

# Six Uses of Technology to Improve Teaching and Learning

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January 4, 2004

ASSA meetings, CEE/AEA Poster Session on Active Learning Techniques

This paper posits in six categories the use of technology to enhance student learning and to make faculty time more efficient in the production of learning. Little in here may be new information to most faculty, but the goal is to show the integration of technologies to make certain tasks less onerous and to assist the learning process of students. The paper is designed with the teaching of economics in mind, but could easily be applied to many disciplines. What makes the application of much technology to the teaching of economics both difficult and important is the highly visual nature of economics such as the inclusion of graphs and mathematical expression. Additionally, technology can play a major role in assisting mastery learning. This paper is a draft of a much better paper to follow. Interested parties can receive updates by contacting the author.

The six uses of technology are:

- I. Electronic Grading
- II. Interactive Presentations
- III. Minute Paper / Muddy Point CATs
- IV. Testing for Mastery Learning
- V. Electronic Portfolios
- VI. Active Engagement Exercises

## I. Electronic Grading

### Current Non-Tech Practice

Writing to demonstrate knowledge and evidence of learning is or should be a critical part of our practice. Writing addresses higher order learning on the Bloom taxonomy scale allowing students to go beyond recall, application and analysis to synthesis and evaluation of ideas. Students get an assignment and turn in their work by the proscribed deadline. The professor now has 20, 40, 60 or more papers to grade and with all due diligence attempts to return them marked with comments in a timely fashion. However the more time pressures on the professor the fewer comments and the less timely this becomes. Students eventually receive a grade of A to F and the student and class has moved well beyond the topic at hand. Whether an A or a F, the student receives that grade with no chance to redeem a poor score. Mastery learning suggests that with a chance to see comments and re-do the learning process is enhanced, but the time pressure on the professor is prohibitive to reassign and re-grade assignments. For those that score less than an A or B, one can question whether learning has occurred and the student has no opportunity to learn from their mistakes.

### Technology Enhancement

- Student requirements: Students must submit writing assignments in electronic form. They must have Adobe Acrobat reader<sup>i</sup> to retrieve their graded papers.
- Professor Software Solution: The full version of Adobe Acrobat for creating pdf files and use of the markup tools.<sup>ii</sup>
- Professor Hardware Solution: One of the following: (i) Laptop and Pen Tablet<sup>iii</sup>, (ii) Laptop and SMART Sympodium<sup>iv</sup> or (iii) Tablet PC<sup>v</sup>

Each of these pen-based hardware solutions when combined with the mark up features of Adobe Acrobat allow for the natural pen to paper feel of grading while never requiring the submissions to be printed or physically handled. Further the marked-up and graded version can be returned electronically to the student.

Steps to do electronic grading:

1. The students must submit their work in a form acceptable to the professor. In the case of the 'typed' submission this might take the form of a MS Word (\*.doc) or a MS Excel (\*.xls) or other file. The student submits either by email attachment or through the course management system at their school such as WebCT. Further, special scripts can be written by a school's server administrators to allow the submission via a web page that may be sent by email to the professor.<sup>vi</sup>

In the case of handwritten documents, the document must be scanned and uploaded in the scanned format. Alternatively, I have had great success with a free product called eFAX messenger.<sup>vii</sup> This software and a trial account of the service allow receipt of faxes in your email, but not to a local number. To get a local number and the ability to FAX from your computer requires a monthly fee. Some schools will also have the a FAX gateway that you might use. In the case of The University of Akron students may FAX to our voice lines and the FAXES are retrievable using a software client.

2. Professor reads the electronic submission and 'prints as a Adobe Acrobat pdf file. The professor selects the printer "Acrobat PDFWriter" and prints the document to a pdf format. If "view PDF file" is checked at the time the file is named for printing, i.e., saving as a pdf, then the Acrobat program opens and displays the student's document in pdf format. If not you only have to use the Acrobat File/Open command and load the newly saved student submission. As you repeat this for each student each file saved will also be available under the window command of the Acrobat program up to the available memory of your computer.

3. Find and select the pencil tool icon on the Acrobat toolbar or type the letter N for the pencil tool or the letter H or the hand tool. When the pencil tool is active you may use the pen of your writing device to annotate the document exactly like writing with ink on paper. After you write the first word or draw the first line you may want to right click on the annotation and change the line thickness and color. Continue annotating each page as you would any graded assignment, return to the first page and write the letter or numerical grade on the paper and save the document. You need to switch between the hand tool (to change pages, for example) and the pencil tool to annotate. A quick way to do this is to select the pencil tool and when you want the pen to behave like a mouse to change the page just hold down the spacebar and the action of the mouse returns until the bar is let up.

Hint 1: To use a grading rubric check-off page, a comment form or a blank page for your comments and guidance to the student, use the /Document/Insert Pages.../ command to load in pre-designed and saved pdf files of your rubric or comment form or a blank page. You can then annotate these, as they become part of the student's submission. Using a blank page is a great way to have room to draw that graph correctly or show that correct equation.

Hint2: Other comment tools are available in Adobe Acrobat such as the note tool and the sound attachment tool. The note tool allows you to insert in a sticky note fashion comments that you type. The sound attachment tool allows you to record your comments, but resist using this too much as the files can get very large and the student must have speakers or a headset to receive them.

4. When finished marking the paper save the graded file as a pdf with the grade at the top. Save early and often! By including all similar submissions in a special directory such as C:\E100\Write1 you will have the beginnings of a well-organized archive.

Hint 3: Adopt a standard naming convention. Students may submit files with varying names regardless of whether you require them to follow a convention. However, you do not have to use the names they provide for the name of your document. What if you have six assignments from 20 students, without a

good naming convention you will have a mess on your hands and on your hard drive. Create a special directory and save each of those files with a name like StudentID\_write1\_01042004.pdf where Student ID is a unique identifier of each student, write1 is your code for the first writing assignment, and the date indicates when you graded the assignment. If the same student resubmits the work after my comments in the file above, I might name the next one StudentID\_write1\_01062004.pdf since I graded it on a different day. By following a standard convention you have an archive that is easy to search, reference and back up at courses end.

5. Immediately email the file with your comments and grade back to the student. This is a key advantage of the process. I have begun to quickly review and return as ungraded papers that are not likely to receive a high mark. In this way students have an opportunity to master the material and learn economics rather than falling further behind with little chance to make up the deficit. The use of electronic grading allows for mastery learning to more easily take place since I can screen and return the worst papers on the same day as submitted so the student can react to my comments and redo the submission while the information is fresh and before the class moves on to a next learning objective. As I grade other papers more close to the standard I am expecting, I can comment and return those for a re-do as well. This mastery learning process can be repeated up to the patience of the professor. The end goal should be that everyone "gets it."

## II. Interactive Presentation

### Current Non-Tech Practice

Presentation in the classroom is quite varied, nevertheless, most presentations fall into the "chalk and talk" or "PowerPoint and talk" mode. With apologies to those that may run strictly or nearly totally discussion and active learning classrooms, this solution focuses on the more lecture and demonstration parts of our craft and is suitable whether just drawing a graph or writing or displaying a full lecture. Campuses have invested large sums of dollars in enhancing classrooms with projectors and more and in our rush to use and validate that expenditure some feel compelled to move towards PowerPoint type displays and presentations.

When we lecture or demonstrate with chalk and talk we have the advantage of being flexible and spontaneous even though the flexibility and spontaneity may take a back seat to the rush to cover content. Everything written and drawn in this mode of delivery is not permanent. It may not be made available to students to read before class, not review after class ends. Students spent their time focused on writing every word rather than listening actively and processing the visual and aural clues.

Because PowerPoint<sup>viii</sup> is permanent and can be made available<sup>viii</sup> before and after the class period, it can be a powerful visual and read-write stimulus for the students. When combined with the aural stimulus of the oral presentation, professors have the ability to cover 3 of the 4 learning style preferences.<sup>ix</sup>

The very strengths of PowerPoint are its weaknesses. The permanence and time consuming creation of a graph yields the inability to deviate from the prepared example. Some professors including this author have turned off the PowerPoint and dragged over the overhead projector in order to be spontaneous. The use of the overhead allowed me to write on a clean slate or if I have an appropriate slide in tow, I can annotate the slide itself. However, this mixed medium does not mix well with taking the time and changing the classroom environment by mixing the mediums. The relatively less bright PowerPoint and the brightness of the overhead create a distraction not desired in the classroom. However, if I use the overhead or the white board in the classroom, again this is not permanent and subject to review by the students.

Perhaps nowhere is their more evidence that a technology is more misused than with PowerPoint. With this technology, as with others, it is how it is used that is most important. Rather than discard the

PowerPoint and projector, I suggest below that we add to the PowerPoint and projector an interactive writing device, thus bringing interactivity to our presentations.

### Technology Enhancement

- Student requirements: Access to instructor website or course management system (CMS) such as WebCT if materials are to be made available before or especially after the class period.
- Professor Software/Hardware Solution: (1) PowerPoint, laptop and Pen Tablet, or (2) any software the professor wishes to display, a laptop, a SMART Sympodium, and the SMART notebook software, or (3) a Tablet PC and any software. Each solution requires a room projector.

The Tablet PC solution has not yet been tested as of this writing and is deferred to later versions of this paper. It seems to be a promising and complete solution rivaling the SMART combination.

PowerPoint and the Pen Tablet: PowerPoint offers a little known pen tool, which can be used to write over existing PowerPoint slides or on a blank (black) screen. By choosing a contrasting color you can suspend mouse functions of the laptop and use the pen to draw and write on the screen. This allows the needed spontaneity, e.g., "What happens if that curve shifts the other way? These annotations are not permanent and are fragile. A wrong key press and the annotations vanish, possibly before you are ready for that to happen. Nevertheless, having a pen tablet as you present your PowerPoint is a vast improvement to PowerPoint alone and allows for interactive presentations. To choose the pen and arrow pointer options, look for the nearly invisible icon in the lower left corner of the screen during a PowerPoint show.

PowerPoint (and all software) and the SMART Sympodium and SMART notebook: SMART is a roomware company creating many versions of interactive white boards. While other electronic white boards exist, none of the solutions is as elegant as the SMART Sympodium. This device is a monitor with an attached pen that lays flat on a podium. What ever displays on your laptop is displayed here and using the SMART Sympodium you can illustrate and annotate whatever is on the screen. This can simultaneously be displayed using a projector to the entire class. The professor can write and highlight on anything on the screen including video (using their video player). You may write on a PowerPoint, Excel, Word, SAS or web page. These annotations are not always permanent depending on the software being used. However the best feature of the SMART family of products is the SMART Notebook. When opened, SMART notebook gives the tools needed for a most elegant whiteboard. One of the more useful features of notebook is its printer driver, that is, you can "print" your PowerPoint or any other document to the printer noted in your print list as SMART printer notebook capture. By selecting this printer driver, which is automatically installed when SMART notebook is loaded, the document being printed appears as pages in the notebook slide by slide. These pages can be presented in order and at anytime the professor can annotate, add pages, cut and paste to be as spontaneous and flexible as the class time demands in a very smooth and comfortable setting. I have used the cut and paste feature to break apart an existing page so I can insert explanation or possibly mathematical proof. Also the cut and paste feature is excellent for acquiring a current page from the Internet, including it with the notebook presentation and annotating it. Say a student asks what is going on with the unemployment rate, without missing a beat you can use internet explorer to display the graph from the economy at a glance page of the Bureau of Labor Statistics, and the cut and paste tool to acquire the graph, it is automatically inserted into the current notebook at the current page and is ready for annotation.

The annotation in SMART notebook is permanent and the entire presentation may be saved to the Web in html format. The student view of the annotated file is fully functional and it is easy to select the exact slide they want by the uses of thumbnails.

I use PowerPoint, pdf files and other files as my lecture notes to be reviewed in advance and when I have annotated them sufficiently in a class period, I can choose to place the annotated version to the CMS WebCT. Students then have the opportunity to review the notes after the class period and see again all the annotations made during class. I find this is especially valuable in my statistics and econometrics

classes. I have scanned handwritten notes (lots of equations) that students are to review before class, and bring a copy to class. I take those same notes and "print" to the SMART notebook. In class I freely annotate those notes in the notebook while adding proofs and demonstrations or giving examples. I can also run the SAS statistical program and acquire part of all of the code and output within notebook and annotate these results as well.

### **III. Minute Paper / Muddy Point CATs**

#### Current Non-Tech Practice

Chismar and Ostrosky<sup>x</sup> have demonstrated the value of the one-minute paper. My use of this combines the minute paper with the muddiest point CAT.<sup>xi</sup> I ask questions seeking to have the student tell me what they have learned, to identify the muddiest point and to ask questions. These CATs allow students the opportunity to reflect on the material presented or assigned and gives the professor an insight into whether students appear to be learning. Typically this is done infrequently at the end of class on paper and passed in before the student leaves. In my experience, this is not always optimal because I cannot or I forget to stop early enough to give students time to write and students at the end of the period are often minimizing their effort in order to head out to their next class or activity. It also does not allow independent review and response since it is often done anonymously.

#### Technology Enhancement

- Student requirements: Access to the web or email.
- Professor Software Solution: Email address and a server side cgi script and web server access.
- Professor Hardware Solution: none

I ask students to go on line to a special web page within WebCT to fill out the CAT. In my online courses they are expected to complete this 'module assessment' after each module. This allows me to check their progress and see in their own words whether they are progressing satisfactorily. In the online course this is strictly required.

In face-to-face classes I use the CAT on occasion asking all to go to the WebCT web page and fill it out before a time certain. In this way I can adjust my presentations accordingly. In both online and face-to-face I encourage students to use the form at anytime.

Some years ago I asked one of our server technical staff at The University of Akron to write a server side cgi script that can be embedded in a web form. The cgi script takes the student submission and emails it to me. The web form controls the subject title of the email so the many emails are easy to spot and sort to the appropriate course. Students may remain anonymous by leaving off their name and email address. Since the web page is found only in WebCT only members of the class can access the class.

Upon receipt of the emails I can adjust my presentation or if signed respond to individual students. Since many of the questions are the same term after term, a frequently asked question file can be very helpful.

### **IV. Testing for Mastery**

#### Current Non-Tech Practice

Having dealt with the writing assignments in Section I above, this section focuses on multiple choice and true-false type of testing. Typically, professors who use this type of testing will set an exam date and students come to class to find an in-class examination which is on paper (lots of trees) and they code in an answer key. Some time in the future they receive their score with some feedback, but no chance to

improve the grade they earned. Students earn a grade of A to F, but learning takes place when studying their mistakes, and if grades are to reflect learning as well as encourage it, the student should be allowed to repeat the material until mastered. In a in-class, paper-based, one-size-fits-all testing environment all students cannot be encouraged to strive for mastery.

### Technology Enhancement

- Student requirements: Access to a CMS such as WebCT or an on-campus testing center. Typically in the latter case appointments are required and in both cases there is a limit to the number and timing of attempts.
- Professor Software Solution: Access to a CMS such as WebCT or an on-campus testing center.
- Professor Hardware Solution: none

Mastery testing consists of testing and retesting until a student scores acceptably high or until they reach a limit of time or attempts. The goal is to enhance student learning by giving students the opportunity to test, study, re-test and improve the evidence of their learning.

This requires a tremendous upfront cost to the professor in the design and production of a test bank. However, the long-term benefits are such that the upfront costs are repaid in automatic grading and feedback over the life of the test instrument. By way of example, the design of a small 10 item examination over 5 learning objectives require that you choose multiple questions per objective that all test at the same level of complexity. For question 1 we might want to test learning about objective 1 at the recognition and recall level. This requires that a number (say for example 10) questions of the recognition and recall level are needed to be in the item bank for question 1. If in question 2 we want to test objective 1 at the complex analytical level we would need about 10 complex analytical questions for that questions as well. The multiple items in each category have to be carefully reviewed to assure consistency of testing. We continue to design the test until we have perhaps 100 potential questions to support a 10-item test.

The software program of the testing center or WebCT will randomly choose a question from the test bank matching the objective and level requirements of the design. The more questions in the test bank, the less likely that two or more students or the same student at different attempts will see the exact same question. In the case of WebCT campus edition a large number of test bank items per question are needed since WebCT lacks the ability to lock a question once presented to a student. Campus testing center software may not have this limitation.

The student is given the assignment to test under certain conditions, e.g., during a particular week or after completion of an assignment. Testing for mastery learning is achieved when the student has the opportunity to test, see their mistakes and successes, and take the time to review and re-learn the material and then re-test. The professor can decide how many attempts a student may have and how long the student must wait between attempts. The score can be the average, the last, or the highest of the attempts. I favor the highest because the student should always have the incentive to succeed and not face punishment for a bad draw of questions.

A benefit of mastery learning is that students stay with a topic until they have 'mastered' that topic and this is the essence of higher learning and has the by product of higher letter grades. While higher letter grades do not indicate higher learning, students that do score higher grades are more likely to stay in school and possibly take more economics.

As with many classroom enhancements, the grades and learning of the best student may not be increased, but the remaining students may have the time and opportunity they need to succeed at higher rates. By shifting the testing time form a uniform time constant to a variable time domain, we allow students who need more time to learn and master a topic the opportunity to succeed. By shifting grading and test design away from the professor we allow the professor to concentrate their efforts on those students who need their guidance the most and away form those who need it the least. Professor time is

additionally freed up to concentrate on the grading of the writing assignments and other more efficient uses of professors' time.

## **V. Electronic Portfolios**

### Current Non-Tech Practice

Mastery learning consists of having the opportunity to re-do until success. Student work as a whole is scattered and disjoint across classes in their major as well as with current classes. Professors do not always consider the implications that their assignments have on other classes in the major. Departments that recognize this often collect a portfolio of student work in a physical file folder. Nevertheless, it is left to the students to package themselves for marking to the work force or to their next school.

### Technology Enhancement

- Student requirements: Training in and access to web creation software such as Netscape Composer and access to server space on either an intranet or Internet.
- Professor Software Solution: Knowledge of Netscape Composer (or standard web writing software) and of the design and scope of the departmental electronic portfolio standard.
- Professor Hardware Solution: none

Our department at The University of Akron decided for assessment purposes to have each student's work captured throughout their undergraduate career in an electronic format. At the same time a new course, Computer Skills for Economic Analysis, was designed to enhance computer skills for all majors. This course provides scaffolding for the needed computer skills, but features the student creating their own electronic portfolio. The portfolios are available to all professors and fellow classmates internally on our Intranet and externally to all if the student chooses to place it in the public web space.

The essence of the portfolio is the student creates a webpage that in a professional format includes career and educational objectives, essays and term papers written by the student, their resume, courses taken and other items. Students are taught a skill to create, maintain and update their portfolio and are encouraged to update items even after the originating course is completed. The goal is to create something the students want to present an employer. This is mastery learning at its finest since the students tend to perfect their websites on a regular basis. They may redo the entire format of their portfolio as they attempt to make themselves via their own portfolio more presentable. Student learning is enhanced and faculty time upfront pays off course after course.

## **VI. Active Engagement Exercises**

### Current Non-Tech Practice

It may be a bit of a straw man to suggest that professors in this age do not use technology in some ways to help students learn. Just requiring the book brings along a companion website or individual CD that students can use to study. Nevertheless, professors may not yet see the benefit or overcome the initial discovery costs to use certain technological enhancements. Those enhancements that shift the work and feedback to the student via the computer make the faculty member's time more efficient. As it keeps the student actively engaged, more and higher learning for at least some of the students is a possibility especially for those students that need it the most.

### Technology Enhancement

Examples:

- (i) Automatic grading of problem sets – Created with a CMS such as WebCT or on a companion website or a purchased product such as Aplia.<sup>xii</sup> Students not only stay on task attempting to answer questions, but get immediate feedback that at an option can be sent to the professor. If those products allowed repetition and retesting, mastery learning could follow without sufficient time expended by the professor.
- (ii) Electronic experiments – While experiments are becoming more and more common in our curriculum they are still limited by the number of rounds that can be completed in a single class period. Electronic sites such as Aplia.com and Charlie Holt's Veconlab<sup>xiii</sup> allow many more rounds and the opportunity to time and space shift the participation.
- (iii) Scaffolding – Math preparation of Aplia.com allows for the kind of scaffolding some students may desperately need. Other examples of scaffolding include campus writing labs and career centers.
- (iv) Making lecture notes and all other course material available to students in a CMS such as WebCT allows students, with upfront organization costs by the professor, to have access to notes and assignments ahead of class so they can be better prepared. They can then concentrate on what is said rather than writing down every word.

## Summary

This paper is in the early stage of development. For all the uses of technology posited here, hard research is yet to identify much as significant over other modes of teaching. However, we know that mastery learning works, that active engagement of students works, that matching learning style preferences with course content works, but how exactly and why is still to be discovered. I like to say that technology should meet two goals before it is adopted or kept. First, professor time should be reduced of the repetitive and mundane chores that a computer can do so well or professor time should be used more efficiently. Second, student learning should be not harmed and if possible significantly advanced. So on each adoption of technology, ask "will faculty work better and will students learn more?" One must be a necessary condition while both are sufficient.

## Endnotes

<sup>i</sup> The free Adobe Acrobat reader can be downloaded from

<http://www.adobe.com/products/acrobat/readermain.html>.

<sup>ii</sup> Information on Adobe Acrobat is available at <http://www.adobe.com/products/acrobat/main.html>.

<sup>iii</sup> For a Pen Tablet example see <http://aiptek.com> for the Hyperpen 8000U. Specifically the 8000U can be seen at <http://aiptek.com/products/pctablets/8000u.htm>. Its included software can also be used for marking papers, but this paper concentrates on the use of Acrobat.

<sup>iv</sup> The SMART Symposium is discussed at <http://www.smarttech.com/Products/sympodium/TL150.asp>.

<sup>v</sup> Since there are so many different brands of Table PCs a great page to find information is <http://thetabletpe.net>.

<sup>vi</sup> On this see the description of the server side cgi script in section III.

<sup>vii</sup> Information on eFAX is at <http://www2.efax.com/efax/twa/page/homePage>.

<sup>viii</sup> By use of the reference to MS PowerPoint, I seek to mean all prepared slides, text, graphs and displays except where the reference is to a specific feature of PowerPoint.

<sup>ix</sup> These learning style preferences are Visual, Aural, Read-write, and Kinesthetic. See Neil Fleming's <http://vark-learn.com> for more information. Fleming makes the point that economics in particular is a highly visual discipline, where most professors of economics have visual learning style preferences and most entering students are read-write.

<sup>x</sup> Chizmar, John F. and Anthony L. Ostrosky. "The One-minute Paper: Some Empirical Findings," Journal of Economic Education, Winter 1998.

<sup>xi</sup> The minute paper and the muddiest point CATs are numbers 5 and 6 in Angelo and Cross. Classroom Assessment Techniques: A Handbook for College Teachers, 2<sup>nd</sup> edition, Jossey-Bass, 1993.

<sup>xii</sup> See <http://Aplia.com>.

<sup>xiii</sup> See <http://veconlab.econ.virginia.edu/admin.htm>.