Are Just-In-Time Lectures Effective At Teaching?

Roger B. Dannenberg and Peter Capell
School of Computer Science
Carnegie Mellon University
Pittsburgh, PA 15213 USA
Email: rbd@cs.cmu.edu, psc@cs.cmu.edu

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ABSTRACT

A ‘‘Just-In-Time Lecture’’ is a low-cost, flexible technology for creating and presenting educational material to groups and individuals. A review of learning concepts and education research supports the notion that Just-In-Time Lecture technology should be as effective as traditional classroom instruction. This finding is based on (1) a large body of research on related technologies, including television and videodisc training, (2) the fact that classroom instruction translates directly to the Just-In-Time Lecture medium, (3) the applicability of Just-In-Time Lectures to a variety of skill categories (e.g. Bloom’s taxonomy), and (4) positive experience using Just-In-Time Lectures at two universities for classroom and individual instruction.

1. Introduction

Technology has been offered as a solution to many education and training problems, but it is often remarked that mainstream education has not changed significantly in centuries. How can claims for technology be valid when the experts are apparently ignoring them? In particular, the Just-In-Time Lecture project at Carnegie Mellon advocates a new, low-cost technology for training and education. Why do we believe this technology is good, and what supporting evidence can we offer? This report presents a summary of research results on this subject and presents justifications for the use of Just-In-Time Lecture technology.

Among educational researchers, there are widely-known principles relating to how people learn effectively. A summary of these principles is that people learn by doing [Anderson 85]. It is therefore a simple extension from this principle to deduce that people learn most effectively when their environment causes them to have continuous high levels of interaction with the instruction system and performance. In this instance, the ‘‘instruction system’’ can be any environment that is designed to impart skills and knowledge to its participants.

Without going very deeply into the assessment of learning, there is also a widely-accepted notion that learning may only be accurately assessed by measuring behavior. The operational question behind this type of investigation being: ‘‘How did the learner’s performance capability

change after instruction?'' For example, is the learner able to recite information that they did not know before the course? Are they able to perform a new task, or have they improved their ability to perform an already known skill? In short, is there evidence that suggests that the instruction enabled them to do something new, differently, or better than before? [Capell 95]

2. Just-in-Time Lectures

While lectures in and of themselves are not considered an excellent way of imparting knowledge, Just-in-Time Lectures (JITL) offer features that are not characteristic of traditional, linear, non-interactive instruction systems.

These features are as follows and include the ability of the learner to:

1. Select specific concepts quickly (using the topic index);
2. Review concepts at will, any number of times;
3. Interact with a human point of contact (POC), who represents the instructor/course developer, via email;
4. Receive homework assignments and receive feedback on assignments;
5. Seek answers to common questions via frequently-asked questions (FAQ);
6. Receive graphic illustrations of concepts.

Despite the use of the term ''lecture,'' Just-in-Time Lectures provide multiple avenues for learner interaction with the system. To this extent JITL's provide an excellent vehicle for the dissemination of skills and knowledge to a wide audience in measurable terms.

A central issue in JITL development, therefore, is quality of design. Obviously, just as in classroom instruction, the design may provide for high levels of interaction, or relatively little. To the educational specialist, the degree of interaction will determine the efficacy of learning according to performance measures applied after the fact. Sloppily constructed instruction, poor illustrations, poor audience analysis, and lack of interaction will also produce predictable results.

As a vehicle for conveying knowledge, skills, and abilities, Just-in-Time Lectures provide as many opportunities as the traditional classroom. By virtue of the structure of the technology itself, it encourages a much greater likelihood of the application of best practices. Further, with the provision of freedom to investigate concepts in any order, including the possibility for human interaction and individualized attention, Just-in-Time Lectures can be created to provide any level of measurable performance according to such de facto educational standards as Bloom's taxonomy [Bloom 56].

At present, there are no formal studies specifically on the effectiveness of Just-In-Time Lectures. However, there is a growing body of experience and a wealth of studies and literature on related topics which point to the effectiveness of our approach. In the following sections, we will address several different areas and issues. First, what evidence is there that the general format of Just-In-Time Lectures can be used effectively? The second is the quality of design. What is the relationship between quality of design and teaching effectiveness? What is the relationship between Just-In-Time Lectures and quality of design? Third, what are the types of knowledge that can be taught via Just-In-Time Lectures, and what are the limitations? Finally,

we present some experience teaching with Just-In-Time Lectures.

3. The Delivery Mechanism

A great deal of study and debate has surrounded the use of video, computers, and other technology to present education and training. As yet, there are no formal studies that address the JITL format specifically, but there are many studies that address the use of video and interactive multimedia as compared to a live instructor format in training. Thomas Russell has compiled a long list of studies that show no significant difference when instruction is delivered through different media. [Russell 97] Some highlights from this and other sources are included below. An excellent review of the literature is available in a monograph by Moore and Thompson [Moore 97]. Chapter 3, ‘‘Implications’’ begins as follows:

> ‘‘The evidence that can be gathered from the literature points overwhelmingly to the conclusion that teaching and studying at a distance, especially that which uses interactive electronic telecommunications media, is effective when effectiveness is measured by the achievement of learning, by the attitudes of students and teachers, and by return-on-investment.’’

The chapter goes on to mention the limitations of studies conducted so far and the need for more basic research in learning. The question for distance education research today is not ‘‘Is it effective?,’’ but ‘‘How can we make it more effective?’’ and ‘‘What are the important considerations for the design of distance education?’’

Based on this ‘‘overwhelming evidence,’’ it seems reasonable to conclude that the Just-In-Time Lecture is as good a delivery mechanism as any, including classroom instruction, at least to the point that any differences will not be measurable in any practical study. Some of the studies that lead to this conclusion are described below.

A large number of studies have examined the use of video in place of classroom instruction. For example, a 1959 report from the Ford Foundation states:

> ‘‘On the final examination there was no difference in achievement between the students in the television classes and those in the regular classes. ... the average total score for the semester also revealed no difference in achievement between the classes taught by the two methods. It is clear, however, that in many college courses students can be expected to do equally well in examinations whether they have been taught by a teacher in a regular classroom or by the same teacher over television. When the final scores were adjusted to compensate for the initial inequality, it was found that there was no difference among students ...’’ [Ford 59]

and

> ‘‘In 29 out of 32 controlled comparisons in seven different courses, there were no significant differences in achievement between students taught via closed-circuit television and those taught in the conventional manner. ’’ [Ford 59]

A three-year study involving 200,000 students and 800 public schools states:

> ‘‘... whereas most comparisons showed no significant differences, 119 were significant in favor of TV-taught students, and 44 in favor of conventionally taught students.’’ [Pflieger 61]

Other studies have investigated the use of computer-based instruction. A common finding is that the effect of the medium itself is difficult to measure. P. L. Beare’s study from Moorhead State University states:

> ‘‘... individual instructional formats had little effect on student achievement or course evaluation. ... the lack of individual opportunity to interact on a daily basis with the instructor did not reduce student learning ...’’ [Beare 89]

Moore and Kearsky sum up many results nicely:

> ‘‘Comparing the achievement of learners (as measured by grades, test scores, retention, job performance) who are taught at a distance and those taught in face-to-face classes is a line of research going back more than 50 years. The usual finding in these comparison studies is that there are no significant differences between learning in the two different environments, regardless of the nature of the content, the educational level of the students, or the media involved ... reasonable to conclude (1) there is sufficient evidence to support the idea that classroom instruction is the optimum delivery method; (2) instruction at a distance can be as effective in bringing about learning as classroom instruction; (3) the absence of face-to-face contact is not in itself detrimental to the learning process; and (4) what makes any course good or poor is a consequence of how well it is designed, delivered, and conducted, not whether the students are face-to-face or at a distance.’’ [Moore 96]

Literally hundreds of studies have found no statistical differences in learning due to the presentation medium. Other factors, including the quality of design, remain to be considered.

4. Quality of Design

If the medium does not make a measurable difference in student learning, we are forced to look elsewhere to explain differences. The quality of design seems to be an important factor. For example, Whittington, states:

> ‘‘... students taking courses via television achieve, in most cases, as well as students taking courses via traditional methods ... Television is a technological device for transmitting communication and has no intrinsic effect, for good or ill, on student achievement. Effective instructional design and techniques are the crucial elements in student achievement whether instruction is delivered by television or by traditional means.’’ [Whittington 89]

A seminal study found that interactive videodisc training was more effective than classroom training due to its intensity of task focus in combination with its compelling interactive character. [Fletcher 90] Other relevant studies are cited below. Although further research is certainly desirable, we expect that the results of these studies are applicable to the Just-In-Time Lecture format.

An Army study explicitly controlled the quality of design and the delivery medium as separate variables. [Lehman 93] Two of the delivery mechanisms were traditional classroom and one-way VTT (one-way video with two-way audio links). Materials were redesigned for one-way VTT presentation. There was no significant difference between the one-way VTT and the traditional classroom groups, but both groups showed a significant improvement over the traditional classroom using the original ‘‘non-reconfigured’’ materials. Thus the course *design* effect was measurable while the delivery mechanism effect was not. Another interesting finding from this study was that fatigue was not a problem: students spending consecutive 8-hour days with one-way VTT performed as well as students in 4-hour sessions spread over several months.

There is evidence that good design can significantly enhance instruction. What does this say about Just-In-Time Lecture technology? Our experience has indicated that JITL’s motivate instructors and instructional designers to put extra effort into content development. For example,

mistakes and unclear content can be corrected, and the undesired portions can be erased through digital editing. By providing a convenient repository for all sorts of visual aids, JITL's encourage the use of high-quality materials that are often unavailable in the classroom.

Of course, there is only anecdotal evidence and common sense to indicate that JITL's lead to an improvement in content. Furthermore, we must be careful not to confuse production value with instructional design. Given the results in the previous section, we should not expect beautiful fonts and graphical layout to have any measurable impact on learning.

One interesting feature of the Just-In-Time Lecture is the capability to assess and improve the content incrementally based on actual experience. The email facility directs all student questions to a single address (or group of addresses) where the email can be archived for review. When the existing content seems to be confusing, new frequently-asked questions can be inserted to offer better explanations, clarifications, and helpful exercises. Material on the Web can be edited and updated. In contrast, my experience as a professor is that it takes time and energy just to repeat a classroom lecture at the previous level of preparation and content. The focus is more on recalling what happened last time, and less on fine tuning.

Regarding the quality of instructional design, the primary feature of Just-In-Time Lectures is their ability to permanently capture instructional content. In contrast to classroom lectures and teleconferencing, JITL technology places all the content — video, slides, diagrams, photos, readings, assignments, and more — in one place where it can be maintained and improved. Another feature is that JITL's allow content experts to reach more students in less time, raising the likelihood that students will have access to the best instructors.

5. Types of Skills and Knowledge

Another issue is the range of training to which Just-In-Time Lectures are applicable. Bloom's taxonomy provides categories based on the level of abstraction of cognitive skills. The major categories (with very simplified explanations) are:

- Knowledge: recall of data;
- Comprehension: an understanding of the data and concepts;
- Application: ability to use knowledge and comprehension in new situations;
- Analysis: understanding of the structure and components of learned material;
- Synthesis: combining and creating new material from components;
- Evaluation: critical assessment of concepts and knowledge.

Orthogonal to Bloom's taxonomy are issues of cognitive skills (such as mathematics) vs. psycho-motor skills (such as operating complex machinery or performing a musical instrument) vs. affective ''skills'' (concerning attitude and emotion).

Just-In-Time Lectures have addressed skills at each level of Bloom's taxonomy and a related system has addressed psycho-motor skills [Dannenberg 90] , but it is natural to ask whether the technology is more suited to some levels than others. Although the answer may seem obvious, it is very difficult to control the quality-of-design factor when courses are adapted from one medium to another. It is therefore difficult to show controlled studies demonstrating that a

particular technology is better for a particular category of skill. The list compiled by Russell includes subjects as far-ranging as Functional Anatomy Laboratory, Dramatic Understanding, Mathematics, General Science, Speech, English, Economics, Physical Education, Grammar, German, Japanese, Intro Biology, General Psychology, Management, and Respiratory Therapy. [Russell 97] In each of these studies, distance learning technologies were found to be as effective as traditional classroom instruction.

There is a general belief that ‘‘interactive-engagement methods’’ enhance the effectiveness of teaching. How can these methods be incorporated into Just-In-Time Lectures? Interactive-engagement methods include: collaborative peer instruction, problem sets, tests and quizzes, computer-based simulation, and model building. Just-In-Time lectures are being used in conjunction with internet chat rooms to facilitate real-time peer interaction, and it is easy to include problem sets, tests, and quizzes in a Just-In-Time Lecture on an associated web site. Simulations and models usually require custom software development, but they can also be distributed via CD-ROM or via the internet and accessed by Just-In-Time Lecture students.

Since low cost is an important feature of Just-In-Time Lectures, one might consider ‘‘budget simulations’’ based on video and choices. Students watch simulations presented via digital video. At various points, the video stops and the student is asked to make a prediction or to choose a parameter value to achieve a certain goal. The JITL student makes the prediction or choice by clicking on a FAQ (e.g. ‘‘Let’s increase the flow rate’’) which leads to a new video showing the outcome of the simulation.

In summary, technology has been used to support the teaching of all categories of skills. There is no clear indication in the literature that technology such as Just-In-Time Lectures is more (or less) appropriate for particular categories of skills. There is a general belief that active learning is important for all categories of skills. Well-designed Just-In-Time Lectures support active learning through a variety of techniques.

6. Experience

Just-In-Time Lectures are being used to teach at Carnegie Mellon University and at the Instituto Technologico y de Estudios Superiores de Monterey in Mexico. To date, sections of a course ‘‘Media Technology’’ have been taught, and two complete courses in software engineering, ‘‘Managing Software Development’’ and ‘‘Personal Software Process’’ are being taught. These experiments mainly provide evidence that the process and technology actually works. Given the negative results cited earlier, we would be astonished to find significant improvements over classroom presentations of the same material. A typical comment from a student of the Personal Software Process course (via email, of course) follows:

> I reviewed the first lecture on the CD and everything worked just fine. The JIT lecture player is a rather innovative concept in distance education. I like it!

A survey of students who took my Media Technology course, partly as Just-In-Time Lectures, indicated that there was at most a slight preference for classroom lectures over Just-In-Time Lectures. Students noted the convenience and availability of the JITL technology as superior to that of classroom lectures. Students felt the ability to ask questions in the classroom was an advantage over Just-In-Time Lectures (note that this perceived advantage is not confirmed in studies of televised education).

I noticed a remarkable difference in class after JITL technology was used. Students came with many more questions; with the lecturing out of the way, there was much more discussion time. As a future experiment, I plan to deliver all lectures with JITL technology, reduce classes from two- to one-per-week, and devote all class time to discussion.

7. Summary

Hundreds of studies have failed to find significant differences between various ways of delivering instructional content. This is good news for Just-In-Time Lectures. *Any content that is delivered in a classroom is a good candidate for delivery via Just-In-Time Lectures*, and *Just-In-Time Lectures should be as effective as classroom presentation.*

The quality of instructional design is a very important factor. The garbage-in/garbage-out principle applies to all educational technology, and the Just-In-Time Lecture is no exception. JITL technology cannot create good content, but it does facilitate the consistent delivery of good content once the content is identified.

Just-In-Time Lectures are suitable for a wide range of skills and knowledge. It is obvious that declarative knowledge — facts and abstract relationships — can be presented with this technology. It should be noted that in combination with Web technology for student communication and physical tasks for student exercises, Just-In-Time Lectures are suitable for virtually any training or educational task, including science theory and lab work, the humanities, foreign languages, management, office procedures, equipment repair, etc.

8. Conclusion

Research studies and current wisdom tell us that the means of delivery is relatively unimportant but the design of instruction is very important to teaching effectiveness. Just-In-Time Lectures offer a technology in which teachers can devote more time to content development and spend less time traveling and presenting. Because Just-In-Time Lecture technology can be applied at low cost, it seems a natural candidate for a wide range of education and training. When it is economically justified, Just-In-Time Lectures can be extended with customized software tailored to specific topics. To sum up, research supports the notion that Just-In-Time Lectures should provide instructional outcomes equivalent to those of classroom instruction. Therefore, a decision to use Just-In-Time Lecture technology should be based on convenience and cost factors.

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