Laptop Computer Integration in a Lower Level Mechanical Engineering Course

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Abstract

Mississippi State University's (MSU) College of Engineering (COE) began requiring incoming freshmen to either purchase or lease a personal computer in the 1999 fall semester. Following the COE's computer initiative, the Mechanical Engineering (ME) Department implemented a laptop computer requirement for all of its courses. This paper will begin with a summary of the larger COE/ME context and then focus on lessons learned in responding to the COE/ME computer initiative for a lower level engineering class, Thermodynamics I. In researching methods to implement the laptop requirement with the special concerns of a lower level class, very little information was found in the literature. Some information was gained through personal communication but most was gained through trial and error in the classroom. The lessons learned have evolved over multiple semesters of experimenting with alternative techniques to arrive at methods appropriate for the particular class. This paper documents those lessons learned in an attempt to help others with a similar challenge.

Introduction

Mississippi State University's ME Department has now implemented a laptop computer requirement for all of its courses. This requirement was phased in over several semesters with more courses added each semester. Thermodynamics I required the laptop early in the implementation process and has now had the laptop requirement for several semesters. Therefore, development of laptop use in this class has spanned a time frame from students needing the laptop for only one or two of their classes to students needing the laptop for all of their classes. Thermodynamics I is also the first course that students take from ME department professors, and there is no uniform, prerequisite computer experience for this course. These facts make the evolution of the laptop implementation in Thermodynamics I particularly interesting to study.

This paper will begin by reviewing the computer integration process in the MSU College of Engineering (COE). Policies set by the ME Department and issues encountered with implementing the laptop requirement into the entire ME curriculum at MSU will then be addressed. Finally, special emphasis will be placed on the challenges associated with implementation in a lower level course such as Thermodynamics I. The paper will

particularly address the move from the instructor and students' use of computers for a course, to the instructor's use of the computer in the classroom, to the "hands on" use by the students in the classroom. The discussion on the evolution of the laptop use will involve issues such as software, websites, quizzes, participation, group projects, minimizing distractions, and setting policies on the laptop use. Information has been collected on these subjects from various professors, informal class surveys, and a formal class computer usage survey. The paper will address pros and cons of various techniques as well as lessons learned.

Computer Initiative Background

With the cost of personal computers going down and performance going up, the trend has been toward requiring students to have their own personal computers. Study of implementing a personal computer initiative began in the MSU College of Engineering in the mid-1990's. A team was established to evaluate the merits of requiring MSU COE students to have personal computers.[1] The driving force behind the team's work was to improve the educational process. The goal within COE was to integrate computers into students' everyday lives so that they use them as we do.[2]

The team found that, at that time, many liberal arts schools were incorporating personal computer requirements but relatively few engineering schools were doing the same.[2] Several "factors for change" in engineering education, however, were related to concepts that could greatly benefit from a personal computer initiative.[3] The team considered many issues and concluded that student ownership offered numerous advantages over computer labs.[1]

A pilot program was implemented in two departments in the 1998 fall semester. The COE then required incoming freshmen to either purchase or lease a personal computer beginning in the 1999 fall semester. A PC compatible platform with a Windows operating system was chosen. A minimum software configuration was specified including an office productivity suite, drawing package, mathematical software, and other packages as needed. Each year, working groups decide on the specifics of the hardware and software required. A minimally configured system is specified along with some optional enhancements. The COE teams with companies to offer quality products to the students at reasonable prices. Financial aid is also available for those who choose to purchase their computers. Each department is allowed to choose whether desktops or laptops are required and sets the final software package required. There is no formal enforcement policy with the requirement just as with textbooks for courses.

Assessments since implementation of the policy have given generally positive results. Several interesting findings include[2]

1. The majority (approximately 85%) of upperclassmen were found to already have a computer; therefore, the policy simply added structure rather than an additional burden to many students.
2. The majority of students were purchasing laptops by choice due to their portability.

3. The majority of students were purchasing middle to upper end computers rather than lower end computers that just met the specifications.

The University is now studying the possibility of requiring all incoming freshmen to have a personal computer.

ME Department Computer Policy

The ME Department began to discuss the possible requirement for students to purchase their own computers in August 1996, and a committee was formed to consider the issue. As stated previously, the COE allowed each department to choose whether desktops or laptops were required. The ME department decided that laptop computers would be used in the junior and senior level classes. Minimum specifications were set for the laptop, and these specifications are updated each year. Software requirements in addition to the COE requirements include MathCad and LabView. The department has a group license for each of these so that the students can install the software. The laptop requirement was implemented incrementally from 1999 to 2001. As of the 2001 fall semester, all junior and senior level mechanical engineering classes require the students to have a laptop computer.

General Issues with Laptop Integration

Computers may be used for a course in several different ways. First, both instructors and students have used computers for a course, but outside of class, for years. Next, instructors may use the computer in the classroom. Finally, students can use the computer in the classroom. The students' use of the computer in class adds many new considerations. This extension to the student's hands-on use of their own computers in class brings a whole new world of possibilities as well as complications. The evolution has been a slow, learning process. ME faculty comments concerning both the instructor's and students' in-class computer use were gathered and compiled.[4] These comments are summarized in the following paragraphs. Various instructor uses are given first. Next, student use in class is presented along with pros and cons. Finally, obtaining feedback to improve computer use is discussed.

Instructors can use the computer in class in many ways. A projector used to display the instructor's computer monitor is very useful for showing electronic classroom materials. Display demonstrations of computer software by the instructor in class are also very useful. Course websites are a powerful tool for both the instructor's use and student's use of the computer for class and in class. Often the instructor will provide the class material on a website or handouts. One disadvantage of making the class material available on a website or handout is that the students may be converted from "active" note taking to "passive" watching. They may not pay attention as closely in this mode. Also, one needs to be careful not to cover too much material too quickly when using any of the aids discussed above. Teachers have individual preferences on these issues.

Student use of computers in the classroom brings many new possibilities as well as many new challenges. The instructor's use of the computer and the student's use of the computer in the classroom are two very different things. It is important that everyone is aware of the distinction. Uses by the students in class include demonstration, instruction, and use of computer software as well as on-line quizzes.

Laptop computer use by students in class has both pros and cons. Overall, laptop use by students in the classroom is seen as positive in the long run. It addresses the more audio/visual style of learning. One can go faster but must hold the students accountable for the material. It is very useful for exams, e.g., students can obtain thermodynamic property values very quickly. Using prepared worksheets, mini-labs, group problem solving, etc., can also significantly enhance the learning experience.

The learning environment is significantly different with computers, however. Problems related specifically to in-class computer usage must be addressed. The primary problem is that students can be distracted and tempted by computers. Without computers, if a student does not pay attention in class, there is *little distraction for the other students*. If a student surfs the Internet or plays a game during class, the other students are distracted and *seriously annoyed*. Countermeasures include shutting laptops while not in use and not allowing connection to the network. Also, a policy on when/how often to bring the computer to class should be set at the beginning of the semester. Computers should not be allowed when the class is not using them. They are too distracting for the other students. Student participation may also be a problem; however, it is most likely typical of other exercises with large classes. Making sure that the students know exactly why they are doing something on the computer and that they will be held accountable for the information helps with participation. Finally, the computer use can slow down progress in class when there are computer malfunctions (students and instructor).

The ME Department decided that there was a need to develop a carefully structured questionnaire for students' in-class use of their laptops. The survey would allow constructive feedback to make improvements. The faculty provided input for questions. The author compiled this input and worked with the University's Evaluation and Assessment Services to develop the survey (Fig. 1). The survey was implemented for the first time in the 2001 spring semester. Improvements were made to the survey, and it was implemented again in the 2001 fall semester. The survey is proving to be a useful tool for improving the laptop computer experience and making it a significant learning tool. Survey results for Thermodynamics I will be discussed in the next section.

Laptops in Thermodynamics I

Implementation of the laptop initiative in Thermodynamics I has several factors that make it particularly interesting to study. First, Thermodynamics I required the laptop fairly early in the implementation process and has now had the laptop requirement for several years. Therefore, development of laptop use in this class has spanned a time from students needing the laptop for only one or two of their classes to students needing the laptop for all of their classes. Next, it is the first course taught to ME majors by ME

professors. As such, there is no uniform, prerequisite computer experience. Therefore, the level of computer skills among students varies greatly making this particular problem a bigger challenge than in more upper level classes. Finally, with the large amount of material to be covered in the course, it is not practical to expect to use the computer every class period. Hence, the issue of when/how often to use the computer for effective teaching is difficult. Several other considerations are common to other classes: (1) Differentiating between the instructor's use of the computer and student's use of the computer in class. (2) Decreasing distractions. (3) Increasing participation. (4) Holding students accountable for material covered while using the laptop. (5) Laptop use on tests and the final exam.

MSU's ME Department began implementation of the computer initiative in the 1999 fall semester by requiring students in two classes, Thermodynamics I and Engineering Analysis, to have a laptop. Class laptop use has expanded and improved each term. The evolution of the class laptop use over multiple semesters of experimenting with alternative techniques to arrive at methods appropriate for Thermodynamics I will be explained in the following paragraphs while specifically addressing the issues of concern mentioned above. Lessons-learned in responding to the COE/ME computer initiative will be compiled.

Semester 1

Use of the laptop in Thermodynamics I began with a course website on WebCT, a course public folder, and thermodynamic property software.[5] The WebCT website was developed particularly for this course and included an information center with the course syllabus, homework problem solutions, extra example problems with solutions, each student's grades, a bulletin board, a calendar, and a mail system. The website also included an evaluation center so that surveys and on-line quizzes could be given. In-class, the laptops were primarily used to view example problems posted on the website while the instructor explained the problems and to take short, on-line quizzes. Also, the students were taught to use Thermodynamic property software after they learned to read the property tables. The property tables were required for the first half of the class, but the students were allowed to use the software for property values during the last half of the class. Using the software during tests provided a significant time advantage; therefore, a test could cover more concepts in a shorter amount of time.

These computer uses provided a nice start for integrating the laptops into the course. The primary advantage was that use of the computer greatly enhanced communication between the students and the instructor as well as communication between students. Another advantage was the time savings on tests with the use of the properties software. Student's evaluations of the laptop use were generally positive, but they asked for further in-depth use. At this point, it did not require enough hands-on use by each student of their own laptop since the instructor already had the ability to show problem solutions from their own computer on a projection screen. Distractions and participation, concerns discussed earlier, become particularly important in this situation. Also, most students were only using their laptops for this one class; therefore, the expectations were very high. After all, they had paid quite a bit for this computer, and they expected to get their

money's worth from this one class! It was difficult for them to realize that they would use their computer for future classes also.

Semester 2

The next challenge was to increase each student's hands-on use in class without having to spend too much time in class teaching computer software. This challenge was particularly difficult for Thermodynamics I. The MSU ME Department does not require its students to take a programming class. Instead, Engineering Analysis is required which uses MathCad. With the prerequisites for Engineering Analysis, students generally take the class after Thermodynamics I along with Thermodynamics II. Therefore, there is no uniform, prerequisite computer experience for students in Thermodynamics I. A computer experience survey given at the beginning of each semester in Thermodynamics I has revealed that, inevitably, there is a very wide range of computer experience among students in the class. Methods to meet this challenge have evolved over the past few semesters.

For the 2000 spring semester, use of the property software continued and use of WebCT and the course public folder was enhanced. Also, in-class problem solving using MathCad was added. The students were provided with a MathCad tutorial and were expected to be able to input text, input equations, and solve simple equations. The tutorial was posted on the class website, and one day of class was devoted to the MathCad tutorial. An instructor prepared worksheet was the starting point for all students on the MathCad problems. The worksheet led the students in solving the problem and provided hints while requiring the students to fill in key equations, answer questions about the problem, and solve. Each problem also required the students to add their own "what if?" to the problem and re-solve. This gave each student a chance to add their own unique perspective and encouraged them to think past the problem at hand. The problems were e-mailed to the instructor at the end of class and graded as a quiz grade.

There were several advantages with this system. One advantage was that the students could see the effects of changes in the problem statement on the solution quickly. This allowed a deeper understanding of the concepts in the problem. Also, the students were involved in the work and held accountable thereby increasing participation and decreasing distractions. Next, the students were able to begin to see the possibilities of the power of the computer in problem solving. Finally, they received an introduction to MathCad with the knowledge that it would be used in future classes.

Unfortunately, there were also several disadvantages with the system. The primary problem was that the students' ability to use MathCad varied greatly. And the large amount of material to be covered in the course simply did not permit much time to be spent on teaching computer software. The students had to take the initiative to come up to speed on the software outside of class, and this generally did not happen. The students with less computer experience had trouble finishing the problems. Also, any computer malfunctions during class made it difficult to finish the problem. As a result, much time was spent in class trying to understand the software rather than trying to understand the

problem. Assigning MathCad homework problems was one possibility for increasing the student's skills with the software; however, the instructor was left to develop and distribute all solutions to these problems since they were not included in the text. Another disadvantage of this method was that the thermodynamic property software was completely separate from the MathCad software. This forced the students to learn both software packages, and the property values had to be input into the MathCad problems. Another disadvantage was that the number of problems that could be worked in class during a semester was very limited. The problems had to be carefully chosen to illustrate key concepts. Choosing the problems and preparing the worksheets required a lot of the instructor's time. Developing grading criteria and actually grading the problems was also very time consuming.

Semesters 3 and 4

The next steps in the evolution of laptop use in the class were taken to try to alleviate the troubles with using MathCad at this level. The advantages, discussed above, of the more hands-on use by the students with in-class problems needed to be maintained. However, new software was sought that minimized the need for previous computer experience and that allowed students to productively use the software relatively quickly. The software needed to have thermodynamic property routines. It also needed to be included as part of a text so that the students could have access to examples and homework problems using the software. This would help to minimize the class time needed to teach the software.

A new textbook was chosen for the course with software that met the criteria.[6] Moran and Shapiro's 4th edition includes Interactive Thermodynamics (IT) software produced by John Wiley & Sons. The advantages of the software include the following: (1) IT includes properties routines. (2) It is relatively easy to learn. (3) The text explains the software. (4) Example problems using the software are given in the text. (5) Homework problems using the software are included in the text. (6) The software is specific to Thermodynamics allowing the students to choose systems, input assumptions, and see the equations applicable. (7) The software allows students to 'sweep" variables and make plots showing them the impact of changes on the problem solution. (8) Other texts (e.g., Heat Transfer) published by John Wiley & Sons use similar software; therefore, the students can use the software in future courses.

The current approach to using the laptops in Thermodynamics I includes projects for active, "hands-on" use by the students along with Web access and the IT software package that requires no previous computer experience. The students are told in class when to bring their laptops at least two class periods in advance. This information is also posted on WebCT. The first computer class is held fairly early in the semester (around class 3) and is used to introduce the students to WebCT and the course public folder. The primary uses of WebCT were discussed earlier. Enhancements to the web system include the addition of links to other websites with helpful information; e.g., additional problems and solutions for their text. This opens the channels of communication early. The next computer class is to introduce the student's to the IT software. Although the software is not particularly useful until the students begin to learn to obtain property values in Chapter 3 of the text, it is useful to have the students go through the IT tutorial while they

are studying Chapter 2 so that they can get a feel for what the software can do. Therefore, the second computer class is spent having each student work through the IT tutorial along with the instructor so that the instructor can show options, discuss possible problems they may experience, etc. Once the class is studying Chapter 3 for obtaining property values of pure substances and ideal gases, the computer class time is spent teaching the property routines available in the IT software. Homework problems using IT can also be assigned at this point. Once the students learn how to obtain property values for different substances and begin to solve 1st Law problems for closed and open systems, they are ready for group problem solving using the IT software. The remainder of the class computer time for the semester is spent in this way.

The group projects encourage peer interaction to learn the software as well as the course material. Having the students work in groups also allow a more complicated problem to be solved in class so that the students learn more from the experience. The instructor assigns the groups. Groups of two seem to be optimum; however, groups of three also work well with large classes. The group assignments are posted on the website. On computer day, the students know to sit with their partner(s). One student, the recorder, is responsible for using his computer for the IT problem. The students take turns being the recorder. The group problem is placed in the course public folder so that the students can access it for class. All directions for the problem are given in the problem file. At the end of class, the recorder must e-mail the solved problem to the instructor for grading.

A sample group problem is given in Fig. 2. Experience has shown that, even when working in groups, the amount of guidance given in the problem is necessary to allow the problem to be completed in one class period. Simply solving the problem is not the primary objective—problems such as this as solved as homework problems. The advantages to using the software are working in groups on a new problem, discussion of the problem solving procedure, discussion and interpretation of the results, and the advanced analysis (part 3). The advanced analysis forces the students to think beyond the problem at hand. The variable sweep and graphing features of IT allow the students to quickly see how variable changes affect the solution to the problem. Forcing students to interpret these results and the discussion that this promotes is the primary advantage to this technique.

The current approach to laptop use in Thermodynamics I still has a few disadvantages. First, the time required to learn the computer software is still fairly substantial although the author believes that it is the best current available option. Next, any computer problems make it difficult for the students to complete the IT group problems in class, and, as noted previously, the most powerful benefits result from the last part of the problem solution. Also, group problems are not very useful until about mid-way through the semester; therefore, few group problems can be worked during the semester. Finally, the property routines available in IT are not as user friendly as other available packages. The students are restricted to the properties routines in IT for Thermodynamics I, but they are allowed to choose from other available property routines in Thermodynamics II. This gives them the needed structure in their first class then grants them more freedom as they are prepared to handle it in the more advanced class.

The advantages to the current approach to laptop use in Thermodynamics I definitely outweigh the disadvantages. The more hands-on use, accountability, and when to bring/use policy have greatly decreased distractions and increased participation. Having the software explained in the text with sample problems as well as homework problems allows the students to begin to benefit from the software relatively quickly. Although the property routines are not as user friendly as one would like, they are incorporated into the problem solving software. And, although the students will not likely use this particular software in their jobs in the future, they are introduced to this type of software and its power.

Results from the laptop survey for Thermodynamics I are given in Table 1.

Table 1. Thermodynamics I Laptop Survey Results

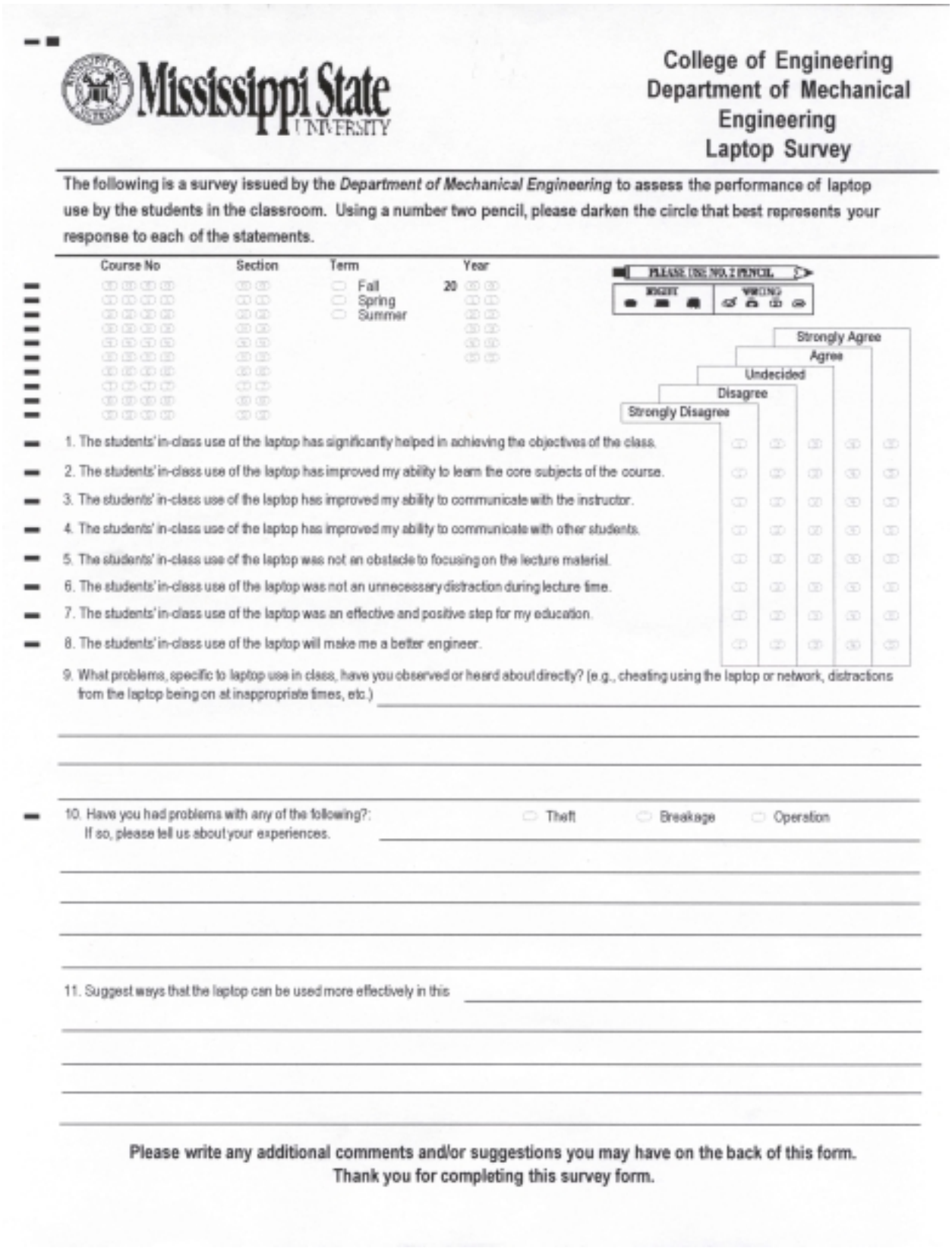
	Spring '01	Fall '01
Question No.	Mean	Mean
1	2.97	3.24
2	2.77	2.98
3	2.87	2.98
4	2.97	2.96
5	3.50	3.80
6	3.71	3.71
7	3.35	3.60
8	3.73	3.73

The question numbers are given in the survey in Fig. 1. All responses were from 1 to 5 with 1 being strongly disagree and 5 being strongly agree. The questions were all structured such that 1 was the most negative and 5 was the most positive response. Therefore, one would strive for a score of 5. Realistically, at this stage in the development of the laptop use in class, numbers greater than 3 are considered a success. Overall, the ratings are favorable. Spring '01 was the first use of the survey and the first use of the Interactive Thermodynamics software. The negative comments were primarily due to the learning curve for the new software. Experience with the software allowed for improvements in the ratings in the fall '01 semester. Particularly encouraging were the high mean values for questions 7 and 8. The students view the laptop use as an effective and positive step in their education that will make them a better engineer. Further evolution and refinement of the in-class laptop use to minimize problems will allow the students to more clearly see the benefits for learning the subject matter and achieving the objectives of a particular class. Although difficult to present in a paper, the students written comments on the survey forms were the most encouraging results. The written comments from fall '01 were much more positive with constructive criticism for improvement and requests to use the laptops more. The greatest complaint remained the time required to learn the software. Again, the author believes that this problem is one that is not likely to improve. The sacrifice must be made to reap the benefits. It was also

evident from the survey comments that having the laptop requirement for all ME classes improved the student's opinion of its usefulness.

Conclusions

The integration of laptop computers into the Thermodynamics I classroom has been a slow, learning process. The current procedure seems to be working well with the students gaining additional benefits from the laptop use over the traditional method of teaching the course. The benefits come at the expense of the instructor's time, however.



Mississippi State University

College of Engineering
Department of Mechanical Engineering
Laptop Survey

The following is a survey issued by the *Department of Mechanical Engineering* to assess the performance of laptop use by the students in the classroom. Using a number two pencil, please darken the circle that best represents your response to each of the statements.

Course No | Section | Term: Fall, Spring, Summer | Year: 20

PLEASE USE NO. 2 PENCIL

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

1. The students' in-class use of the laptop has significantly helped in achieving the objectives of the class.
2. The students' in-class use of the laptop has improved my ability to learn the core subjects of the course.
3. The students' in-class use of the laptop has improved my ability to communicate with the instructor.
4. The students' in-class use of the laptop has improved my ability to communicate with other students.
5. The students' in-class use of the laptop was not an obstacle to focusing on the lecture material.
6. The students' in-class use of the laptop was not an unnecessary distraction during lecture time.
7. The students' in-class use of the laptop was an effective and positive step for my education.
8. The students' in-class use of the laptop will make me a better engineer.
9. What problems, specific to laptop use in class, have you observed or heard about directly? (e.g., cheating using the laptop or network, distractions from the laptop being on at inappropriate times, etc.)
10. Have you had problems with any of the following? Theft Breakage Operation
If so, please tell us about your experiences.
11. Suggest ways that the laptop can be used more effectively in this

Please write any additional comments and/or suggestions you may have on the back of this form.
Thank you for completing this survey form.

Fig. 1. ME Department Laptop Computer Survey

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ME 3513 IT Group Problem 2
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Names:
(Please note the recorder.)
Date:

Problem Statement:
Air expands through a turbine operating at steady-state on an instrumented test stand. At the inlet, p1 = 150 lb_f/in^2, T1 = 1500 ^oR, and at the exit, p2 = 14.5 lb_f/in^2. The volumetric flow rate of air entering the turbine is 2000 ft^3/min, and the power developed is measured as 2000 HP. Neglecting heat transfer and kinetic and potential energy effects, determine the exit temperature, T2, in ^oR.

Part 1, Interpret Problem.

Known:
p1
T1
p2
Volumetric flow rate
Power
Heat transfer
Delta KE
Delta PE

Find:
T2

Assumptions: (Fill in below)
1. Open or closed system?
2. Steady-state (Yes or No)?
3. Assume an ideal gas.

Part 2, IT Analysis.
Follow the guidance below to solve the problem in IT.
***/**

// Known quantities.
// Insert values.
p1 = // lbf/in^2
T1 = // °R
p2 = // lbf/in^2
Wdott = // HP
AV1 = // ft^3/min

Fig. 2. IT Group Problem

/* Energy balance
Insert the appropriate energy balance equation. Note that you can choose a turbine under the process button and select the appropriate options to get the energy balance equation. This equation allows h2 to be calculated since work is given, h1 can be determined from the given data, and mass flow rate can be determined from the given data.
*/

//Continue by inserting the appropriate equation for specific enthalpy, h1.

//Continue by inserting the appropriate equations to determine the mass flow rate.
//Remember the ideal gas assumption.

//Determine T2 based on h2.

//Don't forget to select the correct units and to add unit conversion factors if needed.

/* Solve and comment on your solution. (Answer: T2 = 882.1 ^{o}R)

Part 3, Advanced Analysis.
Allow the work to vary from 0 to 4000 HP in increments of 100 HP.
Plot T2 vs. work and h2 vs. work.
Comment on the trends of the solution.

***/**

Fig. 2. IT Group Problem (continued)

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Biography

HUDSON. Dr. Hudson received her BS degree in Applied Mathematics/Physics Concentration from Presbyterian College, her MS degree in Aerospace Engineering from North Carolina State University, and her PhD degree in Mechanical Engineering from The University of Alabama in Huntsville. She worked for NASA at the Marshall Space Flight Center for 10 years and is currently an assistant professor in the Mechanical Engineering Department at Mississippi State University. She teaches classes in the thermal/fluids area, and her primary research area is uncertainty analysis.