Thermodynamic Cycles: A Multimedia, Independent Study Course

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Abstract

During the 1999-2000 academic year, we developed a one-hour multimedia course covering the final third of a traditional thermodynamics course. In the paper we use the term "media" to describe the manner in which the content is delivered. The thermodynamics course is delivered via CD-ROM or Internet. We introduce the term "genre" to describe the nature of the content based on its application. The thermodynamics course is a combination of two genres: textbook supplement and lecture. The course permits students to complete the final five weeks of the thermodynamics course independently. During the summer of 2000, three students successfully completed the one-hour course.

We are confident that lifelong learning will be an important component in our students' futures, and that much of the learning will take place in a digital environment. For this reason, we feel it is important to introduce students to the importance of lifelong learning and provide them an opportunity to learn independently in a digital environment. Seventy-one students, enrolled in the traditional lecture on campus, successfully completed one of the modules from the multimedia course, delivered over the Internet. They performed as well on an examination question as students who had been exposed to the material in a traditional lecture format.

I. Introduction

A great deal has been written about multimedia and its impact on education. With few exceptions, the research has implied that multimedia tools are at least as effective as traditional tools for teaching. For example, Milton-Benoit et al., developed a multimedia lecture that introduces students to the fundamental concepts and guidelines for finite element modeling.[1] Limited testing on the 45-minute multimedia lecture shows students performed at least as well as students in the traditional lecture on a follow-on assignment. Similarly, Al-Holou developed eight multimedia modules to introduce students to electrical engineering principles.[2] The lectures were followed by on-line quizzes. Eighteen students evaluated these lectures and found them useful and easy to learn from. Bailey et al. developed a multimedia module on phase diagrams used in a basic materials science course.[3] Roughly 40 students used the module while 40 other students had a lecture-based presentation on the material. All students were then administered a multiple-choice quiz and the results indicated that students who experienced the multimedia module performed no better and no worse on the quiz when compared with those who experienced the traditional lecture. Weinberger developed a multimedia lecture/textbook to help students learn fundamental concepts of transport phenomena.[4] Twenty-eight engineering students used the lecture/textbook in additional to traditional lecture and performed significantly

better on an exam question than student who only attended the traditional lecture. In past studies we have compared traditional media to multimedia in a variety of ways and have found similar results.[5,6] Interestingly, Wallace and Mutooni compared performance of students who received web-based instruction with students who attended a classroom lecture and found the average performance of students who received the web-based instruction was higher than that of the lecture-based instruction.[7]

Investigators have also documented studies involving the delivery of complete courses using an alternative to the traditional classroom lecture. For example, a complete course in information engineering was developed for delivery online by Bourne, et al.[8] The course utilized a multimedia lecture/textbook format. They found that although students procrastinated more than those in a traditional lecture course, they learned as much. Latchman and Latchman[9] as well as Sener and Stover[10] describe the use of asynchronous learning networks to delivery multimedia courses to both bachelor's and master's level students. A study by Boulet and Boudreault using a more traditional asynchronous delivery-mode, television, showed students performed as well on examinations whether the material was delivered via television, traditional lecture or a partial television, partial lecture mode.[11] Faculty at the Open University have conducted large-scale trials of internet delivered, multimedia courses compared with traditional lecture courses and found no difference in student performance based on examination results.[12]

In contrast, although, a review of the electronic delivery of multimedia courses or programs by the Institute for Higher Education Policy showed distance learning course outcomes (student performance on examinations and student satisfaction) compared favorably with traditional classroom-based instruction, they question the rigor of many of the studies performed to date.[13] Another review of the literature on the use of information technologies by Kadiyala and Crynes also support the value of these technologies in enhancing learning experiences when the pedagogy is sound, although they also question the extent to which the studies examine time on task, better learning, cost.[14] As we have reviewed the literature, we have found what we believe to be an additional problem. We feel that in the past as researchers have examined "media," they have ignored "genre." Yet, results in our recent studies have implied that although media choices seem to make no difference, genre choices are critical.

Cited problems notwithstanding, a growing number of studies are showing that students perform at least as well learning from a Internet or CD-based instruction as from a traditional, classroom-based instruction. With this in mind, schools are increasingly implementing complete courses and even programs based on these technologies. Working professionals, interested in lifelong learning, have discovered the value of these programs and have returned to school by way of the Internet. Given the need for our students to engage in lifelong learning throughout their careers, it is clear that in the future students will learn material via a CD-based or Internet-based instruction. In short, not only can students learn using multimedia, it is becoming increasingly clear that they will learn using these media. As a part of their education, students need to experience learning in this environment. Drawing on these needs, we developed a one-hour course on the thermodynamic cycles designed to be used by both remote and local students.

The original need for the one-hour course in thermodynamic cycles stemmed from a mandatory change from a quarter-based to a semester-based system within the state of Utah, as dictated by the state legislature. Within Utah, the two state-funded, primary providers of engineering degrees had two different philosophies concerning the number of semester credit hours associated with the first course in thermodynamics. Since the thermodynamics course is

sophomore level, it is also available through many community college programs within Utah. The lack of consistency among the two four-year engineering programs left the community colleges in a quandary – do they provide the two-hour course or the three-hour course? In order to resolve this difficulty, we developed a multimedia, CD-based course for the final hour that emphasizes the various thermodynamic cycles. Students signup for a one hour, independent study and are required to complete the course before enrolling in the second course in thermodynamics.

The purpose of this paper is to describe the development and assessment of a one-hour multimedia course covering the final third of a traditional thermodynamics class. We will describe and explain our media choices, but we will also introduce the term "genre" to our descriptions to help clarify the factors leading to our results and to provide additional material and vocabulary for future researchers. We'll present the results to date of transfer students who have completed the course. Finally we'll present results of the use of the CD-ROM material in a traditional classroom setting to introduce students to learning independently with digital materials-- to assist students with developing lifelong learning skills.

II. Course Design

To clearly describe the thermodynamics course, we will begin by distinguishing between "media" and "genre – two concepts commonly confused. "Media" is the manner in which data is disseminated. The Internet, CD-ROM, television, radio, and paper are examples of media. Although these describe how data will be configured, they say nothing about what it will be. For example, in television, data is broken down into an electronic format and transmitted using radio-wave transmission technology, while in a digital environment, the data is served as bits (packets on the Internet). In each case, if someone lists the media, the reader will be able to identify the physical nature of the data but will know nothing about its content. "Genre" is identifiable by content, structure, voice, and the way in which it will be used. News, short story, tale, guide, help file, manual, textbook, and workbook are all genres. "Genre" says a great deal about content, structure, and use, but little about how it will be delivered. Only by combining the terms may we have a complete picture (e.g., online novel, newspaper, interactive workbook, television news, stories around the campfire, etc.). In the past, researchers have consistently discussed the media they tested, but few in our experience have they examined the genres they were introducing into those media.

In our study, the material was presented using a combination of two genres: textbook supplement, and lecture. The audio portion of the content was similar to the verbal content of a lecture. The graphics were also similar to the types of sketches one might draw on the board during a lecture. Unlike a lecture, text was also used to describe material. The text was similar to that found in the summary section or supplement of a textbook without the level of detail found in a typical chapter. We'll use the term "module" to describe the software package, which houses the media and the genre.

By carefully defining and differentiating "media" and "genre," researchers can better understand their efforts to produce and understand digital content. For example, the work of Baher is probably best described as using Internet-based delivery of text and interactive-graphics, using a workbook genre.[15] Similarly, the efforts of Kirkpatrick, et al., appear to utilize a combination of textbook supplement and workbook genres using Internet-based delivery of interactive text and graphics for course materials associated with internal combustion engines.[16] Although the

workbook format is valuable, it is typically used only after students have background material in hand. Since we planned to deliver an entire course, we felt the need to develop a textbook supplement/lecture format.

Care must be taken in the development of multimedia materials. Researchers have found that for a variety of reasons students using digital media can come to wrong conclusions. For example, Riggs et al., found students exposed to a multimedia lecture on injection molding did not perform well on a written exam, possibly because the students were focusing on the wrong material in the lecture.[17] Another design idea that is important is whether the material is author driven or reader driven. Typically, books are called "author driven" because readers have little choice but to move through the material in a linear fashion—that is to say in the order the author designed. In reader driven texts, the readers make all of the important navigational choices—a dot-com Website is a good example of reader driven content. In 1997, we found that weaker students performed better in an author-driven, multimedia environment than one controlled by the reader.[6, 18] Student difficulties with reader-driven multimedia materials have also been found in the work of Babu et al.[19] and Reamon and Shepherd.[20] For these reasons, we chose an author-driven format for the thermodynamic cycles.

Shown below is a typical page in the thermodynamics module. We have found from previous work that the format of text on the left, graphics or animation on the right and audio in the background is effective.[6,18] The student navigation is limited to "previous" to return to the previous page, "next" to proceed to the next page, and "audio" to play the audio. Limited navigation forces the material to be presented in a linear fashion. Macromedia Dreamweaver™ was used to produce the navigational structure. SoundForge™ was used to produce the audio (lecture), which supports, but does not duplicate, the text on the page. A typical module consists of about 30 pages.

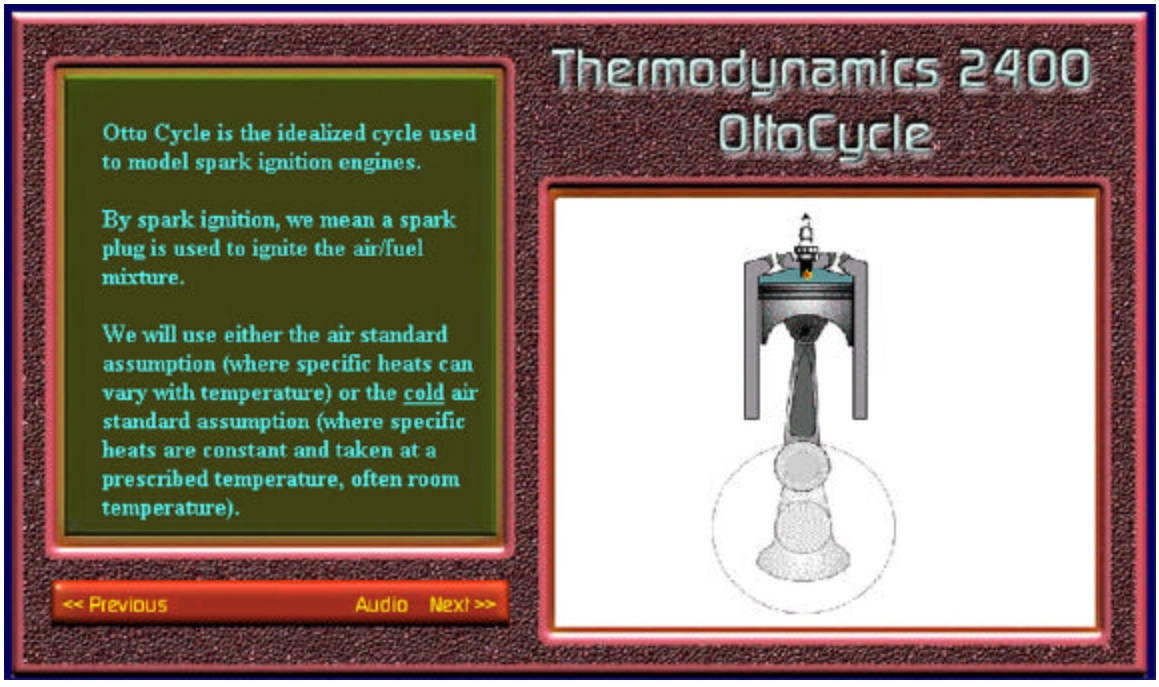

Figure One: Typical Page from a Thermodynamics Cycle Module

The students taking the one-hour course to satisfy the third part of an introductory thermodynamics course complete eight modules: Otto Cycle, Diesel Cycle, Brayton Cycle, Jet Propulsion, Rankine Cycle, Rankine Reheat Cycle, Rankine Regeneration Cycle and Refrigeration Cycle. Once we clearly understood we were producing a hybrid of genres: some aspects of a lecture and some aspects of a textbook, it became clear the students would also need the support of a traditional paper textbook to complete the learning experience. Reading assignments were required and homework assignments were made from the chapter problems.

In order to illustrate thermodynamic cycles, we utilized Macromedia's Flash™. Shown in Figures Two and Three are animations illustrating the Diesel Cycle. Shown in Figure Four is a frame from an animation illustrating an actual spark-ignition engine.

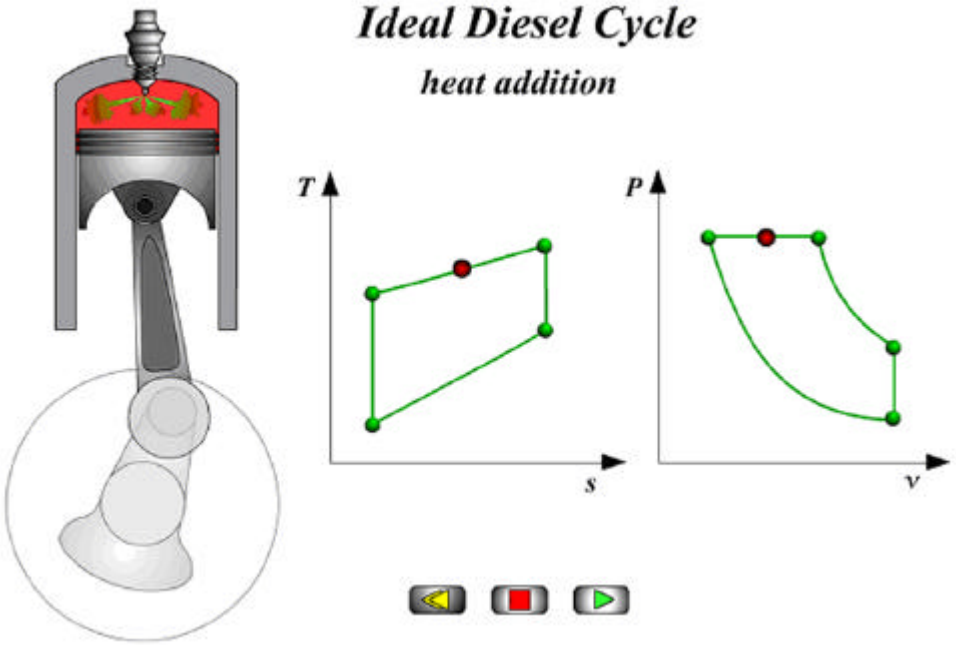

Figure Two: Frozen Frame of a Flash Animation Illustration the Diesel Cycle

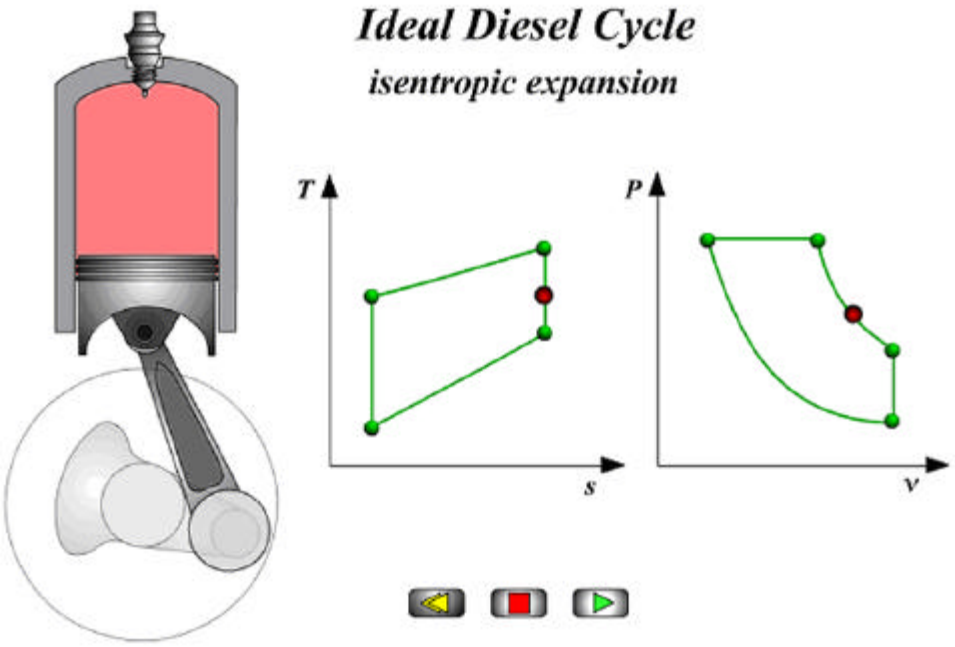

Figure Three: Another Frozen Frame of a Flash Animation Illustration the Diesel Cycle

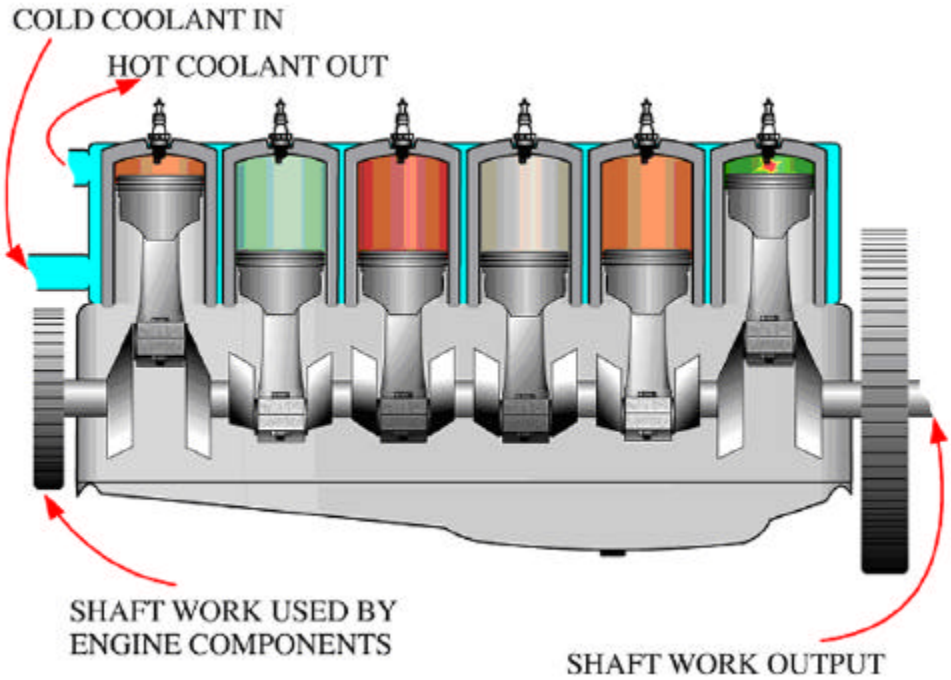

Figure Four: Frozen Frame of An Animation Illustrating a
Six Cylinder, Internal Combustion Engine

III. Results of Distance Delivery of One-Hour Course

During the Summer Semester, 2000, three students enrolled in the one hour course on thermodynamic cycles. Two students lived in Utah and one lived in Wyoming. The students

received CD-ROMS containing the eight cycle modules. They were required to purchase the textbook and asked to do the same homework problems that the students in the traditional classroom were asked to do. They communicated with the instructor via e-mail and telephone. At the completion of summer, all three students took a two-hour final examination over the course with questions identical to those asked of the traditional classroom students. The final examination in thermodynamics is not returned to students so the distant students did not find a copy of an old examination. All three students performed at the "A" level when compared with over 90 students' performance in the traditional classroom. In subsequent classes, the three students performed well during Fall Semester in the fluid mechanics course and the second thermodynamics course.

Given the small sample size, however, only limited conclusions can be made, and we make no claims about module effectiveness for distance learning at this point. The students did indeed learn the material. But we must point out these were good students and the textbook used in the course is excellent. More evaluation is needed with a broader spectrum of student skills before the overall course effectiveness can be understood.

IV. Use of the Cycle Modules in the Traditional Classroom

As we stated earlier, given the need for our students to engage in lifelong learning throughout their careers, it seems clear that in the future students will learn material via a CD-based or Internet-based instruction. We feel strongly that students need to experience learning in this environment even when they are enrolled in classes on campus. But what are the necessary skills students must have to engage in independent learning with digital media? Our answer to this question is simple: students must have a strong background in the fundamental concepts upon which any new material will build. In order to understand a thermodynamic cycle, a student must have a strong understanding in the fundamental concepts of conservation of mass, energy and the second law of thermodynamics. Since in our study the background material was covered in a traditional lecture format, we felt our students had been exposed to the fundamental concepts, had worked problems to reinforce learning the concepts, and had been tested over the concepts. Consequently, in our opinion, requiring the students to learn a new cycle and be able to solve problems on that cycle, without the benefit of additional lecturing, would be the ideal way to introduce them to independent, distance learning with digital materials. Since most students should have the necessary background in place, we had also hoped learning the material over the Internet would be a positive experience for them, giving them confidence they could learn material on their own in a digital environment.

In order to evaluate the ability of our students to learn material in a distance-delivery mode, we required that rather than attend a lecture on the Rankine Cycle, students study a multimedia module on the subject, available via the Internet. During Spring Semester 2000, seventy-one students viewed the module and submitted a homework assignment. The instructor was available to answer questions; however, no class time or lecture was used to cover the material. At the conclusion of the course the students are required to take a comprehensive final examination. One of the questions on the final examinations was on the Rankine Cycle. This same question had been given to students during a previous semester where they had been exposed to the material in the traditional lecture format. We used a Students t-test to determine whether there was a statistical difference in the average test scores of the two groups on the Rankine Cycle question.[21] We found the average score on the exam question was not statistically different between the two groups with a confidence level of 0.99. In order to insure the two classes were

composed of similarly skilled students, we looked at the average final grade given in each course. We found the average final grade given in the two courses was not statistically different with a confidence level of 0.99.

In addition to evaluating student learning through examination scores, we also asked the students whether they would prefer to learn the course material using similar modules delivered over the Internet. Over 90% of the students indicated they preferred the traditional lecture (which met at 7:30 am in the morning). Generally speaking, the students felt they lacked the discipline to effectively use the Internet material -- they felt they would procrastinate and not give themselves enough time to learn the material before a homework assignment was due or an examination was scheduled. They vastly preferred the lecture format, even though it met early in the day, because their attendance in the class provided the discipline to learn the material at a reasonable pace.

V. Summary and Future Efforts

A one-hour, multimedia course covering the final third of a traditional thermodynamics course has been developed. The material in the course is presented using a combination of two genres: textbook supplement and lecture. A typical module consists of about 30 pages and the course consists of eight modules covering a variety of thermodynamic cycles. Audio, text, graphics and animations are used, in an author-driven format, to cover the material. The modules are delivered in CD-ROM format or over the Internet.

Three students successfully completed the one-hour course during the summer semester 2000. They performed well on the same final examination given to students in the traditional lecture-based class. Seventy-one students were exposed to independent learning using digital media by learning the Rankine Cycle using one of the modules delivered over the Internet. They performed as well on a final examination question as students in a previous semester who were exposed to the material delivered in a traditional lecture format. Interestingly, the students preferred the traditional lecture format because attending lectures forced them to learn the material at a reasonable pace. They were fearful they would procrastinate if required to learn the material at their own pace over the Internet.

Studies cited in the literature, as well as this present study, indicate students can learn as well in an Internet or CD-ROM based environment when compared with a traditional classroom lecture format. However, the verdict is still out on whether students can learn better in a digital environment when compared with a traditional classroom.

One of the keys to improving learning, we feel, is to clearly understand the pedagogical format. We feel that perhaps important elements in the success of traditional and multimedia instruction are consistently being left out of the studies – the role of genre. After completing this study, we began examining the role genre played in educating our students, and found that we had limited our selection of genres to nothing more than lecture and textbook supplement – far less than the possibilities available. Given that this limited selection of genres created learning outcomes statistically equivalent to a traditional class, we cannot help but believe that with more effort and more carefully selected genres, we can create classes where student learning exceeds that of traditional courses. Our future research efforts will include these new ideas.

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