

## Evaluation of Experimental Course Formats Utilizing Technology-Based Instructional Delivery

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### ABSTRACT

This paper describes our experiences using a testbed instructional multimedia delivery system in experimental offerings of a "mainstream" computer engineering course. The experimental course formats were designed to investigate how use of technology-based instructional delivery impacts student performance and perceptions. Data from exit surveys, course and instructor evaluations, performance on similar exams, and student comments are presented to document the results obtained.

### INTRODUCTION

We've all heard the hype about how the "information superhighway" will affect the future of education, at all levels. An example to this effect follows: "Ultimately, network access will provide students with instant access to virtually any research document currently published, as well as a convenient mechanism for collaborating with each other on major projects. Additionally, computer-based conferencing will remove the constraints of classroom attendance, allowing students to view lectures from their computer terminals. And, in a two-way, interactive format, they'll still be able to pose questions to the lecturer and interact with the lecturer's data and information in real time."<sup>1</sup>

Many questions, however, remain — such as: What curriculum changes need to be made in order to effectively utilize technology-based instructional delivery? How well can students adapt their learning style to such an environment? How does technology-based instructional delivery impact academic performance — does it *hinder* or *help* students learn? What impact does technology-based instructional delivery have on students' *perceptions* of the course and the instructor? What are the advantages and disadvantages of technology-based instructional delivery, and how can the perceived disadvantages be addressed?

To help answer these questions, several different experiment course formats were designed for one of our "mainstream" computer engineering courses, EE362 *Microprocessor Systems and Interfacing* — a course required on all Electrical Engineering and Computer Engineering plans of study. The experiments were run during the 1994 and 1995 Summer Sessions with class sizes ranging from 40-50 students. A "regular semester" experimental division was also run during the Fall 1994 Session; another is currently in progress as of this writing (Spring 1996 Session). This paper begins with a brief discussion of learning styles in the context of technology-based delivery, followed by a brief overview of the VideoJockey Multimedia Delivery System. The experimental course format is then described along with the results obtained. Included in the results section are data on exam performance and class GPA, course and instructor evaluation data, exit survey data that assess various features of the experimental course format, and student comments. This paper concludes with a brief synopsis of future goals, along with some suggestions for those wishing to try similar experiments.

## EFFECTIVE INSTRUCTIONAL DELIVERY

For instructional delivery to be effective (technology-based or otherwise), it must be able to accommodate (or, better yet, be able to adapt to) a wide variety of learning styles:<sup>2</sup>

- for *active* learners, allow self-motivated pursuit of information.
- for *reflective* learners, provide the opportunity to investigate and understand inter-relationships of material.
- for *sequential* learners, provide the opportunity to review the flow of lecture material.
- for *global* learners, allow navigation of complete course material under individual direction, but present a coherent association of previous, current, related, and future material.

Convincing arguments have also been made for increased use of visual media in engineering education.<sup>3,4</sup> Since print dominates our environment and educational methods, students are forced to process information and learn predominantly with the brain's left hemisphere. Most of what engineering students must learn, however, requires them to develop *right*-brain processing skills. This leads to a fundamental incompatibility in the general learning process, an incompatibility which is particularly acute in engineering education: right-brain processing funneled through left-brain "sequential I/O" (i.e., printed text). In contrast, *visual* media provide a direct, "parallel I/O" path to the brain's right hemisphere. Clearly, in an increasingly vigorous visual culture, use of visual media as an integral part of instructional delivery — for presentation of lecture material as well as for interactive, self-directed study outside of class — is absolutely essential.

The educational delivery requirements outlined above — (1) the need to adapt presentation of course material to students with different backgrounds and abilities, and (2) the need to teach in the "visual arena" — have motivated the push for use of "multimedia" in education. For multimedia instructional delivery to make significant inroads in higher education, though, systems must be developed that possess the following characteristics: (1) utilize low cost, high density, incrementally recordable audio/visual storage media; (2) utilize ubiquitous, low-cost PCs or workstations; (3) provide a high degree of extensibility; (4) provide tree-like as well as cross-indexed access to instructional information; and (5) work equally well in a variety of presentation environments, ranging from large-lecture class formats to individualized instruction.

Based on the criteria outlined above, a testbed multimedia instructional delivery system — called VideoJockey<sup>5,6</sup> — has been developed at Purdue University's School of Electrical Engineering. One of the primary goals of this project has been to provide a means by which students can dynamically adapt presentation of course material to their own learning style by allowing them to access instructional resources in a highly automated, cross-indexed fashion. The VideoJockey System utilizes write-once laser videodisc and autolocatable videocassette playback units that are controlled via networked computers, with multiple channels of audio and video signals available to classrooms and lab facilities via an in-house cable-TV network. The user interface software provides a hierarchical search path through the still frames, animation sequences, and full-motion video segments stored in the multimedia data base. Once a frame or segment is selected, the user interface software schedules the visual material for "broadcast" over the in-house cable-TV network and autolocates the videodisc and videotape playback units to find the selected material. The user interface also provides a text window that can be used to supply additional "annotation" (e.g., textual explanation of material appearing on a lecture presentation frame) or help/see-also information. Via the VideoJockey System, students are able to access visual still frames and videotaped segments presented in lecture outside of class, from a variety of locations. They can also access videotapes of complete lectures as well as homework solutions and lab tutorials. Professors can use the system as a convenient platform from which to produce videotapes of lectures or course modules — either "live" (in class) or in a "studio" environment. The system currently consists of eight videocassette and four videodisc channels; all "head-end" equipment is centrally located.

## EXPERIMENTAL COURSE FORMAT

To investigate the effectiveness of technology-based instructional delivery — particularly in teaching design-oriented engineering course material — an experimental format was devised for EE362 *Microprocessor Systems and Interfacing*, a four-credit hour course that includes a laboratory. This course is required on all Electrical Engineering and Computer Engineering plans of study, and thus encompasses a good cross section of the electrical/computer engineering student population. The experimental course format was run during two Summer Sessions (1994 and 1995) with enrollments ranging from 40-50 students.<sup>7</sup> A similar experimental format was run during a regular semester (Fall 1994) in parallel with the "conventional" (three-lecture-a-week) format; students filled out a form to "apply" for enrollment, and an attempt was made to select a representative cross section of students for the experimental division. The "regular semester" version of the experimental format is being repeated during the Spring 1996 Session.

The experimental course formats were organized and conducted as follows. All the course lecture material was "modularized" and videotaped; each week, new sets of tapes were placed "on line" for access by students on the VideoJockey System. (Here, "modularized" means that course topics were presented in "unitized" variable-length segments, rather than arbitrarily split into the 50- or 60-minute non-unitized "slices" forced by the traditional N-time-a-week lecture format.) At the viewing stations — which consist of a networked terminal plus a standard television receiver — students could access the lecture material on videotape or interactively access the "lecture workbook"<sup>8</sup> still frames stored on laser videodisc. In addition to using the terminal to control the VCRs and videodisc units, students were also able to use it for E-mailing questions about the course material to the professor or course teaching assistant while viewing the lecture videotapes or lecture workbook still frames. An important feature is the *flexibility* provided as to the time of day lectures were viewed, how often a given module was viewed, and how much course material was viewed in a "single setting."

In addition to the technology-delivered lectures, a weekly "recitation-style" class was conducted to give students the opportunity to ask "live" questions about the course material as well as for the purpose of administering a quiz. Also, to provide an opportunity for one-on-one interaction, mandatory "pre-exam" office visits were scheduled for each student prior to the hourly exams (Summer 1994 only).

## RESULTS

To measure the effectiveness of the experimental course format, course/instructor evaluation data and scores on similar exams along with the final class GPA were compared with those obtained during previous "regular" course offerings. In addition, students were asked to complete an exit survey that included an evaluation of how various "features" of the experimental course format helped them learn the course material, plus an assessment of whether the experimental course format helped or hindered their expected performance — and in what way. In the discussion which follows, the Summer 1994 experiment will be highlighted as representative of the results obtained. Comments are included that describe how the other experimental offering outcomes differed.

### Exam Performance and Class GPA

To gain insight concerning how well this class performed relative to other recent (traditional) offerings, the exam scores were tabulated along with the final class GPA. The results appear in Table 1. An important qualification to this data is that the summer session students are, on average, somewhat better than fall or spring semester students — many are either coop students, or are otherwise highly motivated (of course, there are

always those who are *not*). Another significant consideration is that the "software" exams are the *same* each semester, and thus represent a fairly "standardized" measure upon which to base comparisons. Finally, it is important to note that course grades are assigned using a stable, well-defined algorithm coded in software.

Table 1. Exam scores (expressed as a rounded percentage) and final class GPA (out of 4.00) for several recent offerings of EE362; "SS94" is the experimental course format.

Item	S93	SS93	F93	SS94
Hardware Exam #1	60%	72%	62%	69%
Software Exam #1	75%	67%	77%	83%
Hardware Exam #2	50%	63%	58%	73%
Software Exam #2	61%	76%	69%	75%
Average of Above	62%	70%	67%	75%
Final Class GPA	2.56	2.63	2.56	2.97

Perhaps the most significant, or reliable, conclusion one might draw from the exam and class GPA data is that few students — from a statistical point of view — were academically "hurt" by the experimental course format. Stated another way, those students who may have been hurt or hindered in their expected academic performance were simply "outgunned" on the exams by those who were helped. This conclusion correlates well with student comments on the exit survey, that appear later.

### Course/Instructor Evaluation Data

A new, criteria-based course and instructor evaluation instrument has been used in EE362 several semesters, that has been shown to provide consistent, reliable data. The course evaluation metric is based on the average of twelve criteria (e.g., content of course, organization of course, outside help availability, course text, homework assignments, projects, exams, etc.), while the instructor evaluation metric is based on the average of seven criteria (preparation for lecture, clarity of presentation, general instructional technique, effectiveness in answering questions, effort put forth in teaching class, etc.). It was of great interest, then, to find out how the experimental course format affected the course and/or instructor evaluation. The results from previous course offerings that were evaluated using this same instrument appear in Table 2.

Table 2. Course and instructor evaluation results (maximum is 4.00) for several recent offerings of EE362; "SS94" is the experimental format.

Evaluation	F91	S93	F93	SS94
Course	2.82	2.91	2.92	2.90
Instructor	3.32	3.36	3.35	2.99

It is interesting to note that the course evaluation results are consistent with (and virtually identical to) the previous traditional offerings listed — even though the course format was radically different. It is also interesting to note that the instructor evaluation was noticeably lower than the previous offerings listed — even though many of the lecture modules were based on "live" recordings made during the F93 semester (i.e., the material was taught exactly the same way)! This, we believe, is simply a result of the *perception* held by some of the students that the "professor was not putting forth much effort in teaching the class" since the lecture presentation was done by video (this is verified by the relatively low score of 2.69 given for the "Effort Put

Forth in Teaching Class" criterion). This belief, unfortunately, is far removed from reality — as one might imagine, an exorbitant amount of effort was required to organize and conduct this experimental course format!

### Exit Survey

An exit survey was devised to help determine how much each "feature" of the experimental format helped students learn the course material, and to collect written comments on various aspects of the methodology used (e.g., what they liked best about the format, what they liked least about the format, and whether the format helped or hindered their expected performance). The results of the instructional feature assessment appear in Table 3.

Table 3. Rating of how much each feature of the experimental course format helped students learn the course material; table entries indicate the percent of responses (rounded) in each category ("5" corresponds to *a lot*, "3" corresponds to *some*, and "1" corresponds to *not at all*).

<i>Instructional Feature</i>	<i>How Much It Helped You Learn</i>					
	Avg	5	4	3	2	1
Flexibility viewing lecture videos	4.08	43%	35%	14%	3%	5%
Ability to review lecture videos	3.00	11%	25%	31%	19%	14%
Interactive access to lecture slides	2.94	5%	22%	40%	28%	5%
Lecture workbook to facilitate note taking	4.22	49%	35%	11%	0%	5%
Modularization of course material	3.76	22%	43%	27%	5%	3%
Weekly recitation class period	3.22	16%	27%	27%	22%	8%
Mandatory pre-exam office visits	2.73	8%	13%	36%	30%	13%

In addition to use of a lecture workbook, the flexibility afforded students in viewing the lecture videos along with the explicit modularization of the course material were deemed as the most significant "helpful" features of the experimental format. It was encouraging to note that *most* students thought that *all* features of the experimental course format helped them, on average, *at least some*.

### Student Comments

Perhaps the most illuminating information about the experimental course format was derived from student comments. In response to what students liked *best* about the experimental format, comments such as the following were typical:

- "it allowed me to watch a video at a time when my mind was alert and ready to learn"
- "could learn material at my own pace",
- "the flexible hours of lecture viewing helped me learn more — I went to watch lecture when I was ready to learn something, not when I had to"
- "I learned far more from this style of lecture format than coming to class everyday — it fit my schedule instead of me fitting it"
- "ability to review lectures if needed"

As one might imagine, though, there were some students who did not like the experimental course format *at all*, as illustrated by the following comments to the same question:

- "nothing — I can't concentrate watching TV"
- "don't like the idea of videos, prefer lecture atmosphere instead — [the experimental course format] should not be done again!"

Responses to the question, "Indicate whether you think the experimental course format *helped* or *hindered* your expected performance, and in *what way*" were perhaps even more illuminating. 70% of the students indicated that the experimental format helped their overall performance, 5% were not sure if it helped or hindered their performance, and 25% of the students indicated that they thought it hindered their performance. What is particularly interesting (some might use the term entertaining) is the *variety* of reasons given for *how*, or in *what way*, the experimental course format affected their performance. The following is a representative sampling:

- "Helped, because we had more time to work on labs and homework instead of *having* to go to class"
- "It helped me, because I came to lecture when I was ready to learn, not when I had to — if I was tired, I didn't go watch a lecture, because I knew it would be a waste of time"
- "I believe it helped because related material was viewed in one chunk instead of broken up into three days where memory can slip sometimes"
- "It helped my performance because the well-written notes were a good learning aid, and talking them through during lecture helped more"
- "I believe it helped my performance by allowing me to choose a time at which I am truly alert to consume the material"
- "Helped — I learned a lot (with a lot of effort) — the videos were very thorough"
- "I think the format helped my expected performance because it allowed me to schedule my own time effectively and view tapes when I was most receptive"
- "I was surprised — it helped!"
- "I feel it helped — the videos made access to the material extremely convenient; however, they seemed to remove the professor from the system"
- "Helped...I wasn't forced to endure lectures when I wasn't up to them — my schedule became more flexible, making less stress and more receptive learning"
- "I don't think the format had much of an effect on my performance — I seldom 'learn' much during lectures (taped *or* live)"
- "I think neither...the experimental format does not 'force' you to attend and watch them"
- "Helped because I was more interested in lectures, hurt because no ability to ask questions in lectures"
- "It probably helped somewhat — for some reason, I had an easier time paying attention to the video than I would have with an in-class lecture"
- "I think it might have hindered it slightly because I found that actually having a live voice makes a difference on how well I retain the material"
- "It hindered me greatly — it is very boring and hard to concentrate watching the videos"
- "Hindered a lot — too used to lecture atmosphere"
- "This format hindered my expected performance in the way that the flexibilities to watch videos on my own gives me no 'real' obligation to go to class like in other courses"
- Hindered — as a hands on type learner, I prefer to ask questions immediately upon them occurring to me, as well as the sense of 'approval' from the professor as incentive"

- "This experiment in theory elevates active self learning; however, since I am more of a passive learner, it doesn't quite work in my favor — so, this format actually hinders my expected performance since I am not 'forced' to learn"
- "It hindered (I think) — if there were regular lectures, I think I would learn more appropriately"
- "I think it helped my expected performance, but I don't think it helped as much as taking the class in the summer hurt my chances of getting a high grade because of the high averages"

There is but a single, cogent conclusion one can draw from all the above: "diversity of opinion is wonderful".

## HOW RESULTS DIFFERED IN OTHER EXPERIMENTAL OFFERINGS

As mentioned above, the results obtained during the Summer 1994 Session are fairly representative of all the experimental offerings. In particular, the *kinds of written comments* on the exit surveys were very similar in nature: the aspect *liked best* was the *flexibility* afforded in learning the course material; the aspect *liked least* appears to boil down to lack of a *live warm body N-times-a-week*. The exit survey "feature ratings" were also strikingly similar, with "flexibility" and "modularity" topping the list. The overall academic performance was similar as well, although somewhat less pronounced during the "regular semester" version (Fall 1994). One last difference worth mentioning is that, while conducted nearly identically (with very similar "academic" results), the relative quantity of "negative" comments received from the Summer 1995 Session was greater than that from the Summer 1994 Session. The only substantive difference the author has been able to identify between the two offerings is the quality of lab teaching assistants: the *lack* of experienced teaching assistants available for the Summer 1995 Session appeared to skew the *perceptions* of the students as to the effectiveness of the experimental format (again, *despite* the high level of academic performance attained!).

## SUGGESTIONS FOR OTHERS WISHING TO TRY SIMILAR EXPERIMENTS

Be bold! One of the keys to success is to make the technology-based experimental course format "different enough" from a traditional format. It is doubtful that a course format based on "just showing students videos" will be very successful, i.e., the course and material need to be organized to *take advantage* of the special capabilities afforded by technology-based delivery — such as the "non-linearity" both in terms of length and "density" of the course modules that can be exploited, the interactive "see also" links among modules that can be established, etc. One of the "biggest hurdles" to overcome, though, appears to simply be student *perceptions*, or perhaps their reluctance to accept a different way of learning. The culture, however, appears to be changing — more students are used to "getting information" using computers (e.g., via CD-ROMs and/or the Internet), and thus are more open to learning course material using a technology-based delivery system.

## SUMMARY AND FUTURE GOALS

The experiments described in this paper provide merely a "starting point" for addressing how the vaunted "information superhighway" will affect the future of education. Based on the results obtained from these experiments, a fair conclusion might be that *most* (but certainly *not all*) students are able to adapt to — and perhaps even *flourish* — in a technology-based educational environment. The comments also document that some students, for whatever reason, are inextricably rooted in the "live-warm-body, N-times-a-week" traditional lecture format. Thus, for technology-based delivery to be *truly* effective, i.e., in order for us to reap the maximum educational benefit from the up-and-coming information superhighway — for a wide range of educational environments that span distance education to life-long learning — we need to develop delivery systems, curricula, and instructional techniques that reach *all* students and accommodate *all* learning styles. *That* is the challenge.

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## REFERENCES

1. House, D., "Cruising Your PC Down the Information Highway," *Innovator*, Vol. 7, No. 2, August 1994, pp. 10-12.
2. Felder, R. M. and Silverman, L. K., "Learning and Teaching Styles in Engineering Education," *Engineering Education*, April 1988, pp. 674-681.
3. Waldheim, G. P., "Understanding How Students Understand: A Prerequisite to Planning Effective Teaching-Learning Methods," *Engineering Education*, February 1987, pp. 306-308.
4. Waldheim, G. P., Murr, L. E., "In the Visual Culture," *Engineering Education*, December 1988, pp. 170-172.
5. Meyer, D. G., Krzyzkowski, R. A. and Hoefflinger, M., "The VideoJockey System: A Testbed for Cost-Effective Multimedia Instructional Delivery," *Proceedings of 1992 Frontiers in Education Conference*, November 1992, pp. 168-172.
6. Oakley, B., "Computers and Networks in Engineering Education: One Educator's Perspective of Where We Are Today and Where We Are Going to Be Tomorrow," *IEEE Education Society Newsletter*, Spring 1994, pp. 1-6.
7. Meyer, D. G. and Krzyzkowski, R. A., "Experience Using the VideoJockey System for Instructional Multimedia Delivery," *Proceedings of the 1994 Frontiers in Education Conference*, San Jose, California, November 1994, pp. 262-266.
8. Meyer, D. G., "The Lecture Workbook as an Instructional Tool," *Proceedings of the 1984 Frontiers in Education Conference*, Philadelphia, Pennsylvania, October 1984, pp. 570-574.

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