Electronic Assessment, Evaluation and Archiving of Online Student Assignments

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Abstract

The tablet PC is beginning to have the potential to fulfill the dream of many students and instructors to dispose of paper notebooks in favor of computerized systems. Software that will allow in-class interaction on such systems is beginning to emerge, and handwriting recognition has finally become usable. One area that shows particular promise is the area of annotation, where up until now paper-based systems have dominated.

Many teachers currently prefer students hand in written assignments in paper form, rather than electronically. The reason for this is commenting, correcting errors in content and grammar, and marking up papers is more easily performed with a pen than with a keyboard. With a tablet PC using the latest revision of its operating system, it is now possible to use an electronic pen to mark up assignments, combining the speed, flexibility, natural resource preservation, and organizational advantages of electronic media with the usability advantages of paper media.

This paper describes the changes that result from using this method, including electronic paper submission, markup and grading, and returning the assignment with usable electronic feedback. Electronic archiving of marked-up assignments for accreditation and other program evaluation purposes are also presented, along with various storage and presentation issues. The results of a small study are shown, where an instructor and students who used the methods of this paper rated their effectiveness.

Introduction

Even though there have been a number of attempts at making the paperless office or classroom a reality, most have ended with mixed results. However, recent advancements in technology, usability and user skill are showing promise in making this a reality. In particular, the development of tablet computers, annotation software and Internet connectivity now enable educators to provide feedback on student work with the advantages of both traditional paper grading and electronic communication and archiving.

The advantages of electronic paper submission and grading are similar to those found in other computer fields. Firstly, space-shifting allow students to submit assignments from anywhere they have Internet access. Students do not need to physically carry the paper to a central drop-off point or allow for the delays and additional expense of mailing an assignment. This is a

significant advantage for distance education and a convenience for every student. In addition, the instructor enjoys the convenience of being able to pick up the assignments over the Internet.

Secondly, record keeping is improved. As we focus more on continuous improvement in technical tertiary education for accreditation and other reasons, it is necessary to develop and keep records of student performance for assessment and evaluation. The instructor can easily store a copy of every student submission and its associated feedback. It is therefore necessary to have a system for archiving all this material, which can be accomplished through modern database technology. This is especially true for accreditation, where students' work in electronic format can provide a valuable resource for showing how accreditation criteria are met,[1,2] especially when packaged with instructor feedback.

Prior to several recent developments in hardware and software, instructors have used various mechanisms to handle electronic submissions and grading. However, many of these have demonstrated significant disadvantages.[9]

For example, students could submit word-processed papers, which the instructor could then type annotations onto using a word-processor, an approach previously used by some of the authors. In practice this is very cumbersome and slow. Furthermore, any feedback text that the instructor inserts into the document disturbs the layout of the student's original paper.[9] It is also a departure from the "red-pencil" annotation traditionally used by instructors.

Some instructors have used tape recorders to comment on students' papers while reading them. Although this does not allow for space-shifting, it does allow the instructor to make lengthy comments without disturbing the original submission. This is more typically used for grading longer essay-type papers or theses. This requires that both the instructor and student have compatible audio equipment. It is also difficult to synchronize the two media types, as the instructor must continually refer to page and paragraph numbers to keep the feedback in context. Oral feedback is also unsuitable for numerical or calculation-based assignments typically found in technical and scientific education. The fact that this method has been around for decades and is almost never used is strong evidence of its weaknesses.

This paper details both research and experiences of several instructors that suggests that paperless grading, feedback and archiving is now becoming practical under certain conditions.

The Electronic Submission, Feedback and Archival Process

While the preparation, submission and evaluation of electronic assignments follow the same basic process as their physical counterparts, several important differences exist. As with physical assignments, electronic assignments follow the basic submission-feedback cycle. The differences are in how each step is carried out. Figure 1 details the process for electronic submission, evaluation, feedback and archiving. A number of different approaches are available for the actual implementation of the electronic approach.

Once the student has created their assignment, it is submitted electronically to the instructor. The instructor retrieves the electronically submitted assignment and proceeds to read and annotate it.

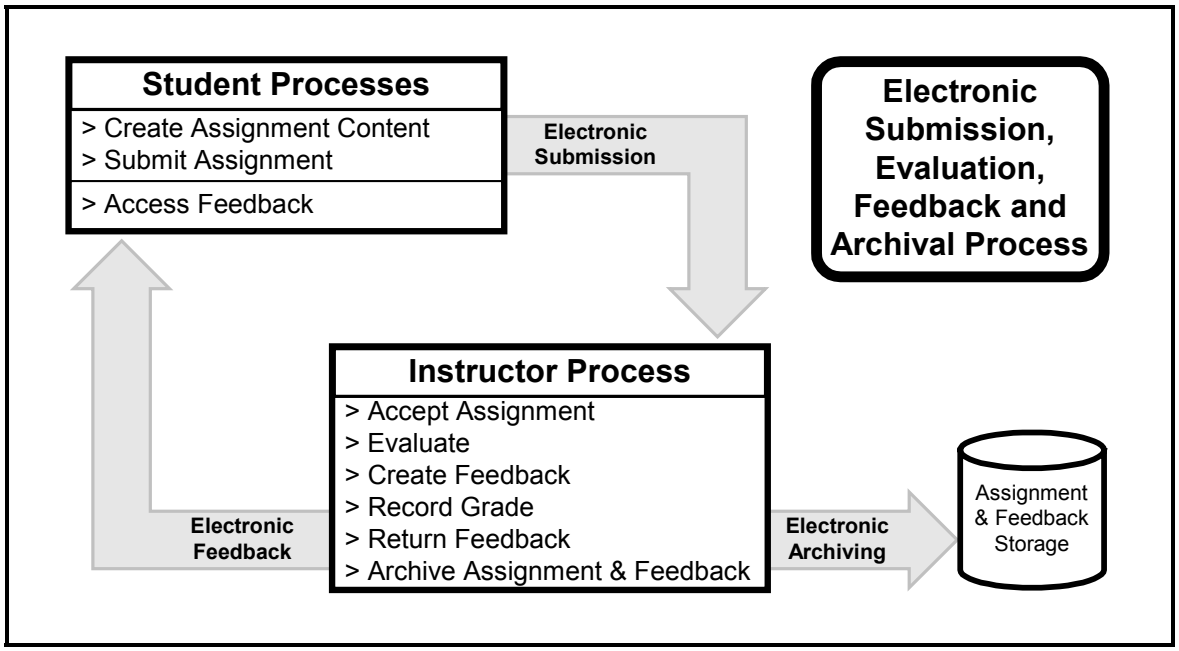

Figure 1. Electronic submission, feedback and archival process description

Once this is done, the instructor returns the annotated assignment electronically and archives an additional copy for future reference (e.g. accreditation). The student must then retrieve the returned annotated assignment to access the feedback provided by the instructor.

While the electronic process provides some benefits such as greater convenience and a reduction in paper, a number of issues still exist with the implementation of this process, including:

- System construction
- Assignment creation
- Assignment submission
- Assignment acceptance
- Evaluation and feedback
- Feedback communication
- Assignment archiving

System construction refers to the costs and constraints resulting from implementing a system to handle the electronic submission-feedback cycle. Such systems range in complexity and cost. For this study a simple email system was used. However, this would be impractical for widespread deployment in a university environment due to its maintenance costs and lack of features. A course management system, such as Blackboard or WebCT, provides more centralized control and features. Other researchers have explored the use of such systems.[3] Decisions on the overall system construction have a ripple effect on the overall process and must be weighed carefully.

Assignment creation provides a unique set of issues to the student. Certain assignment types lend themselves to electronic assignments, while others do not. For example, the creation of a basic term paper on the computer is significantly easier then one with mathematical formulas, which often requires specialized software. In addition, student-created drawings or pictures must often

be scanned into the computer. Consequently, for certain types of assignments, a great deal of additional time and steps are required to prepare it for electronic submission.

Assignment submission processes also vary. Examples include email attachments or submission via an HTML form. Also, issues related to preparing the assignment for submission, such as creating a compressed archive or data format conversion, must be considered.

Assignment acceptance issues are closely related to assignment submission issues. Once an assignment is submitted, the instructor must retrieve it for evaluation. The retrieval process depends on the submission process and ranges from simply receiving email to downloading submitted assignments from a web archive.

Evaluation and feedback deal with the annotation systems used to markup the submitted assignment. Several different annotation systems are available, all requiring the assignment be a certain data format. Currently, this limits submission to those products that support 'digital ink', such as current versions of Microsoft Word and Journal. Before the instructor can even begin annotating, it must be loaded or imported into the annotation system. Once this is done, issues then arise with the hardware and software used to do the actual annotation. For this paper, tablet PCs were used, though other methods, such as stylus pads, do exist.

Feedback communication happens when the instructor sends the annotated assignment back to the student. This has its own unique set of issues, as the student must be able to view the data format of the annotated assignment, which may differ from the data format of the original. The instructor must also electronically package the annotated assignment before returning it.

Assignment archiving issues depend on the intended use of the material. For some applications, a simple email folder may suffice. However, if the material is to be used for future evaluation or accreditation, a more sophisticated archival system is preferable. In either case, the instructor must insert the completed annotated assignment into the archival system.

As can be seen, a number of issues exist. While many of them have fairly simple solutions, these solutions almost always incur additional steps and time costs to the student and/or instructor, thereby decreasing usability and increasing complexity, both of which can adversely affect the overall efficiency of the system.

Study Description

The study was done with students in an introductory digital electronics class (IT104 – Digital Electronics Foundation). Part of this class is a series of single page homework assignments, two of which were selected for the study. Students were to complete one of these using the traditional paper method and the other using the electronic submission process. Comparisons were then made between the two methods from both the students' and professor's points of view.

For the electronic submission process, all students completed the assignment using Microsoft Word or comparable word processor and then submitted them to the professor via email. Students voiced no objections to this method.

Once the professor had received the assignments, he divided them into three equal groups, one to be graded using the traditional paper method and the other two to be graded using different software packages on a tablet PC. One of these groups was annotated using Microsoft Word 2003 and the other with Microsoft Journal, both of which allow free-form annotation. After the grades had been recorded, the graded and annotated papers or files were returned to the students for their review.

For this study, the archiving process was performed by the email client, which provides a simple, albeit primitive, archiving mechanism.

Study Results

For the assignments completed using the traditional paper method, the professor simply graded them by hand using a pen. The resulting assignments were then handed back to the students during the regular class period. During the grading phase, the professor timed how long was required to grade ten papers using this method, resulting in a time of 35 minutes.

After spending a couple of hours to gain proficiency with the tablet PC and the related software, the professor graded the electronically submitted papers. Half of these were annotated using Microsoft Word 2003 and the other half with Microsoft Journal. The resulting file was then returned to the student via email.

Because preliminary tests indicated Journal's additional conversion step slowed the overall process, the timing test for the study was conducted using Word. In addition, Word appeared to be more ubiquitous for the students. Once again the grading of ten assignments was timed with a result of 45 minutes. The additional ten minutes required for the electronic process is believed to result from the overhead of the additional steps required to retrieve, load, save and return these assignments, with little resulting from the actual annotation process. As these assignments were only a single page, this overhead was more significant than it would be for a longer, multi-page assignment or paper.

At the end of the semester, each student was given a simple survey as the last page of the final exam. While not a blind survey, it did allow for students to respond to the experience. It should be noted that this formative assessment was done with too small a sample to allow for detailed statistical analysis. Thus the responses are simply presented as raw data.

The students were first asked which format was used for their reading report feedback and which format they would prefer. Not all students responded to both questions. This can easily be seen by the fact that the test group had been equally divided, while only a few reported using Microsoft Journal. The results are shown in Figure 2.

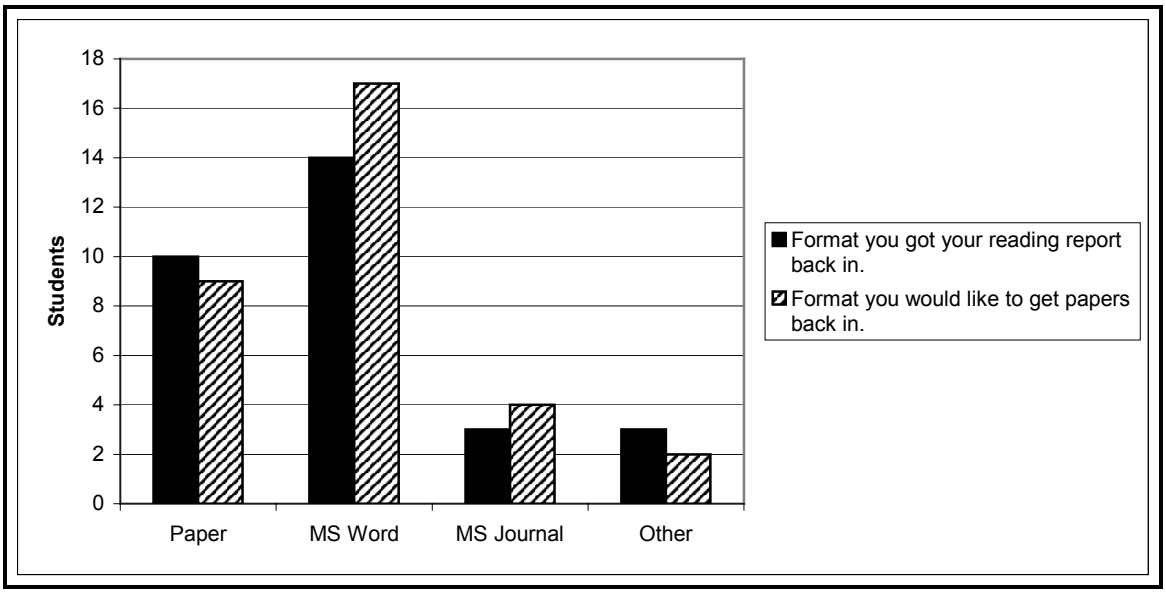

Figure 2. Feedback formats

The students were then asked to respond to the following questions using a numbered scale from 1 (strongly disagree) to 5 (completely favor):

- I prefer to submit assignments electronically.
- I prefer to receive graded assignments back electronically.
- I was able to easily review my scored paper with the professor's markings.

Their responses are shown in Figure 3 and Figure 4. As would be expected in a technology-oriented class, most students were in favor of electronic submission and feedback. However, there were a surprising number of students who were not in favor of electronic means. It should also be noted that not all students responded to every statement.

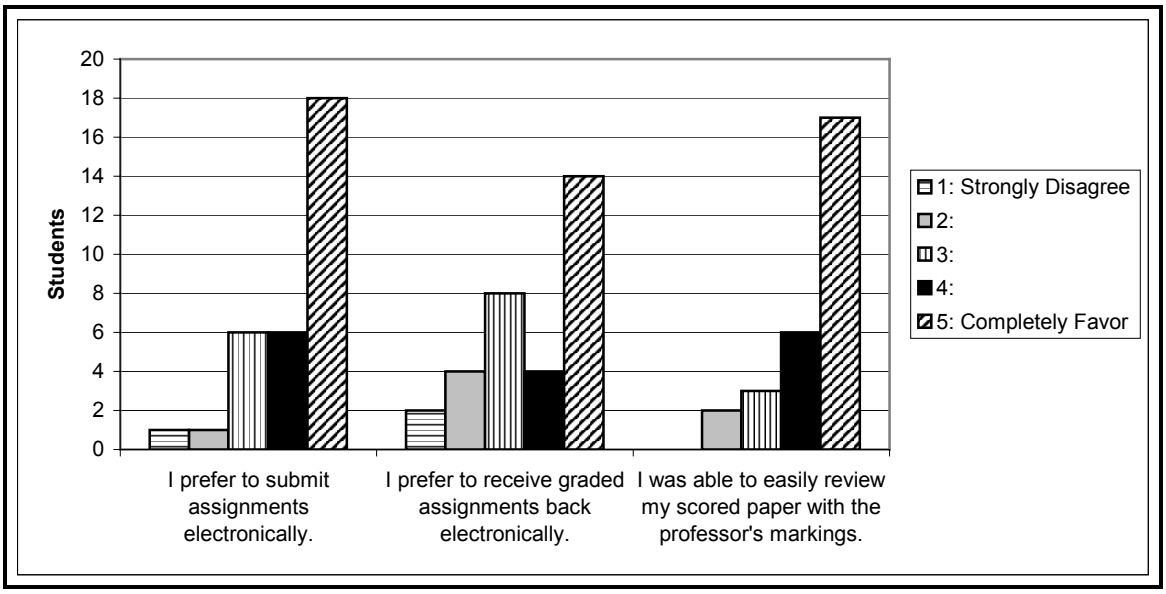

Figure 3. Assignment submission preferences

	Strongly Disagree				Completely Favor	Total Student Responses	Average	Median	Standard Deviation
	1	2	3	4	5				
Question 1	1	1	6	6	18	32	4.2188	5	1.0697
Question 2	2	4	8	4	14	32	3.7500	4	1.3198
Question 3	0	2	3	6	17	28	4.3571	5	0.9512

Question 1: *I prefer to submit assignments electronically.*

Question 2: *I prefer to receive graded assignments back electronically.*

Question 3: *I was able to easily review my scored paper with the professor's markings.*

Figure 4. Assignment submission preferences data

Since these are IT students, they have considerable familiarity with electronic media. Future research needs to address a much wider and more diverse group. This study, due to its small size and restricted participant pool, makes no attempt to establish a general conclusion in regard to students' acceptance or feelings towards electronic submission and feedback of assignments.

The students were also asked to provide additional comments on the survey. Below are several of these comments, which show the range of responses:

> "Come on! It's the future! Who really wants to print out a paper (wasting ink and paper) only to have to travel all the way to the professor's office to turn it in??? With one click of the button, it's turned in electronically."

> "I have not found any preference to the method of submitting assignments. If it can be submitted electronically, it is usually very easy to submit in paper. I have seen both get lost. So, I find I have no real preference."

> "I really like submitting papers electronically, though it would be somewhat difficult to submit homework electronically w/out at[sic] scanner, and would be difficult to read."

> "I don't like electronic submission because the email services you are using might not be able to hold attachments. And, the Internet is not as reliable as hard copy submission. The email server may go down as you submit, or your submission may never get through at all."

> "Very good way of doing it. It makes it easier to hand in and get back promptly."

As can be seen, there was a wide range of responses. The responses were chosen for inclusion in such a way as to show the difference of opinion, and thereby do not represent a balanced sample of responses. These are provided solely to show the range of student thought and response on electronic submission and feedback for this particular usage. It is expected that responses would differ under different circumstances, and are meant only to suggest different areas and concerns for additional research.

One item that should be noted is trust or distrust in the electronic submission process appears to have a large impact on the student's overall opinion of the entire process. Paper submission is a process that the student is familiar and comfortable with, having done it since the earliest school years. It is therefore important that the instructor strive to engender the same level of confidence and trust in the electronic submission process, which may be new and possibly intimidating to the student. Without this trust, the process is more likely to fail from the student's perspective.

Additional Observations

During the study, a number of observations were made regarding Microsoft Journal. In addition, the authors have made other observations regarding their anecdotal experiences with electronic submission, annotation and related technologies and processes.

Microsoft Journal Observations

Microsoft Journal comes packaged with Microsoft's tablet PC version of Windows XP, and provides the user with free-form annotation functionality. While it provided the ability to provide hyperlinks as annotation, it tended to struggle in other areas. It had a difficult time with some handwriting to text conversion tasks, such as fractions. For example, if the professor wrote 8/10 vertically stacked, it could not convert it to an underlined '8' with '10' directly below it. Also, Journal flattens imported documents to a bit-mapped graphic image before annotation is applied. The result is that the original text cannot be altered after annotation, which can be seen as a good or bad thing.

Journal allows the user to save annotated documents in one of three formats: a journal file, TIFF graphic, or MHTML. Each of these presented different problems to the students when trying to view the professor's feedback. Journal's native format requires a viewer that appears to only be supplied by default in Windows XP Service Pack 2. Other versions of the viewer must be downloaded either through Microsoft's website or Windows XP's 'Windows Update' feature. Several students reported difficulty in getting this viewer downloaded and/or installed. Likewise, students using non-Microsoft operating systems did not have a viewer available.

TIFF graphics provided the largest range of compatibility between operating systems. However, when Journal exported the annotations to TIFF format, the color information for all of the annotations was lost. While this appears to be done to reduce the size of the resulting TIFF, it greatly impairs readability and usability for the student.

While MHTML is defined in IETF RFC 2557, which is currently classified as *Standards Track*,[5,8] it was originally intended for use only in email. Since then Microsoft has expanded its use into its other Office products. However, due to this and the fact that Microsoft requires that Outlook be installed on the system with its Inetcomm.dll,[6,7] several students had a difficult time accessing these documents.

Anecdotal Experiences

One of the authors used tablet PCs for all homework and project report grading for a semester. Problems encountered included the necessity of students scanning hand-drawn diagrams

requiring an extra step and access to a scanner (available in student labs). The assignments were submitted through the Blackboard course management system, which grouped the submissions by assignment and allowed downloading of complete class submissions as a single compressed (.ZIP) file. Individual files were opened in Microsoft Word, annotated using a tablet PC, saved and emailed back to students in marked-up form. Since many of the homework assignments were short, typically one page, the overhead of opening the file and saving and emailing copies was significant compared to the time required to evaluate them. While not measured, these processes definitely lengthened the overall grading time. Problems were also experienced due to one student submitting papers written on the Apple version of Word, which had compatibility problems with the PC version of Word. The benefits experienced were that the assignments were carried in the tablet PC, which the instructor normally carries and thus were always available to the instructor.

Any changes to an established process are expected to bring new experiences to its users. This includes the learning curve associated with use of the tablet PC. The experience of the authors is that though basic navigation is fairly simple, it takes several hours to feel proficient with using the tablet PC's user interface.

Another such experience happened to one of the authors while grading assignments on the tablet PC. The assignment directed students to provide an introductory section and then supporting material. Almost all the student responses were approximately the same length. However, with one of the assignments, the professor started marking a student down for insufficient supporting material before realizing that he was still in the introductory section, which was significantly longer than the other students' submissions had been. It appears initial judgment of paper length is based on physical weight and size, which are missing in the electronic format. Had the professor been able to physically lift the paper, he would have immediately ascertained the existence of additional material. While this problem can be avoided by training oneself to check the page count when opening the student submission, it was an unexpected learning experience. Other such disconnects are sure to arise.

The tablet PC has been used by some of the department instructors, including authors, for marking up draft versions of graduate theses. This activity is well suited to the electronic medium. Here, the ability to use multiple color inks (to distinguish between style issues versus technical issues, for example), the ability to erase comments and re-write them when later areas of the thesis change the perception of the earlier areas and the ability to carry a large thesis as just one more file on the tablet PC provide considerable advantages. In this case the overhead involved in downloading and uploading the document is proportionally small.

Another observation dealt with the tablet PC screen. Unlike paper, which has a slight roughness, the tablet PC screen is relatively slick, which caused a slight annoyance to one of the authors while grading.

As a side note, computer literacy appears to be increasing among students in general. One of the authors has been teaching a non-technical course for the last two and a half years comprised of students of all disciplines and levels of university study (Freshman through Doctoral students). During the semester, the students are required to submit a written assignment. While the

assignment must be typed, the students are given the choice between either submitting a paper hardcopy or sending it as an email attachment. During the first year of the course, almost all of the students submitted the paper hardcopy. However, in the last year, almost all of the students submitted their work electronically. While only anecdotal, this suggests that students are becoming more comfortable with technology as part of the learning process.

Lessons Learned – Process Strengths

Through the study phase as well as personal experimentation with the tablet PC, a number of lessons were learned. While many of these matched expectations, a few surprises did surface.

To begin with, it was learned electronic grading did indeed provide more convenience and space-shifting for both the student and instructor. Students had more flexibility in submitting their assignments. Instructors were also able to more easily select when and where they would grade the assignments, which Harris[4] also noted.

As the entire process is paperless, large stacks of paper were not necessary for the submit-feedback cycle to work nor were they physically in the way of the instructor. In addition, as the assignments were in an electronic format, instructors can create and store electronic assignments and feedback for accreditation[4] or other future reference. However, a better archival system than the one used for this study would need to be utilized for this to be practical in terms of accreditation.

Electronic submission and annotation works well for large papers and theses, where the overhead of electronically handling the paper (e.g. downloading, conversion, etc.) is proportionally smaller to the overall time spent with the paper or theses as compared to smaller assignments.

The electronic process is also a natural extension for those involved in distance learning programs, where the Internet is often already utilized to provide communication and work submission. Without the need to handle physical paper copies, communication and feedback can occur faster between the instructor and student in such situations.

Monetary costs for this process can be kept relatively low. While the instructor requires a tablet PC, students do not. Existing email and course management systems, such as Blackboard or WebCT, provide sufficient infrastructure for electronic submission and communication. However, additional work needs to be done on archival systems, which provide a valuable asset for accreditation.

Finally, students appear to be becoming more comfortable with the electronic submission-feedback cycle. It is expected this trend will continue, providing for even greater acceptance of the electronic process by students and instructors alike.

Lessons Learned – Process Weaknesses

Usability is an ever-present issue with any electronic process. For example, the initial learning curve for the tablet PC is an important consideration. The instructor should be prepared to initially spend several hours to not only learn, but also become comfortable with the tablet PC's

user interface and annotation software. Some of the authors noted an occasional sense of frustration while originally learning to use the tablet PC.

Several other areas of usability need to be addressed as well. Regardless of the system, several steps are required to open/import student submissions as well as to save/export the resulting annotated file. Following this, the instructor must return the annotated file to the student. These add additional overhead to the time used by the instructor when working with assignments.

In addition, the instructor must be able to import the student's submission and the student must be able to view the resulting annotated file. The authors found that this could sometimes be more difficult than expected, resulting in protracted email discussions with students who were having difficulty. These issues often resulted from file format or operating system incompatibilities. Strictly enforcing what hardware and/or software the students are required to have for the assignment could reduce the problem for the instructor, but would likely increase the costs on the students, as they would need to either acquire said hardware and/or software or physically go to a location where it is available for their use.

Certain types of assignments also proved to not work well with the electronic process. Scientific or mathematical assignments that require students to scan hand-drawn figures and/or diagrams fall into this category. In addition, smaller assignments often take much longer to evaluate using the electronic process due to the overhead of electronically manipulating the assignment (e.g. loading, converting, saving, etc.).

Conclusions

The tools used for electronic submission, assessment and feedback of students' work are improving. However, they are still not to the point where they are practical in a wide range of applications. Within certain spheres they can provide advantages that outweigh the costs, such as when working with large papers, theses or dissertations where step and time costs are marginalized. However, for small papers or mathematically based assignments, the additional steps required for each produces a high overhead time cost.

The feedback from students for the overall process was generally positive, though there were a few staunch supporters of traditional methods, mainly due to their distrust of the new electronic system. The instructor's process of downloading, opening, saving and returning the annotated file to the student still needs to be streamlined. This is especially true for small assignments or in cases requiring importing the original assignment and/or exporting the finished annotated file. When these issues are addressed, the electronic process will become an even more powerful tool for both instructor and student.

With the improvement of input systems, such as the tablet PC, it is expected that improvement in annotation systems will continue, as a solid platform is now available. Continued research in this area should yield more favorable results as the technologies mature. While not yet perfected for general use, the paperless office or classroom is now within reach. Indeed, for certain types of assignments, electronic annotation is even now quite appropriate.

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