Use of Computer Technology in the Classroom
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1.0 - Introduction

We really don’t NEED computers to teach well. But, when used effectively, computers can be an excellent learning, communication and presentation tool.

I had taught Statics to engineering students at Ryerson Polytechnic University for three years using blackboard methods. In this time a complete set of notes was developed and refined. After moving to Grand Valley State University, I found myself teaching Statics again. To make the course more interesting, I decided to explore some creative teaching methods. Some exploration of departmental resources made it clear that computers would be a good avenue to pursue. Upon examination of the available equipment, it became obvious that it would be possible to make extensive use of computers in teaching. Not only were faculty well equipped, but the student to computer ratio was 5:1. In the end the course was developed to include extensive computer use in and out of class.

It is my intention to describe my experiences, and make suggestions to other faculty thinking of using computer tools to support their classroom activities.

1.1 - Computer Use In Teaching

It is worth beginning with a quick outline of some computer applications for teaching. I used a majority of these when preparing the computer supported course.

1.1.1 Presentation

At worst you may think of a computer as a replacement for overhead transparencies. Basically we can turn out the lights, turn on the computer and projector, and lecture off the notes on the screen. But, like overheads, this approach requires caution. The dark room encourages drowsiness and the presenter can be tempted to ‘rush’ through the material. Color and motion can be added to stimulate the audience. We can also present a copy of the materials to the students, and free them from the chore of transcribing the overheads. When well done the effects can be stunning, including ad-hoc experiments in class with simulations, movies, sounds and pictures. The method also allows presentations that are consistent between sections, and relatively error free.

1.1.2 Simulation/experimentation

Concepts and experience can be obtained by software set up to model experiments or situations. One example is simulation software for conceptualization of a manufacturing layout. We can create a miniature model of a factory with machines, products and sequenced routes. Each machine is given a random distribution of breakdowns and cycle times. The students can see products flow through the factory, change values, reroute work, etc. After some time ‘playing’ they have a grasp
of the material not possible with other methods. Another example is obtaining experience by using simulated situations. For example we could teach electrical engineering students how to run a nuclear power plant by having a set of events prerecorded on video. Each event models a situation changing in the plant. After each small segment of video they make a decision, and a new loop of video (and new decisions) is selected. This allows them to test knowledge through trial and error in a safe environment. These techniques are often visually compelling and provide immediate feedback. This tends to move the learner into a more active role.

1.1.3 Communication

The most powerful application of computers is communication. Some of the more enthusiastic practitioners have tried to incorporate real-time video links between instructors and students. The methods that have already become solidly accepted are email, newsgroups and World Wide Web (WWW or Web) access. These links allow us to send and receive information to the students at any time. The students can access these resources from the privacy and safety of their own home, or at most computers on campus. For many inquiries this eliminates a lot of time travelling to the professor’s office door. One particular challenge for engineering students is the text oriented nature of the web. When we want to describe technical figures or equations we are hard pressed to do it with written text. This can be overcome by attaching files to email that contain drawings, equations, etc. One hidden benefit is that when a student must put the question down in words, it often avoids the impulsive and often premature ‘drop by inquiries’. And, after the professor has reviewed questions, the response can be directed at individuals, or groups. At the end of the term, records of discussions can be reviewed, and used to improve the course content.

1.1.4 Visualization/conceptualization

At times we can use prepared graphics or audio to aid visualization. For example, when teaching drafting the idea of orthographic projections seems unusual, but an unfolding glass box can illustrate this effectively. By using these graphical simulations we can expose things not normally visible, or not physically possible. The disadvantage to this method is that it shifts the learner into a passive role.

1.1.5 Testing

Setting and grading tests can be a very tedious task at times. There are tools available that will accept banks of individual questions. They can then be mixed selected and combined into tests. The systems are also capable of analysis of the test scores and questions. Although this system requires a great deal of effort to create the question bank, it is possible to create elaborate tests that may be customized to specific students, and given at any time.

1.2 An Educational Web Site

The Internet has recently moved from university computer rooms to full public view. As a result a number of easy to use tools are now available, and access from home is a common option. The WWW browsers distributed by both Netscape and Microsoft are proving to be the ideal access choice. The Web browsers are highly flexible, and allow other software and file types to coexist.
seamlessly in the same document. More recently the Java programming language, and VRML (Virtual Reality Markup Language) have permitted interactive Web documents. These tools allow creation and publishing of notes at a professional level. We can create basic text, equation and figure content using a word processor. Conversion of the word processor documents to HTML (Hypertext Markup Language Format) is a common option in word processors now. We can then add pictures, links to other Web sites, video, sounds, Java programs, etc. The completed document is posted to the web, and instantly accessible to students. A special note, HTML, Java, VRML and Internet Protocols are standardized across all current computer platforms and many generations of hardware.

1.3 Application Software for Statics

Computer software is not normally suited to a problem solving course like Statics. But, we found some professional software tools that are well suited to mechanisms (Working Model) and mathematics (MathCAD).

1.3.1 Working Model

![Figure 1 - Working Model Screen Capture](image)

Working Model (see figure 1) has been designed to allow sketchpad entry of mechanical mechanisms, and then simulation of the dynamics. The user begins by defining objects and properties. This is followed by definition of contacts, connections and applied forces/moments. When the user starts the simulation a numerical integration algorithm is used to estimate motion, including collisions between rigid bodies. In the Statics course this was used for a variety of conditions. It was used to.
- emphasize the difference between statics and dynamics
- investigate slip and tip friction cases
- demonstrate the stability of frames and trusses

The software results in a visually active display that quickly illustrates complex topics. But the trade-off for speed and convenience is the inaccuracy of the numerical integration.

1.3.2 MathCAD

The ability to symbolically solve equations allows students to quickly do some calculations not reasonable by hand. MathCAD (see figure 2) allows entry of variables, values and equations. Integration, differentiation, substitution, solving and graphing are some of the operations possible. This was used in the course for the analysis of an exercise machine.

\[
\begin{align*}
F_y & = 11693 \text{ N} \\
F_t & = 26480 \text{ N} \\
F_{\text{tot}} & = 371 \text{ kgm/sec}^2
\end{align*}
\]

So the reaction forces at the pivot are 372N in y and 60N in x direction.

\[
F_{\text{tot}} = (372 \text{ newtons})^2 + (60 \text{ newtons})^2
\]

The total force on the pivot is 377N.

Let's still assume that the force applied is applied normal to the handle. Sum of forces around the pivot (the applied force and the tension will be moved to act directly on the arm and the counter will be taken care of later). Now let's take a look at the final state in the movement of the arm (Drawing 2).

\[\text{Figure 2 - MathCAD Screen Capture}\]

1.4 Other Media For Lecturing

Other devices can be used to enhance the course. For example, when trying to illustrate the importance of Statics, I found an MPEG (Motion Pictures Expert Group) format video of the collapse of the Tacoma Narrows bridge. A number of digital photographs were also used to show the principles of Statics in a variety of Mechanical and Civil structures.

1.5 Document Structure for Course Notes

Most books have a linear structure that begins with a table of contents, followed by a preface, chapters, appendices, and index. When using web publishing techniques there are some interesting options available,
2.0 - **EGR 209 Statics and Solid Mechanics**

The Statics course covers forces, moments, equilibrium, trusses/frames, friction, centroids, moments of inertia, internal forces, stress/strain and deformation. A well known textbook was used, and the students still solved most problems by hand. But a variety of exercises were specifically designed to make use of the computer. One of the assignments was given to be done by hand and with working model. A competition was also held in which students created and voted on working model files. For the students that submitted entries, the level of interest and use was very high. Later in the course students were split into teams of two. Each team was assigned an exercise machine to analyze in the campus weight room. They were directed to use MathCAD for all calculations. The final report included analysis of moving members to estimate forces, moments, factors of safety and deflections. Throughout the course the notes were presented in class using the computer, and a Web site was set up with course notes, bulletins, notices, links, etc.

2.1 - **The Timeline**

Experience is the best teacher. To give an exposure to my experiences, I have condensed some selected journal entries down to the relevant points (please excuse the terse grammar) and these may be seen as an appendix to the paper. As would be expected, the start of the term was filled with difficulties, but by early November most of the difficulties had been overcome, thus the log is not given past November 7th.

3.0 **Technical Aspects of the Computer Supported Lectures**

Not apparent in the log are some directions that may want to be observed when doing lectures of these sorts.

3.1 - **Before the Course, Preparing the Notes**

It is not necessary to have students transcribe material to learn it. If they can bring the notes to class already done, they can spend more time thinking, and less time copying. I normally distribute note sets to all students ahead of time, and have the students bring the notes to class. One significant criticism of distributed note sets is that some students will then see classes as optional. To offset this the lectures must give something more to the students. A useful attitude is that the lectures should run parallel to the notes, and try to expand the content, the students will see lectures as a valuable addition to the course.

To prepare the note set I used a set of notes that were handwritten and presented on the blackboard before. This noteset was later entered into the computer, distributed to students, and pre-
sented using transparencies and markers in a 200 seat lecture hall. For the computer based statics course the notes were distributed to the students again, but they were also converted to HTML format and placed on the Web Site. In the note set the content is still the most important aspect, but other enhancements can be used to make them effective for the students. First, if the notes are single sided the students are free to add comments and ideas of their own. Some questions may be given with no solutions, but open space so that they may be done in class. In my personal opinion the best approach generally seems to be,

1. Some overview that sets the reason and objective for the section. (a good place for pictures)
2. An overview of relevant theory.
3. A simple example problem - with solution and notes about steps, notations, etc.
5. Additional notes on technique and methods. (working model files work well here)
6. An advanced problem with solution
7. An unsolved complex problem, done on the board

This approach can make the student an active participant (steps 4 & 7). Some of the passive steps (1, 2 & 5) can have multimedia components added to keep up the students interest. Steps 3 & 6 require added notes to explain how the new material is applied.

3.2 - In the Lecture

The technology makes a few additional demands of the instructor. First, the time to setup, and disconnect the equipment requires a few additional minutes of time before and after the lecture. These few minutes have been traditionally spent talking with students, or reviewing notes. It might be necessary to budget extra time when student needs are greater. Second, during the lecture there may be technical problems that must be solved. If these are discovered ahead of time they will have minimal impact, or can be avoided. For example, when the network failed, I could start my word processor and present with that instead, at a time penalty of about 2 minutes.

The technology also requires some style changes. The pace of the lecture can be difficult to control. It is necessary to be more dynamic and interactive when using the computer. When the lights are off and the room dark, it is easy for some students to hide or become drowsy. This can be overcome by using a few techniques,

- Use the computer to present new material, then turn on the lights and do problems on the board.
- If the computer screen is in front of a whiteboard, pull up the screen, and add notes using the screen underneath.
- Ask students questions about what was just covered.
- Get the students to calculate numbers.
- Say something ridiculous to get a response.
- Tell a joke.
- Walk into the seats.
- Borrow something for an example.
3.3 - Presentation Tools

Getting the pictures from the computer to a screen was challenging. Various option were tried, but the worst was a computer screen to normal TV converter. The rows of pixels on the television are set at 60” angles, and the converters are not very precise. As a result the pixels were all blurred, and it made the 680 by 480 resolution seem more like 400 by 300. The best solution was a computer data projector. On these units the pixels are lined up horizontally and vertically, and the pixels are all crisp and clear. The downside is that these units are very expensive so availability is typically low. With any of the units there will be some need to play with controls to focus, zoom, adjust screen position, or to synchronize them. In any case the controls are typically hard to reach, so you should investigate their locations before turning the lights off. In addition, all of the projector units had limited brightness, and were best when sitting in the dark (they also have no ambient light as we would get from overhead projectors). As a result the level of acceptable lighting was very limited. In one room there were adjustable blinds on the windows, but on sunny days the room was always too bright. Another room had no windows and the lighting could not be dimmed near the screen - in this case an overhead projector was directed at a wall, and turned on.

The picture on the computer screen was also a complication. Only 600 by 400 or the possible 640 by 480 screen was visible. But this was turned into a plus by positioning scrollbars and menus so that they were visible on the computer screen, but not on the projected screen. It was also found that enlarged font sizes made the material much clearer. This was relatively easy to configure on the word processor and Netscape.

The computer was best placed on a table near the front of the room. But, this meant that longer cables were needed for the network, power and video. Also, the notebook had a trackpoint mouse which was difficult to control for presentation. As a result a normal mouse was obtained, and this made control much easier, but then required a flat surface. The notebook computer I was using had power management software. When disconnected from power, or left too long it would start turning off devices. Typically the screen would go off after a few minutes of inactivity, and the CPU would halt after 10 minutes of inactivity. At best this was a nuisance for longer discussions, at worst the computer would crash. As a result I concluded it was best to disable the power management software for presentations, and connect to a power socket when possible.

4.0 - Students Opinion Surveys

Surveys were taken during the term to estimate the students reaction to the computer use. At the time the surveys were distributed great effort was made to get critical feedback. The methods for conducting the survey were not rigorously scientific, but should be a reasonable reflection of opinions. For both surveys, only the relevant responses are included.

4.1 - Middle of Term Survey

The first survey was presented in the middle of the term, and included a variety of questions about the notes, the web, and the lectures. The text of the questions is below, and histograms of the responses follow in graphical format.
a. Overall Usefulness
b. Pictures help comprehension of topics
c. Working Model helps comprehension of problems
d. The course notes make the material more appealing
e. The on-line Web pages are useful
f. It is useful getting other information off the Web (eg. problem numbers)
g. Links to other Web sites are useful
h. The use of the computer to present in class is useful
i. You can keep track of the lectures by writing in the notes

In analyzing the result there is an obvious high response rate to all questions. There were only a few responses in the mediocre to poor range, and I suspect that there is a correlation between familiarity with computers and the response (see question f). The support for computer presentation, working model and pictures is high. One student commented “The course notes are great. Instead of trying to write everything down, you can pay attention to the information.” Overall the poorest responses (questions d and i) related to the note set, as a result, some changes were made to the course notes to include additional unsolved problems.
4.2 - End of Term Survey

The end of term survey was also set up to draw criticism of the use of the computer in and out of the classroom. In total there were three quantitative questions, and three qualitative questions. The first three questions were,

1. The use of the computer to present in class was effective
   - strongly disagree - 0
   - disagree - 3
   - undecided - 4
   - agree - 27
   - agree strongly - 3

2. The use of the web was effective
   - strongly disagree - 0
   - disagree - 0
   - undecided - 7
   - agree - 20
   - agree strongly - 10

3. The modified notes distributed in November were better than the previous notes
   - strongly disagree - 0
   - disagree - 0
   - undecided - 8
   - agree - 22
   - agree strongly - 6

It is clear that the improved noteset (question #3) with more unanswered questions addressed the need of the students. The response to web usage was very strong as well, with no negative responses this time. Finally, the opinions about the use of the computer were not as strong, but this can be attributed to the technical problems encountered throughout the term. This speaks to the importance of avoiding technical problems.

The written comments of the students tended to expose most of the expected weaknesses of the computer based lectures. A few students mentioned the pace of material coverage. One student commented on the use of prepared notes: “it’s difficult to follow a pattern of thought with respect to problem solutions when it has already been printed out, and condensed or simplified.”. Another student commented on the use of fully solved problems in the notes, “This is a personal preference, but I don’t really like the use of ‘instructional technology’ in class. Pointing at steps in a problem and saying ‘I did this and this and this and there’s the answer’ is not as effective to me as working through concepts, step by step, to show how they evolved is more effective for me...” A few other students made comments about accuracy of the printed notes. A very large number of students expressed a desire to have a larger number of examples in the notes.

5.0 - Strategies for Success

The following list is a short set of points to help make a computer based course more likely to succeed. These points are based on both what I have done, and what I will do next time.
Know the software and hardware.
Keep a bit of ‘MTV’ style in mind. Videos, sounds and other moving things help.
Do a ‘dress rehearsal’ well before the first class - small details such as fonts can ruin all the other efforts. Ask somebody to sit through a short trial run.
Try to make computer use unavoidable for some aspects - If not some students will ‘get it from their friends’ and you never get good contact.
Provide a good tutorial guide for all software students use, and offer assistance when possible.
Try to avoid commiserating with students when they have software problems. They need your confidence. If necessary find the answer and get back to them.
Get full administrative support
Give the students something to do during the class - drill problems are one good idea
Turn on the lights and solve problems on the board frequently, it will wake up students going to sleep in the dark.

6.0 Conclusion

This paper has outlined the techniques and outcomes from a sophomore Statics course that was taught using computer in the lecture room. In all cases attempts were made to point out expected difficulties, and make suggestions to help others thinking of trying similar ventures.

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References

Appendix - Abbreviated Time-Line For Course
Pre-August Notes entered into computer.
Aug., 12 Notebook computer arrives.
Aug., 13 Notes handed to printer.
Aug.,20 Investigate computer projection equipment in assigned classrooms, the overhead projectors are only for TV, but there are 10baseT network sockets in rooms. There are data projectors in a locked hallway cabinet. Keys for cabinet are ordered.
Aug., 23 Staff up software to test run, it. Results are OK.
Aug., 26 Classes start. The keys are not ready yet, I need to arrive early to ask somebody to unlock the closet. Test data projector, it only displays 640x480. The setup time was under five minutes. The last ten minutes of first lecture done with computer and data projector. When the lights are turned out the room is too dark to see paper (no side scatter of light as with overhead). The lights only go on in half of room. The trackpoint on the computer is very awkward to control scroll bars, etc. Even though part of the screen is chopped, it is mainly scrollbars. Using the word processor software, only half a printed page appears, and page breaks can fill a screen. The second section had windows with screens, and the light levels were fine. - Lesson Learned: do an early test run before the first lecture.
Aug.,28 Arrived ten minutes early to get cabinet unlocked and equipment set up In the dark room I decided to use overhead projector pointed at wall for ambient light seems to work well, but proper lighting would be better. Took a regular mouse (instead of trackpoint) to help control problems. Used working model to run a simulation, seemed to clarify conceptual difference between statics and dynamics.
Aug., 30 Settled on IO minutes early as the expected pre-class preparation time. Noticed dark made some students sleepy. Ran entire lecture in dark, including questions. In second section I tried to do problems on board to parallel what was on the computer, had to remove fluorescent bulbs at front of room to get reasonable lighting. Show-of-hands survey indicated that; they liked not having to copy down notes - more time to think, no problems seeing screen, or following along. Projector cabinet key arrives today. Lesson Learned: Be aware that the dark room puts students to sleep.
Sept,  4 Arrived a bit late, having to pick up the data projector cost lecture time. Students seemed a bit sluggish in dark, tried turning on lights to solve a problem on the board, this seemed to help a bit. Lesson Learned: Change the mode of presentation to keep them active.
Sept., 6 The bulk of books, computer, etc. is somewhat annoying needed to take the power supply because of the extended (3 hours) of lectures
Sept., 9 - The notebook power manager was shutting down the laptop every couple of minutes, went to lecture on blackboard. Took power supply to second lecture.

Sept., 13 - Power manager acted up in first class, PC was almost unusable. Lesson Learned: decided to take power supply each time after, or disposable power manager software. Picked up digital camera Apple Quicktake 100 - the camera was relatively easy to setup and use, but battery life was too short (<5 minutes) so the power supply was needed when downloading to computer. The camera took 32 or 32 pictures. The lower resolution of 320x240 was too poor for sharp detail, so the camera could really only hold 8 pictures.

Sept., 16 - Web Site almost ready.

Sept., 17 Introduces students to Web pages, reception was good. Worked on getting web pages up, including hypertext links to gifs. This was only possible by tricking WebWorks into passing it through without converting characters. Lesson Learned: plan for the document conversion process, the software available still limits abilities. Made some graphics to go with pages - gives the pages a polished look. Took pictures with digital camera - it was very sensitive to light levels, and distance/close detail was blurry.

Sept., 18 Presented in class using Netscape off local disk files - increased font sizes, and DPI for gifs (up to 120 from 74) to better fill screen. The text was more viewable on screen. By contrast the normal screen font is too small. Lesson Learned: Use Netscape instead of Framemaker to present.

Sept., 20 - Presented with netscape again, this time using the network and the Web site - this ran well, but as the morning progressed the transfer rates slowed, especially as the hour approached.

Sept., 23 Presented off local disk again, ran much faster. Added course info to web site, including sample problems and syllabus. Prepared first midterm, and had answers prepared, and ready to post after test.

Sept., 24 Got camera and started taking more pictures. Got copies of Working Model quick start guide, plan to give to students tomorrow, and will suggest a problem to try next week.

Sept., 25 - Demonstrated Working model in class by building a ball between wedges, a robot, and a block hung by two cables. Also gave out tutorial manual, and indicated that next week some problems will be assigned to be done on working model. Student reaction was 'WOW'.

Lesson Learned: Visual impact should be used whenever possible.

Sept., 26 - Fixing up things, but realize that pictures collected in future must be to fulfill need. There are too many pictures to take, and not enough disk space. Got some email questions about textbook problems. Did not have textbook. It would have been nice if all questions were on-line for easy reference, and so that notes could be added to the problems.

Sept., 27 - Exam day. Showed meg movie of Tacoma Narrows bridge a good visual part. More videos would be great. Solutions posted on line, and students seemed to have them printed shortly after the exam. Lesson Learned: When possible post exam solutions on-line.

Sept., 28 Some Working Model examples created for classes this week. Misalignment was a small problem, but more practice expected to reduce problems. A 3D problem is not possible using the current version.

Sept., 30 - Presented in class using Netscape only. This included working model links, and photographs. The models were Static, and a loss of interest was apparent. First working model assignment discussed as bonus. Student interest picks up. The lab version is not working well, (it later turns out that some computer labs don’t support the package) I load a copy of the demo software to my website for local download.

Find transcription error in the exam solution posted on-line, fix problem on-line and mention to students. Lesson Learned: Even though we can change things on line, if it is printed mistakes are permanent.

Oct., 4 - The network locked up, had to present using framemaker considered keeping copy of course on hard drive. Lesson Learned: The Internet is not reliable, have alternate solutions. SVGA to NTSC converter arrived - tried in class, very poor with high resolution graphics. Went back to data projector. Other problems, cables too short, and s-video connector only on ceiling mounted projector. Good rule of thumb, count on a loss of 50% of resolution, and avoid thin lines.

Oct., 7 - tried using the SVGA converter in class again, very poor appearance, but as okay with larger fonts, but the unit seemed to shut down after a few minutes.

Oct., 11 Had classes, and then working model contest at the end. This seems to have set a fire in some students. Most were impressed. In general the interest level was higher in the smaller class. One very good technique with the data projector is too project the image onto a whiteboard and draw over the image using markers. This allows the students to add/refer to their notes.

Oct., 18 - A very effective use of working model to show the students slipp/tip case for a block, and then calculate to verify.

Oct., 22 - Tried a test of SVGA to TV converter in class with large fonts. The students seemed to be happy with presentation styles, and agreed to an in class trial. Helvetica font seemed to be perceived as slightly better, by show of hands Took a while and changed some of the notes to helvetica, and posted to net. Put some problem solutions on the net that were missing in the text.

Oct., 23 Went to present in class with SVGA to TV and the network was misbehaving, so could not connect to site. The network was down today, so the students could not get access to the web pages, and I could not update.

Oct., 25 - Data projector did not work in first class, used the board instead. In second class found that the data projector was set for the wrong input. Lesson Learned: Even when the equipment works well, figure out why it is working well just in case. In the conversion process the multiplication sign was changed to a ‘yen’ sign. I also noted that in printing some of the equations were not printed properly, but the students were able to copy off the screen (or could use the web pages).

Oct., 28 Data projector stopped working, and sent to get repaired/presented on board in class.

Oct., 29 Presented in morning class using SVGA to TV converter. Did not seem to cause many problems

Oct., 30 Exam day. Did not have time to put exam solutions on net.

Nov., 1 Returned exams solutions not yet on net, but meeting students face to face to return papers (one at a time). Did the first survey in class.

Used the SVGA to TV converter to present, the second class was seeming it for the first time, and complained of the poor quality.

Nov., 4 - Presented in class as normal using board mainly. Projector is still missing.

Nov., 5 Computer did not work.

Nov., 6 Data projector did not work again. Will use computer and projector next class.

Nov., 8 Data projector fixed, lecture proceeded as normal.