AC 2008-1237: HYBRID CONTENT DELIVERY: ON-LINE LECTURES AND INTERACTIVE LAB ASSIGNMENTS

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Hybrid Content Delivery: On-Line Lectures and Interactive Lab Assignments

Abstract

A few Purdue University Electrical and Computer Engineering faculty members adopted an experimental format for content delivery in a programming course. In the experimental format, lectures are recorded and delivered on-line. Students attend laboratory sessions and can obtain interactive and individualized assistance; each session teaches one programming tool, including version control, visual programming, creating graphical user interface. Four larger-scale programming assignments require design, implementation, and documentation. We have observed that students sometimes "get stuck" by simple programming errors (syntax or logic). Most errors are unique by individual students and difficult to generalize in a traditional lecture setting. Some students respond very positively to this approach. An on-line discussion forum is established for interaction. This hybrid format has been experimented in one sophomore and one junior course on hardware design. This paper presents the results when applying this approach to a senior-level software course. We plan to assess the learning experience of the students and compare the results with the two hardware courses many students have taken earlier.

Introduction

Since the 1990s, streaming videos through the Internet has become widely adopted for entertainment as well as education. Today's college students are familiar with this technology. Our institution started podcasting in several classes in August 2005, but many universities have not exploited using streaming videos to enhance learning experience. One objection is the belief that learning should be interactive among students and instructors.

A few Purdue University Electrical and Computer Engineering faculty members[1] started an experiment to use "hybrid content delivery" since Fall 2005. In this experiment, lecture materials are pre-recorded and delivered through streaming videos. Students watch the videos at their convenience asynchronously. In addition, students had to attend mandatory lab sessions in which students could work with the instructors and their peers to solve homework problems and the hands-on lab activities. This was called "Directed Problem Solving" (DPS) as the students solved the problems with the guidance of the instructors synchronously. This hybrid format has been offered to a sophomore-level class on digital design and a junior-level class on microcontrollers. Every semester two parallel sessions are offered: one with traditional lectures and the other with DPS. Students were encouraged to select the sessions based on their own learning styles. Since this experiment started more than two years ago, the students have now reached the senior level and a continuation of the experiment is conducted in a senior-level programming class "Object-Oriented Programming using C++ and Java".

This paper presents the organization of DPS and the comparison with the other two classes. All lectures are recorded in advance and the lecture hours are converted to "lab hours". The instructor and the teaching assistant use these hours to answer questions and help students in their programming assignments. Many of the students in this programming class took one or both DPS sessions in earlier semesters. A survey and discussion was conducted to obtain students' feedback comparing the classes and directions for improvement.

Related Work

Using videos in education has been widely discussed in literature. Videos can be viewed for live lectures (also called synchronous learning) or recorded lectures (also called asynchronous learning). Learning from videos is often called "distance learning"; the market of such learning environment was estimated to exceed $11 billion[2]. Distance learning provides flexibility in time and geographical location. Moreover, students can watch the same lecture multiple times to enhance understanding. Dougonik et al.[3] described a typical procedure and system requirements for creating videos used in distance learning. Nykvist[4] described a work-in-progress of understanding students' activities in network communities. This study was conducted in Queensland Australia to learn how students benefited from on-line communities where they could communicate, discuss, and share images or videos. Deniz and Karaca[5] presented "pedagogically enhanced video-on-demand" for synchronous and asynchronous learning describe a system for developing such education materials. Leonard et al.[6] surveyed video technologies to support education; they classified education videos into three categories: interactive, live streaming, and video on demand. The paper examines which technology is more appropriate for synchronous or asynchronous learning, or both. Nelms et al.[7] use videos as supplement of traditional lectures and office hours for providing additional examples. The videos allow students to learn the examples at their convenience and preferred pace. Codone[8] used a broad definition for "distance" in distance learning. She studied how to utilize websites as better ways to communicate and reduce the distance students feel between traditional classes and learning activities. Vicent et al.[9] compared the learning experience of two groups of students studying Electromagnetics: one group used multimedia materials and the other used textual contents. Their comparison found that multimedia could enhance learning but some other technology had negative effects; for example, virtual lab could not deliver sufficient performance due to network delays. The study by our colleagues[1] is closely related to the teaching style presented in this paper. They offered two parallel sessions, one using traditional lectures and the other using streaming video and "direct problem solving" in laboratory. The comparison was conducted on a sophomore-level course on digital systems and a junior-level course on microcontroller. They discovered no significant difference in students' performance but students strongly preferred the new teaching style.

Our work differs from previous studies in the following ways. First, all students are on campus and this course is not distance learning[2]. In fact, students are encouraged to use campus computers to watch the videos with a higher bandwidth and better quality. Second, this is a software programming course and all tools can be downloaded from the

Internet without charge. Thus, students can do all their work at home, if they prefer. This is unique because previous experiments were conducted on hardware courses[1], and students had to physically appear in the laboratory. Third, many of the students have taken the sophomore and/or the junior level hardware courses and are familiar with the new teaching style.

Class Organization

The experiment was conducted in an elective senior-level course "Object-Oriented Programming using C++ and Java". In this class, the students learned the concepts of object-oriented design and programming, including (1) class and objects, (2) inheritance and polymorphism, (3) function overriding in derived classes, (4) operator overloading in C++, (5) exception handling, (6) container classes, (7) multiple inheritance in C++, (8) graphical user interface using Netbeans and Qt[10], (9) client-server networking, and (10) multithreading. The textbook is "Programming with Objects: A Comparative Presentation of Object-Oriented Programming with C++ and Java" by Avinash C. Kak published Wiley. All lectures were recorded in advance (approximately two third had been recorded before the semester started) using Camtasia Studio. This tool performs screen capture with narration so that the instructor could show slides, websites, code, and demonstrations of program execution. There were three lecture sessions (50 minutes per session) scheduled per week.

Students had to submit four programming assignments: one in Java, one in C++, and the other two determined by the students. A decision was made to use interactive games for all assignments. The first was a Java breakout game written from scratch. The second modified the Tetrix game available from Qt's example. The third extended the first or the second assignment (chosen by the students) to two-player games. The last programming assignment was divided into two parts: design and implementation and the program had to support concurrency using either multiple threads or networking with multiple connections. In addition to the programming assignments, each student had to submit eight on-line homework assignments in WebCT; each homework contained five questions that could be automatically graded by WebCT so students could receive the correct answers with explanations immediately when they submitted. There were three midterm exams and one final exam. Exams had to be taken synchronously in a classroom. Twenty two seniors and eight are juniors enrolled in the class. Because of the smaller enrollment, only one session was offered and there was no parallel session using traditional live lectures.

Even though the class had three sessions scheduled per week, only two lecture videos were provided each week so that the students could use attend the lab during one of the three lab hours. A computer room with dual-core Linux desktops was reserved for this class during the originally scheduled lecture hours. In addition, students had access to servers, each with eight cores (two quad-core processors) when they studied multithreading. This programming class uses free software (including Java, Netbeans, Qt, Eclipse, Visual Paradigm for UML, and GNU tools). All tools are available for different platforms, such as Linux and Windows. Thus, students could learn asynchronously without any interactions with the instructor. The interactions are created by using twelve graded lab assignments that can be signed off only when a student physically appears in a computer room during lecture hours. This is fundamentally different from the two earlier classes which had hardware equipment and students had to attend the laboratory sessions.

Many demonstrations were given in the lecture videos, particularly for programming graphical user interface. The videos included some self-test questions, asking the students to pause the videos and find the answers before proceeding. Many sample programs were shown and the instructor modified the programs, executed them, and explained the differences. Each lecture was recorded and edited to remove the time waiting for compilation or programming startup delays. Even though there were only two lecture videos per week, there was no reduction of the materials. Each 50-minute lecture required approximately one hour to prepare, 70 to 90 minutes to record, and two more hours to edit the video. Only two formats—Real Player (RM) or Windows Media Player (WMV) - were supported by the streaming servers from the IT Department of our university. It took nearly two hours to generate the final videos.

Technologies and Activities

This course adopts several different technologies and activities, including

1. On-line lectures,
2. On-line video tutorials,
3. On-line homework,
4. Classroom response system,
5. On-line newsgroup, and
6. On-line chat room as one of the instructor's office hours. The instructor has two office hours in the software laboratory.
7. Working on teams

In addition, the instructor also adopts collaborative learning: During lectures, the instructor sometimes posts a question and asks the students to discuss before presenting their answers. There are usually 2 or 3 questions during a 50-minute lecture. The students are also divided into teams of 2 or 3 students for the three programming assignments. Their teammates change for each assignment.

On-Line Video Lectures and Tutorials

Two types of videos are posted on-line: tutorials of software tools and lectures. The tutorials are recorded in advance and the students can watch the videos at their convenient time. Some important portions of the videos are also shown during lectures. In this course, the students learn several programming and design tools, including Netbeans for Java programming, Eclipse for Java or C++ programming, Concurrent Version Systems (CVS), Data Display Debugger (DDD), Visual Paradigm for UML (unified modeling language). On-line videos provide a better way for the tutorials of these tools because some students already have experience using some of these tools.

Giving a live demonstration in a lecture of all these tools is too time-consuming. Since WebCT contains all course materials and students submit homework and programming assignments through WebCT, the instructor also created a video tutorial to explain how to use WebCT.

Each lecture is recorded and posted on-line. All videos are recorded using Camtasia Studio. This program records everything on the instructor's Tablet PC screen with the instructor's audio explanation. The program can generate different types of video, such as Flash, Microsoft Media Player, or Real Player. This program is used for recording, instead of a digital camcorder, because the recorded videos have much higher resolution (800×600). Meanwhile, the videos require lower bandwidth so the students can watch the videos at home with their broadband connections. The instructor uses a TabletPC so additional handwritten marks can be added to the Powerpoint slides. Even though WebCT can track students' on-line activities, the video files are too large to be stored in WebCT. Our university has a separate streaming server for storing educational videos. This server does not provide the statistics of viewing activities (how many students watch a particular video and when a video is watched).

On-Line Homework

It is well accepted that students should review the course content soon after each lecture. Cramming course materials before an examination is not an effective approach for learning. Using WebCT, the instructor created on-line homework that could be automatically graded immediately after a student submits the homework. In this semester, all questions are multiple-choice questions. In future semesters, other types of questions, such as True-False, Filling-the-Blank, Matching, or Short-Answer, may also be used. The instructor added explanations if a student makes a common mistake. In this course, each lecture is followed by one homework assignment with five multiple-choice questions. The homework must be submitted before the first lecture of the following week. A student can submit the same homework multiple times before the deadline and only the highest score is recorded. This allows the students to learn from their mistakes without waiting for the instructor or the teaching assistant to grade. It is possible that a student could submit a homework assignment without studying for the purpose of seeing the correct answer and then submit the correct answers to achieve the full score. However, the students are discouraged to do so because some homework questions are used in examinations.

Classroom Response System

In a traditional classroom, when an instructor asks the students a question, due to time constraints, only a few students can respond. Furthermore, usually the same few students respond and the other students remain silent throughout the whole semester. They do not actively participate in the lectures. In this class, every student receives one "Classroom Performance System" (CPS) from eInstruction.com in the first lecture. CPS uses wireless communication to record the response from every student during a lecture. The instructor integrates CPS with the concept of active and collaborative learning[11]. Every lecture includes 2 or 3 questions in the slides. When the instructor reaches a question slide, the instructor pauses and asks the students to discuss with the other students. After the discussion, each student can send the answer independently. This technology allows all students to answer the questions anonymously. As a result, the students do not fear embarrassed if their answers are wrong. If most students respond incorrectly, the instructor reviews the concept or asks some students to explain their answers. Even though CPS allows anonymity, the students can still speak to the whole class about their answers. CPS improves class participation but has one serious drawback: it allows only multiple-choice questions. Hence, the instructor sometimes has to design a two-phase question by using a multiple-choice question to encourage the students' participation for the subsequent discussion that cannot be written as a multiple-choice question.

On-line Newsgroup

The on-line newsgroup in WebCT is frequently used by students to post the questions and sometimes answers to other students' questions. Among 525 posted messages, the instructor posted 200 messages, including announcements (such as the average score of an exam), clarification of the programming assignments, or supplements of lecture materials (such as sample code).

On-Line Chat Room

The instructor held one evening office hour per week in an on-line chat room. However, no students used this facility in the first three weeks of the semester. Thus, the instructor canceled the on-line office hour and moved it to a "traditional" face-to-face office hour.

Survey Results

The Object–Oriented Programming course using C++ and Java is offered in the Fall semester of each academic year. This study has involved student in the Fall 2006 and Fall 2007 semesters. Students were asked to volunteer to complete a survey and participate in a focus group. The surveys had three components. The first component captured students' responses to open-ended questions about the technologies and activities. This qualitative portion sampled the highlights, challenges, frequency of usage, and helpfulness in learning. The second component evaluated the effectiveness of various technologies and activities on improving students' learning experience through the use of a Likert scale. The final component asked students to rank the various technologies and activities according to how helpfulness each was in relationship to the other technologies and activities in the class. Once students completed the surveys, a facilitator asked them to discuss the statements with the student next to them. After approximately 2-3 minutes in pairs, students were asked to elaborate on their written statements to the entire group. The responses were recorded. For this paper, the results from the second and third component will be reported. Tables 1-4 provide survey results for the second and third components for the Fall 2006 and Fall 2007 cohorts. Tables 5-8 provide the survey results for the comparison group.

Table 1. Survey Results for Object Oriented Programming Using C++ and Java, Fall 2006, First Component, (N = 16). Scale: (VE – Very effective, E – Effective, NE – No effect, SI – Somewhat ineffective, VI – Very ineffective)

Statement	VE	E	NE	SI	VI
1. Rank the effectiveness of on-line lecture in improving your learning experience.	**3**	**5**	**6**	**0**	**2**
2. Rank the effectiveness of on-line video tutorials in improving your learning.	**4**	**8**	**2**	**0**	**1**
3. Rank the effectiveness of on-line homework in improving your learning experience.	**3**	**8**	**1**	**0**	**3**
4. Rank the effectiveness of the on-line newsgroup in improving your learning experience.	**8**	**6**	**2**	**0**	**0**
5. Rank the effectiveness of the on-line office hours in improving your learning experience.	**0**	**1**	**8**	**0**	**2**
6. Rank the effectiveness of Classroom Performance System ("Clickers") in improving your learning experience.	**1**	**6**	**5**	**2**	**2**

Table 2. Survey results of ranking of each technology according to helpfulness in your learning experience for Object Oriented Programming Using C++ and Java, Fall 2006, Second Component, (N = 16). Scale: (6 – most helpful to 1 – least helpful)

Technology and Activities	Average
On-line lecture	**3.3**
On-line homework	**3.8**
On-line tutorials	**4.1**
On-line newsgroup	**4.2**
On-line office hours	**2.0**
Classroom Performance System ("Clickers")	**2.9**

Table 3. Survey Results for Object Oriented Programming Using C++ and Java, Fall 2007, First Component, (N = 27) Scale: (VE – Very effective, E – Effective, NE – No effect, SI – Somewhat ineffective, VI – Very ineffective)

Statement	VE	E	NE	SI	VI
1. Rank the effectiveness of on-line lecture in improving your learning experience.	**1**	**10**	**7**	**5**	**2**
2. Rank the effectiveness of on-line video tutorials in improving your learning.	**2**	**8**	**6**	**1**	**3**
3. Rank the effectiveness of on-line homework in improving your learning experience.	**0**	**11**	**8**	**3**	**2**
4. Rank the effectiveness of the on-line newsgroup in improving your learning experience.	**8**	**10**	**3**	**1**	**1**
5. Rank the effectiveness of the office hours and lab hours in improving your learning experience.	**3**	**11**	**7**	**2**	**1**
6. Rank the effectiveness of working in teams in improving your learning experience.	**8**	**7**	**6**	**0**	**0**

Table 4. Survey results of ranking of each technology according to helpfulness in your learning experience for Object Oriented Programming Using C++ and Java, Fall 2007, Second Component, (N = 27). Scale: (6 – most helpful to 1 – least helpful)

Technology and Activities	Average
On-line lecture	**3.5**
On-line homework	**3.4**
On-line tutorials	**3.0**
On-line newsgroup	**3.3**
Office hours and lab hours	**3.7**
Working in teams	**4.3**

Discussion

For the second component of the survey, the respondents in both cohorts rated the technologies and activities in the following categories: Very Effective (VE), Effective (E), Not Effect (NE), Somewhat Ineffective (SI), and Very Ineffective (VI). In the third component of the survey, respondents ranked each of the technologies and activities with

6 serving as the most helpful to 1 serving as the least helpful. Some of the respondents did not record a response to some of the technologies and activities.

The Fall 2006 cohort had 16 respondents. The on-line newsgroup was rated as the most effective with 14 of the 16 respondents reporting VE or E. On-line video tutorial received the next highest rating with 12 of the 16 respondents reporting VE or E. The on-line video tutorial was followed by on-line homework with 11 of 16 respondents reporting VE or E. On-line lecture, Classroom Performance System, and on-line office hours rounded out the final six technologies and activities, respectively. The effectiveness rating corresponded with to the helpfulness ranking. The ranking with their averages are as follows: on-line newgroup (4.2), on-line tutorials (4.1), on-line homework (3.8), on-line lecture (3.3), Classroom Performance System (2.9), and on-line office hours (2.0).

The Fall 2007 cohort had 27 respondents. The on-line newsgroup was rated as the most effective with 18 of the 27 respondents reporting VE or E. The on-line newsgroup was followed by working in teams with 15 of the 27 respondents. Office hours and lab hours was rated third with 14 of the 27 respondents reporting VE or E. The remaining three technologies and activities were on-line lecture and on-line homework tied with 11 respondents reporting VE or E and on-line video tutorial closely followed with 10. The rankings for this cohort were different than the ratings. The ranking with their averages are as follows: working in teams (4.3), office hours and lab hours (3.7), on-line lecture (3.5), on-line homework (3.4), on-line newsgroup (3.3), and on-line tutorials (3.0).

There were four technologies and activities that were common between the two cohorts: on-lecture, on-line video tutorials, on-line newgroups, and on-line homework. There were two distinct differences in technologies and activities between the two cohorts. In the Fall 2006 cohort, the Classroom Performance System was used and office hours were on-line. In the Fall 2007 cohort, working in teams was an activity and there were face-to-face office and lab hours.

The comparison group survey results are in Tables 5-8 in the Appendix. Results from the comparison group reveal that 33 of the 46 respondents in the Junior-Level Trial 1, Fall 2005 DPS cohort Strongly Agreed (SA) or Agreed (A) that the on-line lecture and DPS combination helped prepare them for programming exam questions. In Trial 2, Fall 2006 of the Junior-Level DPS cohort 26 of the 29 respondents either SA or A with the same statement. In the third trial of this same Junior-Level course the following Fall semester, 20 of the 31 respondents denoted SA or A to statement 4. In the Sophomore-Level trial, 23 of the 25 respondents reported that on-line lecture enhanced their learning experience.

Conclusion and Future Work

A preliminary analysis of the survey indicates that the technologies and activities selected for this course can be effective and helpful for a student's learning experience. This is evident from the results reported from the survey in Table 3 and 4. In the effectiveness category (Table 3), respondents reported an average in the range of 2.72 to 4.09 for technologies or activity. For helpfulness (Table 4), respondents reported an average in the range of 3.0 to 4.3 for the technologies or activity. From the preliminary results of the study, one might conclude that courses that present a fair amount of code would benefit from the on-line lecture and on-line tutorials. The asynchronous tools allow students to grasp an enormous amount of code at a pace that is comfortable to them.

Future studies are planned to further examine the effectiveness of these technologies and activities. Further analysis might allow us to conclude if there are statistically significant findings the quantitative portions of the survey. In the next round of analysis, the open ended questions and the additional comments section in the survey will be analyzed to provide some qualitative results. A summary of the focus group will also be provided. To further enhance the comparison portion of this study, one suggestion would be to attempt to synchronize the surveys as much as possible.

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Appendix

Table 5. Survey Results for Junior-Level Trial 1, Fall 2005 (Directed Problem Solving, N = 46). Scale: (SA – Strongly agree, A – Agree, N – Neutral, D – Disagree, SD – Strongly Disagree)

Statement	SA	A	N	D	SD
1. The on-line lecture and directed problem solving session combination helped me learn the material better.	**13**	**23**	**7**	**2**	**1**
2. The on-line lecture and directed problem solving session combination helped me prepare for the short answer and analysis questions on exams.	**7**	**27**	**7**	**4**	**1**
3. The on-line lecture and directed problem solving session combination helped me prepare for the programming questions on exams.	**16**	**17**	**10**	**3**	**0**
4. The on-line lecture and directed problem solving session combination helped me prepare for the laboratory experiments.	**9**	**25**	**11**	**1**	**0**
5. I would choose the on-line lecture and directed problem solving session combination in another ECE course (if available).	**15**	**16**	**8**	**5**	**2**
6. I would prefer only a live (traditional) lecture over the on-line lecture and directed problem solving session combination for this course.	**3**	**6**	**13**	**17**	**7**
7. I would prefer a live lecture and directed problem solving combination for this course.	**10**	**21**	**6**	**8**	**1**
8. I enjoyed learning course material in the directed problem solving format.	**11**	**28**	**7**	**0**	**0**
9. I would prefer taking other courses with the directed problem solving format.	**13**	**21**	**10**	**2**	**0**
10. The directed problem solving sessions enhanced my learning experience.	**11**	**29**	**4**	**2**	**0**
11. I enjoyed interacting with my peers during the directed problem solving sessions.	**10**	**24**	**10**	**2**	**0**
12. I feel that most of the other students enjoyed learning in the directed problem solving format.	**8**	**28**	**10**	**0**	**0**
13. The on-line lecture enhanced my learning experience.	**6**	**21**	**13**	**5**	**1**
14. The on-line lecture prepared me for the directed problem solving sessions.	**3**	**26**	**14**	**3**	**0**
15. I viewed the on-line lecture before participating in the directed problem solving sessions.	**4**	**18**	**17**	**5**	**2**

Table 6. Survey Results for Junior-Level Trial 2, Spring 2006 (Directed Problem Solving, N = 29). Scale: (SA – Strongly agree, A – Agree, N – Neutral, D – Disagree, SD – Strongly Disagree)

Statement	SA	A	N	D	SD
1. The on-line lecture and directed problem solving session combination helped me learn the material better.	**10**	**17**	**1**	**0**	**1**
2. The on-line lecture and directed problem solving session combination helped me prepare for the short answer and analysis questions on exams.	**0**	**14**	**5**	**7**	**3**
3. The on-line lecture and directed problem solving session combination helped me prepare for the programming questions on exams.	**14**	**9**	**5**	**0**	**1**
4. The on-line lecture and directed problem solving session combination helped me prepare for the laboratory experiments.	**14**	**12**	**2**	**0**	**1**
5. I would choose the on-line lecture and directed problem solving session combination in another ECE course (if available).	**10**	**13**	**3**	**2**	**1**
6. I would prefer only a live (traditional) lecture over the on-line lecture and directed problem solving session combination for this course.	**1**	**2**	**5**	**12**	**9**
7. I would prefer a live lecture and directed problem solving combination for this course.	**11**	**7**	**7**	**3**	**1**
8. I enjoyed learning course material in the directed problem solving format.	**8**	**15**	**5**	**0**	**1**
9. I would prefer taking other courses with the directed problem solving format.	**7**	**16**	**5**	**1**	**0**
10. The directed problem solving sessions enhanced my learning experience.	**10**	**14**	**4**	**1**	**0**
11. I enjoyed interacting with my peers during the directed problem solving sessions.	**12**	**12**	**4**	**1**	**0**
12. I feel that most of the other students enjoyed learning in the directed problem solving format.	**2**	**16**	**11**	**0**	**0**
13. The on-line lecture enhanced my learning experience.	**6**	**11**	**7**	**4**	**1**
14. The on-line lecture prepared me for the directed problem solving sessions.	**2**	**16**	**6**	**4**	**1**
15. I viewed the on-line lecture before participating in the directed problem solving sessions.	**9**	**13**	**4**	**3**	**0**

Table 7. Survey Results for Junior-Level Trial 3, Fall 2006 (Directed Problem Solving, N = 31). Scale: (SA – Strongly agree, A – Agree, N – Neutral, D – Disagree, SD – Strongly Disagree)

Statement	SA	A	N	D	SD
1. The on-line lecture and directed problem solving session combination helped me learn the material better.	**8**	**17**	**2**	**4**	**0**
2. The on-line lecture and directed problem solving session combination helped me prepare for the short answer and analysis questions on exams.	**8**	**13**	**6**	**3**	**1**
3. The on-line lecture and directed problem solving session combination helped me prepare for the programming questions on exams.	**7**	**12**	**5**	**7**	**0**
4. The on-line lecture and directed problem solving session combination helped me prepare for the laboratory experiments.	**9**	**11**	**7**	**4**	**0**
5. I would choose the on-line lecture and directed problem solving session combination in another ECE course (if available).	**8**	**16**	**1**	**5**	**1**
6. I would prefer only a live (traditional) lecture over the on-line lecture and directed problem solving session combination for this course.	**2**	**4**	**4**	**16**	**5**
7. I would prefer a live lecture and directed problem solving combination for this course.	**7**	**13**	**4**	**6**	**1**
8. I enjoyed learning course material in the directed problem solving format.	**5**	**16**	**4**	**3**	**1**
9. I would prefer taking other courses with the directed problem solving format.	**3**	**18**	**5**	**1**	**2**
10. The directed problem solving sessions enhanced my learning experience.	**7**	**17**	**4**	**2**	**1**
11. I enjoyed interacting with my peers during the directed problem solving sessions.	**8**	**15**	**6**	**2**	**0**
12. I feel that most of the other students enjoyed learning in the directed problem solving format.	**3**	**16**	**11**	**1**	**0**
13. The on-line lecture enhanced my learning experience.	**6**	**16**	**5**	**2**	**2**
14. The on-line lecture prepared me for the directed problem solving sessions.	**4**	**17**	**6**	**3**	**1**
15. I viewed the on-line lecture before participating in the directed problem solving sessions.	**9**	**12**	**6**	**2**	**1**

Table 8. Survey Results for Sophomore-Level Trial, Fall 2006 (Directed Problem Solving, N = 25). Scale: (SA – Strongly agree, A – Agree, N – Neutral, D – Disagree, SD – Strongly Disagree)

Statement	SA	A	N	D	SD
1. The on-line lecture and directed problem solving session combination helped me learn the material better.	**12**	**12**	**0**	**1**	**0**
2. The on-line lecture and directed problem solving session combination helped me prepare for the short answer (concept) questions on exams.	**7**	**13**	**5**	**0**	**0**
3. The on-line lecture and directed problem solving session combination helped me prepare for the written (application) questions on exams.	**13**	**9**	**3**	**0**	**0**
4. The on-line lecture and directed problem solving session combination helped me prepare for the laboratory experiments.	**11**	**10**	**3**	**0**	**0**
5. I would choose the on-line lecture and directed problem solving session combination in another ECE course (if available).	**15**	**9**	**1**	**0**	**0**
6. I would prefer only a live (traditional) lecture over the on-line lecture and directed problem solving session combination for this course.	**1**	**2**	**2**	**12**	**8**
7. The Index of Learning Styles Survey helped me choose the course format best for me.	**1**	**13**	**6**	**4**	**1**
8. I enjoyed learning course material in the directed problem solving format.	**10**	**13**	**0**	**1**	**0**
9. Having a choice of course delivery options enhanced my ability to learn.	**9**	**12**	**2**	**1**	**0**
10. The directed problem solving sessions enhanced my learning experience.	**10**	**14**	**9**	**0**	**1**
11. I enjoyed interacting with my peers during the directed problem solving sessions.	**12**	**8**	**3**	**2**	**0**
12. I feel that most of the other students enjoyed learning in the directed problem solving format.	**5**	**16**	**4**	**0**	**0**
13. The on-line lecture enhanced my learning experience.	**13**	**10**	**1**	**1**	**0**
14. The on-line lecture prepared me for the directed problem solving sessions.	**13**	**9**	**3**	**0**	**0**
15. I viewed the on-line lecture before participating in the directed problem solving sessions.	**5**	**11**	**6**	**3**	**0**