as well as their opinions on possible benefits or disadvantages of the paperless process. Also included were questions asking for their suggestions for improvements on the paperless process. Student feedback from this first trial was used to make some enhancements to the paperless process which was repeated in the spring 2014 offering of the class with 60 students who then completed the same survey used in 2013.

This study shows that the penultimate "hold out" of going paperless – handwritten homework – can be accomplished with the hybrid process to be described in this paper. All participants in both semesters – students, graders, and instructor – concur that paperless grading is the way to go.

In this paper, a more detailed description of the paperless grading process for handwritten homework will be presented. In addition, the quantitative results of the project evaluation for both semesters will be discussed as well as suggestions for future improvements in the process.

Introduction

Paperless submission and grading can already be efficiently done for assignments for which students create and/or assemble their work using software to produce an electronic file. These types of assignments are fairly typical in "General Education" courses in which students submit papers, essays, writing assignments, etc. and electronic grading is making significant inroads as evidenced by the "electronic grading v. paper" forum on the Chronicle of Higher Education web site[1]. In STEM, this type of assignment includes typewritten (word-processed) lab reports and final design reports and as such is equally well suited for electronic grading.

In STEM, the primary challenge to going totally paperless is those assignments which are ordinarily created by hand on paper such as homework or exams. These products may involve sketches, formulas which may contain special symbols, as well as calculation steps. The most time efficient way for students to do this work is by hand and on paper. To then convert these handwritten solutions to word-processed text for electronic submission can be – and usually is – an unacceptable time burden, particularly for "low stakes" assignments such as homework many times tends to be. And, it is also still faster and easier for instructors to <u>handwrite</u> comments on papers.

There are many previous and on-going efforts to accomplish electric grading of handwritten materials. In 2005, for example, Park and Hagen described a homework submission and grading process used to support the Distance Education Network of the Viterbi School of Engineering at USC. The foremost goal for their process was to deliver handwritten homework to the instructors "in a manner they could grade quickly – paper"[2]. The automated system used a web portal and a set of fax servers to facilitate receipt, acknowledgement and routing of papers and processed on the order of 2500 10-plus page "typical" assignments. It was also proposed that technology trends would support the submission of assignments via an automated e-mail delivery and dispersion system. Dean described a system called "dynamic homework annotation" in 2007[3] in which more personalized feedback on assignments submitted as pdfs can be done by adding audio comments to the usual "inked" annotations. Dean used LectureScript, his personal program, to read, markup, and add audio comments, though other programs which could provide similar features were listed; for the annotation, a Wacom Cintiq tablet monitor was used. While well received by the students, the addition of audio annotations to the graded homework appeared to substantially increase the time required to grade and no data was presented to show that there was increased student learning as a result of this homework grading method. Chang[4] proposed a template based homework system in 2007 where the instructor creates a template with header information as well as the homework questions that students download. The students appear to enter their answers into the template via keyboard (as shown from student examples); these documents are then uploaded to the system. Instructors then use markup tools to grade the pdf documents. A full-featured "stand alone" digital paper exam grading system under development as of 2010 at the University of Virginia uses open source software and supports both typewritten and handwritten annotation as described by Bloomfield[5]. This system requires instructors (or staff) to preprocess the papers to add an identifier information footer. After the students complete their handwritten work on these pages, each student paper is scanned to pdf and uploaded to the server. One of the benefits of this level of automation is that individual question statistics can be automatically compiled. Other schools, including AUT

University in New Zealand[6] and Penn State[7] have automatically incorporated an electronic homework grading process similar to that described in this paper during overall redesign of the manner of teaching their courses to better take advantage of technology.

The goal for this project was to pilot <u>paperless grading for handwritten homework assignments</u> in ELEN 2040 (Engineering Systems) in the spring 2013 semester. The grading with handwritten feedback comments given on the majority of handwritten assignments was done electronically.

The pilot study concluded at the end of the 2013 spring semester and was deemed successful by all participants: students, teaching assistant, and instructor. Student feedback on the electronic grading process used in this pilot student provided significant advice that was used to modify the electronic process per student suggestions for the 2014 spring offering of this class.

Project Details

In spring 2013, 33 students, mostly sophomores from the electrical engineering major and the bioelectronics major, were enrolled in ELEN 2040 and a teaching assistant was assigned to provide 4 hours per week grading support. Funds granted to this project were used to purchase an iPad (16 GB, Wi-Fi), a stylus and a Bluetooth keyboard cover. Associated software purchased for this project included the iOS application, *iAnnotate PDF,* from Branchfire, Inc. The iPad was used by the TA; the instructor already had an iPad. The paperless homework grading process was employed for 10 of the 12 homework assignments in the pilot study. In spring 2014, the paper-less homework process was repeated for the 60 students enrolled in this same class; for this larger class, 8 hours per week of grading support was provided.

The paper-less homework grading process is summarized as follows. All homework assignments are posted to the content section of the class site in the university's learning management system, *Desire2Learn (D2L).* Students write up their problem solutions in the "traditional" manner on paper. These handwritten solutions are then scanned to pdf. Many students do this scanning using university supplied "Multi-function Devices (MFD)" which in addition to the traditional photocopy and printing features allows students to scan documents to pdf which they can then e-mail to themselves. The pdf copies are then submitted to the D2L drop box associated with the homework assignment in advance of the posted due date.

The grader then downloads a zip file with all posted submissions; from this file the individual student pdf submissions are extracted and aggregated within a folder. This homework folder is then placed in the grader's cloud storage account for easy access from within the iAnnotate application. Each student's homework paper is then marked up (graded) using appropriate iAnnotate markup tools; the iAnnotate app automatically synchronizes the annotated papers to the cloud storage account. When all grading is done, the papers are returned to the individual student through the assignment D2L drop box using the "evaluate submission" tools to both upload the graded paper and enter a grade for the assignment into the D2L gradebook. The folder in the grader's cloud storage account is then deleted as all papers, both original and graded versions, are available from within D2L.

Two examples of graded student submissions with handwritten annotations are shown in figure 1. Figure 1a shows a paper that was scanned with the university MFD, where figure 1b shows a page scanned with an iPhone app. The border on each

Figure 1: Graded Student Homework Examples

(a) scanned with MFD	(b) scanned with iPhone/iPad application

paper represents the standard 8 ½ x 11 size page if a hardcopy is made from the scanned image.
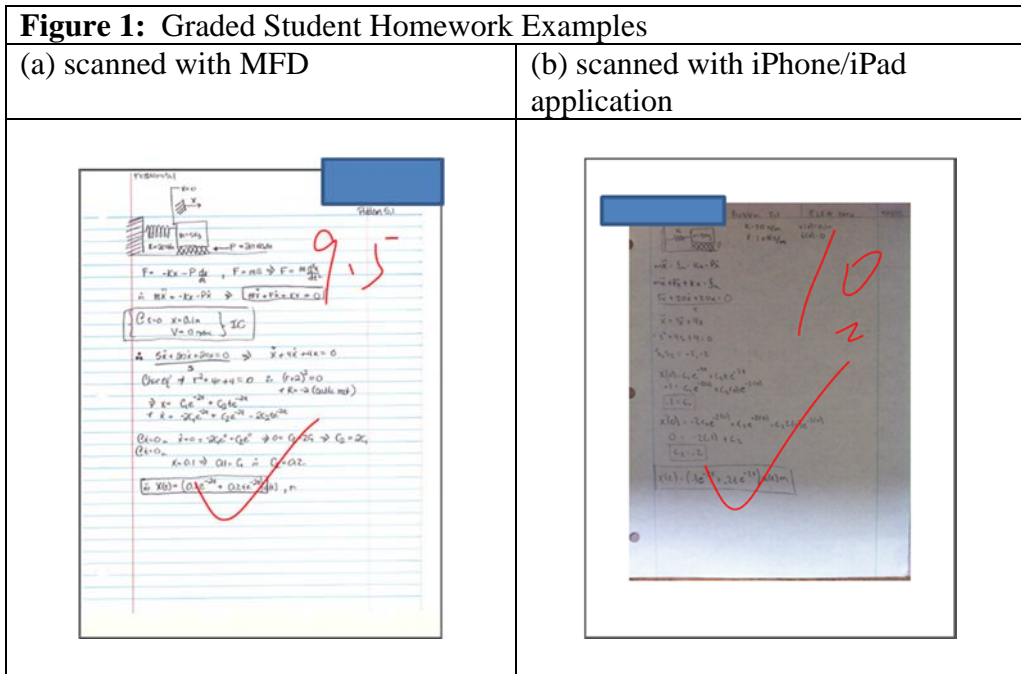
Project Assessment

At the end of both semesters, the students completed a 23 questions survey posted as a quiz on D2L; 17 of the questions were directed towards understanding the students' opinions on paperless grading. Some of the questions asked them to compare the paperless process with the process associated with the more traditional homework submission and grading process; other questions asked for their opinions on possible benefits or disadvantages of the paperless process with another set of questions asking for their suggestions for improvements on the paperless process.

1. Student perceptions of electronic homework submission compared to traditional paper homework.

Based on the results shown in tables 1 and 2, it appears that in terms of feedback quality and timeliness, the majority of students perceive that the electronic submission and grading of handwritten homework is as effective as the more traditional paper submission process. From these results alone, it appears that the students feel that the hybrid paperless process is an acceptable alternative to the traditional process.

Table 1: Quality of the grader's comments –		
electronic compared to paper homework submission		
	2013	*2014*
Less meaningful	6 %	25%
about the same	**91%**	**72%**
more meaningful	3 %	4%

Table 2: Rate of return of electronic homework compared to h/c submission		
	2013	*2014*
Faster	**42 %**	**25%**
Same	**58 %**	**60%**
slower	0 %	15%

The most important result is shown in table 3; almost 100% of the students would willingly use the paperless homework process again in other classes.

Table 3: Would you do paperless submission again?		
	2013	*2014*
Yes	**79 %**	**64%**
No strong opinion- will do as required by instructor	21 %	32%
No	0 %	4%

2. Student perceptions of benefits of the paperless homework process.

The data in table 4 show the percentage of students choosing from among a list created by the instructor of benefits of the paperless homework process. The most cited benefit is the ability to submit their homework when it was ready and not having to wait until it was due to deliver to the instructor in class. This benefit was also often listed by students in the free comment area.

Table 4: Benefits of paperless homework (choose all important to you) *(Note: percentages will not add to 100%)*		
	2013	*2014*
can submit homework whenever its ready	**91%**	**89%**
always having my original copy of the homework	82 %	68%
being able to access my graded homework on-line	76 %	64%
not having to remember to carry the homework with me to submit in class	64 %	49%
not having my homework lost or misplaced by the grader	52 %	57%

While students often reiterated the above benefits in the free comment area of the survey, the most cited benefit was the ability to access their work – either graded or original – anytime, anywhere. One student gave the scenario of being at the library and when all the rest of her work was done, (she) could then turn to studying for this class even though the "stuff" for this class

was not with (her) because the homework and other materials could just be "pulled up" from D2L. These numbers and this anecdote point out that these students are quite comfortable having their materials available "on the cloud" and relish having their work so accessible.

There were also several questions on the survey which probed student behaviors associated with the paperless grading process. As shown in table 5, a significant proportion of students took advantage of the ability to submit their homework early (or, rather, when they completed it); an option which is seldom available for traditional homework submission.

Table 5: I generally electronically submitted the homework		
	2013	*2014*
Early	**42 %**	**26%**
on time	54 %	70%
Late	3 %	4%

The other interesting behavior the students showed through their responses on the survey is that they are – in general – not compelled to save their <u>graded</u> homework either electronically (through download to their computer) or by printing it, preferring instead to simply view the grader's comments on-line as can be seen in table 6.

Table 6	How often did you VIEW your graded hw ONLINE?		How often did you <u>download or print</u> your graded hw?	
	2013	*2014*	*2013*	*2014*
At least once	**76 %**	**79%**	39 %	36%
Several times	**18 %**	**11%**	12 %	11%
Never	6 %	9%	**48 %**	**53%**

These last behaviors have ramifications for students who do review their work in semesters SUBSEQUENT to when they take the course. Since a course D2L site closes after the semester ends, students lose access to their graded work if they have <u>not</u> downloaded or printed it.

In 2013, students noted that the most frustrating part of the process was creating the scanned pdf (too much time) particularly when they had to include MATLAB code or graphs as part of their submission. It was suggested by several students that some minor amount of class time be spent showing how to do the scanning using the university multi-function devices to get the best result without a lot of trial and error. This suggestion was acted upon in 2014. This "scanning issue" comment was still the number 1 cited in 2014, however, the percentage of student citing this declined from 17% to 10%. In 2014, however, there were significantly more comments from students about totally eliminating paper by writing up the homework using a tablet computer.

3. Grader/Instructor evaluation of paperless homework process

The teaching assistants were interviewed about their perceptions of the ease of the paperless homework grading process as well as any benefits and/or disadvantages.

When asked about the amount of time it took them to become comfortable with the hardware, software, and process used in this project, the 2013 TA stated that within 1 or 2 assignments, he had developed his process flow and was comfortable with use of the annotation application tools. On the other hand, the 2014 TA stated that she would prefer to use Adobe Reader on her laptop and use typewritten comments rather than using the iPad to insert handwritten comments. After completing the grading for the first assignment, she found that laptop process was very time consuming. After speaking with the 2013 TA for this class, she switched to using the iPad for the remainder of the assignments.

The 2013 TA reported "likes" about the paperless system such as "not having to haul papers around", "not losing student papers", and "learning the new process/application", that it was "easy to compare work in the application to facilitate fairness in grading", and to "being able to give quick response and feeling like I have a direct link with the students (emailing for advice, etc.) The 2014 TA was less positive about the experience, primarily because she felt "tethered" by the need to be within range of Wi-Fi in order to access the papers for grading. Unfortunately, this dissatisfaction was not voiced until the end of the semester and can be easily remedied by a minor change in the process to download all the papers directly to the iPad for access even in the absence of a Wi-Fi connection.

The biggest negative issue that both TAs reported was papers submitted in the wrong format, i.e., not as pdf documents. Some students submitted OneNote sections, others created zip files with each problem as an individual pdf. The TAs felt awkward asking the students to resubmit these papers. The number of assignments submitted in the incorrect format was substantially lower in the 2014 class because "how to" instructions were given in class prior to the first homework submission as per the suggestion by the 2013 student cohort.

The experience of the instructor with the paperless grading process in this and other classes is similar to that reported by the 2013 TA. An additional benefit noted by the instructor is that the paperless grading process eliminates the need to make arrangements to pass the physical homework papers back and forth to the teaching assistant. The TA automatically has both access to the original and the ability to directly return graded papers to the students. In addition, homework keys and grading guidance can also be given to the teaching assistant electronically. Notes for the grader can be incorporated into a pdf copy of the key (including a handwritten key) using the same annotation application used for homework grading. And, when the TA is grading, if they need some guidance from the instructor on a particular student's submission, sending an e-mail to the instructor allows the instructor to look at the electronic version of the student's paper "in parallel" with the TA and respond to the TAs request via e-mail with suggestions including directly marking the particular paper if warranted! In addition, electronic return of the graded submission directly to the student electronically helps ensure compliance with FERPA requirements while minimizing time spent in class returning homework assignments individually to each student.

The FINAL analysis

The technology tools available to instructors and students have progressed to the point where the use of electronic submission and grading for ALL assigned work is viable, both in terms of ease of use and the benefits accrued. This work – in both 2013 and 2014 – shows that the penultimate "hold out" of a totally electronic grading process – handwritten homework – can be accomplished with the hybrid process described in this project.

Bibliography

1. The Chronicle of Higher Education Forums "Careers>In the Classroom>Electronic grading v. paper", http://chronicle.com/forums/index.php/topic,164051.0.html (last accessed 3 Aug 2014).
2. Park, James and John Hagen, Jr. *Managing Large Volumes of Assignments*, Educause Quarterly, 2 Nov 2005, pp 64 – 67.
3. Dean, Brian C., *Dynamic Homework Annotation*, Proceedings 1st International Workshop on Pen-Based Learning Technologies PLT2007, 2007 (pp 1-4).
4. Chang, X., *PDFeH: A PDF Based Generic Teacher-Student e-Homework System,* Proceedings of the 2009 International Conference Computational Intelligence and Software Engineering, CiSE 2009. (pp 1-4)
5. Bloomfield, Aaron, *Evolution of a Digital Paper Exam Grading System*, Proceedings of the 40th ASEE/IEEE Frontiers in Education Conference, 2010, pp TIG 1– TIG 6
6. Maclaren P., S. Singamemni, and D.I. Wilson, *Technologies for Engineering Education*, Proceedings of the 11th Global Congress on Manufacturing and Management (GCMM2012), 2012 (pp 1 – 10)
7. Gregg, Andrea, James Mundie, and Juan Xia, *Overcoming the Quantitative Divide: Penn States' Approaches to Online Mathematics,* 29th Annual Conference on Distance Teaching and Learning, 2013, (pp 1 – 5)