

## **Project Report**

Active Learning through WWW: Just-in-Time Teaching in Electrical and Computer Engineering

Supported by 2006 CELT Summer Grant for Instructional Development

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## Overview

In the summer of 2006, I was awarded with CELT Summer Instructional Mini-Grant to adapt of one undergraduate education's most promising and readily adoptable instructional technique in recent years – Just-in-Time Teaching (JiTT), in an introductory electrical and computer engineering course – ECE 270: Introduction to Digital Systems Design. JiTT involves web-based warm-up assignments which students are required to complete and submit before class. Students' responses to these assignments are then reviewed by the instructor who makes appropriate adjustments in teaching based on student's understanding and concerns. The warm-up assignments, combined with classroom teaching, will lead to increased teacher-student and student-student interactions in the class. The outcomes of this project will be assessed by means of surveys/questionnaires. If successfully implemented, JiTT will benefit both the traditional and non-traditional student groups in engineering at IPFW. This project will not only introduce JiTT into a very important engineering program, but also serve as an example of using technology and innovative teaching strategies to promote active learning in undergraduate engineering education.

The following project activities were conducted:

- Attending CELT Summer Institute. Through the meeting with Dr. Dina Mansour-Cole and previous awardees, it helped me to be better prepared for this project. Dr. Cole provided some constructive suggestions of JiTT implementation which will definitely be adopted in the instructional activities of ECE 270.
- Participating ITS-CELT sponsored WebCT summer workshop. Though WebCT has been used in previous courses, some features have to be explored to adapt it in JiTT applications. Through this workshop, I became familiar with the Assessment tools, Learning Module tools of WebCT which will be used in JiTT exercises.

- Developing JiTT warm-up exercise questions. The key component of JiTT exercises is to develop warm-up exercises, which is very time-consuming and challenging. Short-answer problems, essay problems and multi-choice problems were developed in this stage.
- Developing pre-JiTT and post-JiTT questionnaires. Project outcomes, such as the teacher-student interactions, time spent in and out of class presentations, the natures of JiTT presentations, students' attitude, will be assessed and evaluated using surveys/questionnaires before and after JiTT exercises.
- Scheduling and organizing the JiTT adoption activities in the future ECE 270 instructional activities. The updated teaching activities in ECE270 will be introduced in the fall semester of 2007.

Further discussions of these activities are presented in the following parts in this report.

### **Introduction of JiTT**

Just-in-Time Teaching is a feedback-intensive teaching and learning strategy [1]-[7]. In a typical implementation, students respond electronically to carefully constructed warm-up assignments due before class, and the instructor reviews the answers and adjusts the classroom lesson to meet student needs. The central component of JiTT is the feedback loop from students before class that will fundamentally affect what will happen during the subsequent in-class time. Warm-up assignments are at the heart of JiTT's web component. These are short, web-based assignments, prompting students to think about the upcoming lesson and answer a few simple questions prior to class. These questions, when fully discussed, often have complex answers. The students are expected to develop the answers as far as they can on their own. The responses are submitted to the instructor electronically to form the framework for the classroom activities that

follow. Typically, the instructor duplicates sample responses on transparencies and takes them to class. The interactive classroom session, built around these responses, replaces the traditional lecture/recitation format. In general, JiTT strategy pursues three major goals [1]-[3]:

1. To maximize the effectiveness of the classroom session.
2. To structure the out-of-class time for maximum learning benefit.
3. To create and sustain team spirit. Students and instructors work as a team toward the same objective — to help all students master course contents with the maximum amount of retainable and transferable knowledge.

Here is how JiTT format differs from the traditional teaching format. In a traditional teaching environment (see Figure 1), the instructor comes to the classroom with prepared lecture notes. Students are passive information receivers without knowledge of what will be taught. In a JiTT teaching classroom (see Figure 2), the instructor adjusts lecture contents based on students' responses to warm-up assignments and comes to the classroom with proper knowledge of students' questions and concerns. Students will be more attentive in class because the lecture contents are adjusted to their level of understanding and students' concerns are addressed through properly designed classroom discussions. The results of JiTT implementations in other disciplines have been encouraging [1].

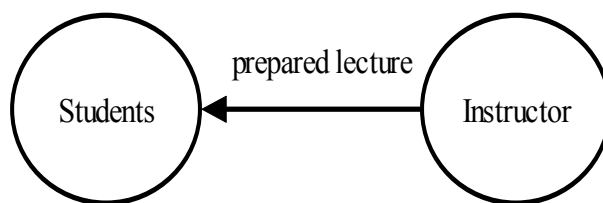


Figure 1. The Traditional Teaching Environment

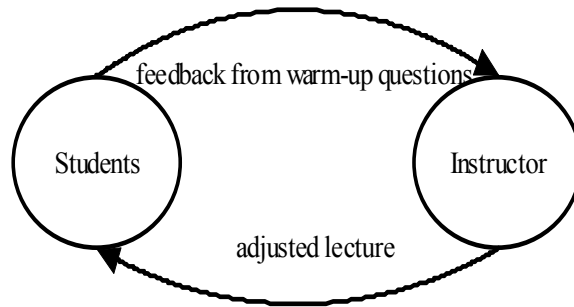


Figure 2. JiTT Teaching Environment

To date, over 300 faculty members in 25 disciplines at approximately 100 institutions across the US, Canada, Europe, and Israel have adopted the JiTT strategy. A review of the literature shows that although JiTT has been adopted in many disciplines, including science, arts, and humanities, it has not been applied to electrical and computer engineering [8].

### **Proposed JiTT Adoption**

ECE 270 – Introduction to Digital System Design is a required course for students majoring in both electrical and computer engineering at IPFW. It includes regular lectures and lab sessions and is offered each semester. The typical enrollment size varies from 15 to 20 students each semester. The traditional teaching format is to present new materials to the students in class followed by lab sessions, the purpose of which is to help the students learn what they have received in the classroom. This format involves few interactions between the teacher and students and between the students themselves.

Upon implementation of the lecture in the JiTT format, students will be required to finish on-line warm-up assignments (using WebCT) due a few hours before class. The warm-up assignments consist of two or three short questions or an essay question and a comment feedback

box. The answers will be graded on the quality of the thoughts and details. Students can receive a full credit even if their answers are not correct. Based upon students' feedback, the instructor will adjust the lecture contents to address students' concerns and questions.

### **Development of Warm-Up Questions**

It should be noted that it is challenging to develop these warm-up questions due to the nature of the subjects compared to the arts and sciences. In the arts and sciences courses, most of the warm-up questions could be subjective, and thus they could lead to some good discussion during the lecture time. In contrast, most of the warm-up questions in the engineering field are objective. Thus the development of these questions may require a different approach.

The warm-up questions are based on the categories adapted from a classic article on college science teaching by A.B. Arons [9]. JiTT assignments are introduced to examine students' understanding of new terms and definitions and their ability to explain the meaning of a concept, or a particular jargon, articulate their thinking processes when dealing with difficult ideas, draw inferences from data and evidence, translate words into written symbols and written symbols into words. Samples of short answer and essay questions for ECE 270 are in attached in Appendix A which were developed during the summer 2006.

During the implementation of this JiTT project, WebCT will be used to deliver warm-up assignments and collect students' responses. In the event that WebCT server is down, both the warm-up assignments and students' responses can be delivered via email. The assessment tools in WebCT will be used to deliver these warm-up exercises and gather students' response for JiTT practices.

## **Project Assessment Plan Development**

Project outcomes, which include students' attitude change, student-instructor's interactions, time spent in and out of class presentations, the natures of JiTT presentations, will be assessed and evaluated using surveys/questionnaires. Student responses to a standard attitudinal survey and anonymous end-of-course survey responses will be used to generate information regarding students' attitudes and thoughts relevant to this JiTT course. Pre-JiTT and post-JiTT questionnaires (see Appendix B) will be conducted.

In addition, based on the nature and frequency of questions students ask, and the percentage of warm-up question completeness by the students, the instructor will get a good understanding of the students' attitude and thoughts during the implementation of this project. Data gathered from the surveys/questionnaires' results, will provide the basis for assessing the outcomes of the project.

### **Plan Development of JiTT Implementations**

JiTT exercises in ECE 270 will be conducted in one semester with control (JiTT) and non-control (non-JiTT) sessions. Though all content areas are not equivalent in difficulty levels, the students' view on both methods could be provided of having the same students. The results of this experiment could be reached in one semester. The teacher-student interactions, time spent in/out of class presentation, the nature of the preparation, and student attitudes toward the content could be measured through comparing between JiTT and non-JiTT lecture sessions.

The model of Integrated Course Design (see Figure 3) proposed by L. D. Fink [10] will be followed during JiTT exercises in ECE 270, which conclude three phases as depicted in the following.

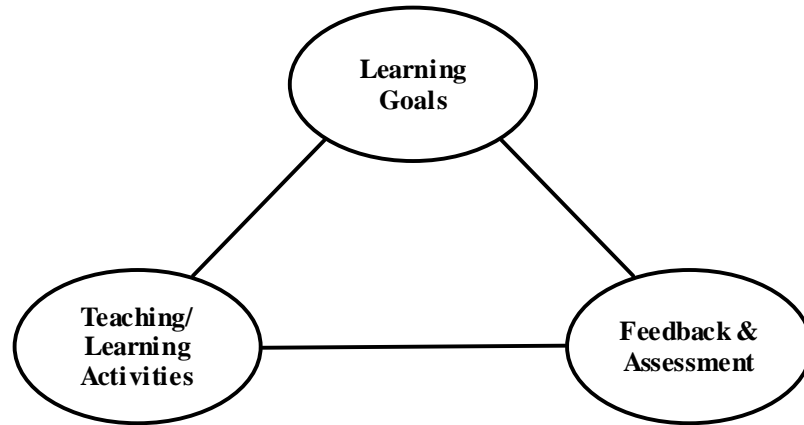


Figure 3. A Model of Integrated Course Design Proposed by L. D. Fink [10]

Weeks 1 to 5, phase 1: Topics from chapter 1 to 5 will be taught using traditional lecture/recitation format. Pre-JiTT questionnaires will be conducted at the end of phase one.

Weeks 6 to 10, phase 2: Topics from chapter 6 to 8 will be taught with JiTT exercises. Post-JiTT questionnaires will be conducted at the end of phase two. During the phase two, the instructional activities in Figure 4 will be carried, which includes students' warm-up exercise preparations, adjusted classroom teaching, project assessment with questionnaires, etc.

In-Class	Pre-JiTT Survey Conducted	In-Class, 1. Adjusted instruction 2. Group discussion	In-Class, 1. Adjusted instruction 2. Group discussion	Post-JiTT Survey  JiTT Project Assessment
Out-of-Class		1. Reading 2. Warm-up Exercise	1. Reading 2. Warm-up Exercise 3. Homework	1. Reading 2. Warm-up Exercise 3. Homework

Figure 4. JiTT-Exercise Activities

Week 11 to 13, phase 3: All data gathered from pre-JiTT, post-JiTT and interim comments will be analyzed and processed to evaluate the effectiveness of JiTT exercises. The strengths, weaknesses, and value of the project experiences will be assessed during this phase.

Results will be used to improve the quality of the program in the next semester and to ensure the faculty and students continue to see this project as a worthwhile education experience.

Besides the pre-JiTT and post-JiTT survey, the interim survey will also be conducted to assess the JiTT practice. A comment box in each warm-up exercise will be added to get students' feedback. If anything necessary is brought to the attention of the instructor, it can be corrected in a prompt approach.

Warm-up exercises will be due four or five hours before next class begins, thus it gives the instructor sufficient time to adjust the teaching materials for JiTT exercises. In the JiTT classroom practice, to facilitate some essay questions, students with different answers to warm-up questions will be divided into groups. Thus it will create a cooperative learning environment and lead to a good discussion.

This JiTT implementation plan is only preliminary and it will get updated once in practice to get it running smoothly.

### **Acknowledgement**

The mini-grant support from CELT is greatly appreciated for this project, which not only provides the faculty career development, but also introduces JiTT to Electrical and Computer engineering educational activities which has not been done nationwide. Upon the implementation of JiTT in ECE 270, the lecture sessions of the course will be enriched with problem-based classroom interactions. These interactions not only promote active learning and cognitive engagement among the students, but also support problem-solving and critical thinking activities. Because their questions and concerns are addressed in the class, students will be more motivated to learn, resulting in increased time on task and improved learning outcomes. For a cross-disciplinary course like ECE 270, the JiTT strategy will significantly transform classroom

practice from one that is teacher-centered to one that is student-centered. Classroom teaching and learning will shift from the traditional format into a student-centered learning environment. The successful implementation of JiTT will not only set up a valuable and instructive example of how innovative teaching strategies can be employed in electrical and computer engineering, but also contribute new knowledge and experience to other engineering courses at IPFW and the JiTT community at large.

An extensive proposal – Preview, Exercises, Learning, and Teaching in Digital Electronics Educations has been submitted to National Science Foundation – CCLI (Course, Curriculum, and Laboratory Improvement) program and received excellent reviews. As of today, it has been recommended for funding by NSF Division of Undergraduate Education.

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## Appendix A: JiTT Warm-Up Questions

### Chapter 6 Exclusive-OR and Exclusive-NOR Gates

- 1) Design a one-bit comparator with two inputs X and Y and one output Z.  $Z=0$  if  $X=Y$  else  $Z=1$  if  $X \neq Y$ . Please provide the truth table and write the logic equation of Z.
- 2) Such a circuit in 1) is called XOR-gate. Using one-bit comparator(s) (XOR-gate) and extra logic gates (AND, OR, INV), design and implement a four-bit comparator. Please attach your multisim screen shot in your solution in WebCT.
- 3) You'll need to send an 8-bit electronic message to your friend. Could you think of a way to check whether there could be any error during the transmission?

### Chapter 7 Arithmetic Operations and Circuits

- 1) Thinking of pen and paper method for binary division and multiplication, which operation would be faster? Why?
- 2) Design a one-bit adder with two inputs X and Y and two outputs S and Cout. S stands for Sum and Cout stands for Cout. For example, If  $X=0, Y=1$ , then  $S=1, Cout=0$ , if  $X=1$  and  $Y=1$ , then  $S=0, Cout=1$ . Please provide the truth table and logic equation for S and Cout.
- 3) Design a one-bit adder with three inputs X, Y and Cin, two outputs S and Cout. Cin stands for Carry-in. For example, if  $X=0, Y=1, Cin=1$ , then  $S=0, Cout=1$ ; If  $X=1, Y=1, Cin=1$ , then  $S=1$  and  $Cout=1$ . Please provide the truth table and logic equation for S and Cout.
- 4) Such a circuit in 2) is called half-adder and in 3) is called a full-adder. Using circuits in 2) and 3), design and implement a four-bit adder with inputs  $X(3:0)$  and  $Y(3:0)$ , with outputs  $S(3:0)$  and Cout. You may draw a simple diagram to illustrate your design. Attach the scanned picture in your solution in WebCT.
- 5) Up so far the binary number we have met are positive numbers, they are also called unsigned binary numbers. Could you please think of some methods to represent both positive and negative integers? How about representing fractions?
- 6) For an 8-bit unsigned binary numbers, what is the maximum number it can represent? What is the small number? If a number is very big, for example, 100,000; think of some methods to represent it. Could you please represent it using 8-bit ?

### Chapter 8 Code Converters, Multiplexers and Demultiplexers

- 1) Please represent the alphabet letters A,B,C,D,E,F,G,H using binary numbers. Please explain your answers and answer the following questions.
  - a) Is it necessary to encode all the letters in the same length of bits? Please explain your answer.

- b) Is it necessary to encode all the letters in the binary ascending or descending order? Please explain your answer.
  - c) Is ASCII the only representation?
- 2) Given a four-bit unsigned comparator with inputs  $X(3:0)$ ,  $Y(3:0)$  and outputs GT, LT, EQ where  $GT = 1$  if  $X > Y$  and  $LT = 1$  if  $X < Y$  and  $EQ = 1$  if  $X = Y$ . How could you compare two 8-bit binary unsigned numbers? Please describe your approach. You may provide the truth table.
  - 3) Given a four-bit unsigned comparator with inputs  $X(3:0)$ ,  $Y(3:0)$  and outputs GT, LT, EQ where  $GT = 1$  if  $X > Y$  and  $LT = 1$  if  $X < Y$  and  $EQ = 1$  if  $X = Y$ . How could you compare two 4-bit binary signed numbers? Please describe your approach. You may provide the truth table.

### Short Answer Questions

1) Introducing the idea of AND, OR operations in Boolean algebra.

Please draw at least two graphs to control a light bulb while using two switches at your home.

2) Introducing different radices.

Please give some examples of number counting in your daily life besides using decimal number system. If you can only use the number 0 and 1, can you think of a way counting the numbers from 0 to 20?

3) Introducing the new concepts of encoding and decoding in digital logic system.

Think of at least two methods to represent the alphabet letters A,B,C,D,E,F,G,H using binary numbers 0 and 1.

### Sample essay question and the classroom discussions:

**Essay question:** Please represent the alphabet letters A,B,C,D,E,F,G,H using binary numbers. Please explain your answers and answer the following questions.

- d) Is it necessary to encode all the letters in the same length of bits? Please explain your answer.
- e) Is it necessary to encode all the letters in the binary ascending or descending order? Please explain your answer.

This essay question will be used as a warm-up exercise early in the course after the binary number concept has been introduced. This is an open-ended question with answers that can lead to a good discussion in the classroom. Some possible answers are listed in the following:

- 1) Binary number representations of letters from A to H as  
A-000, B-001, C-010, D-011, E-100, F-101, G-110, H-111
- 2) ASCII code representations  
A- 1000001 (41H), B-1000010 (42H), C-1000011 (43H), D-1000100 (44H)  
E- 1000101 (45H), F-1000110 (46H), G-1000111 (47H), H-1001000 (48H)
- 3) 1-out-of-8 representations.  
A- 00000001, B-00000010, C-00000100, D-00001000  
E- 00010000, F-00100000, G-01000000, H-10000000
- 4) Other answers.

The above essay question is assigned to the students when the binary number system has just been introduced and students have learned how to represent a decimal number in binary system. The answer to this warm-up question seems very simple and straightforward. Answer one is a direct and straightforward answer. As to answer two, some students may look it up in the textbook and other reference books to find the ASCII encoding. It is also possible some students may come up with answer three or other answers. Here are some thoughts for the discussion following these answers.

### **Question 1: Is it necessary to encode all the letters in the same length of bits?**

This discussion can lead to the introduction of not-the-same-length encoding. If the probabilities of these letter appearances are different, the encoding bit length may not be the same for each symbol. Assume that the probabilities of the letter appearances are: A-0.25, B-0.2, C-0.175, D-0.125, E-0.1, F-0.075, G-0.0625, H-0.0625, the following encoding will result in the minimum entropy.

A-1, B-01, C-001, D-0001, E-00001, F-000001, G-0000000, H-00000001.

### **Question 2: Is it necessary to encode all the letters in the binary ascending order?**

The encoding of these letters isn't necessarily encoded in binary ascending or descending order. The concept of Gray encoding can be introduced here. Gray encoding is a binary encoding in which only one bit changes between each pair of successive code words. The 3-bit Gray codes are listed as:

A-000, B-001, C-011, D-010, E- 110, F-111, G-101, H-100

The concept of combinational logic circuit encoder and decoder could also be introduced in this discussion. Basically encoder and decoder perform the code conversions between these different encoding systems. In a decoder, the number of input codes is bigger than that of the outputs. For example, a 3-8 decoder is needed to convert a binary encoding in answer one to 1-out-of-8 encoding in answer three.

Vice versa, an 8-to-3 encoder can convert 1-out-of-8 encoding in answer three to a 3-bit binary encoding in answer one.

The ASCII table can also be introduced in the discussion following answer two. The American Standard Code for Information Interchange (ASCII) represents each character with a 7-bit string, yielding a total of 128 different characters. The code contains the uppercase and lowercase alphabet, numerals, punctuation, and various nonprinting control characters. It is the most commonly used character code.

