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Design and Development of a Hybrid Instructional Model for a Computer Engineering Course

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Abstract

This paper describes our experiences in applying a hybrid instructional model to a newly developed computer engineering course at UW–Stout, which includes the delivery of online lectures through streaming videos combined with bi-weekly in-class lectures as well as hands-on laboratory exercises related to the course material. The design of this curriculum follows a framework that was developed to fulfill the course requirements. In addition to traditional class settings, the course also implements a team project which has several reporting components to monitor students' learning progress. Multiple in-class surveys were conducted throughout the semester to obtain course feedback from the students. The instructor also constantly solicited and collected student comments about the course during the semester. This study reports the survey data collected from the class and discusses how the data help design and develop the course. It makes recommendations to improve future courses when applying a similar hybrid instructional model.

Introduction

Engineering education plays an essential role in preparing students to innovate advanced technologies in the future. New course design and development are part of the strategic plan to help students advance their learning goal while in school. In order to effectively deliver course content covering a broad range of topics and facilitate interactive learning activities, engineering courses have been traditionally delivered in classroom settings until recent years when Internet technologies have become an integral part of the higher education systems[1]. Internet technologies have had a significant impact on the recent development of engineering education system[2]. In recent years, many institutions have deployed numerous online courses. Some of these online courses completely replace the need for traditionally in classroom courses. While these online courses provide flexible scheduling and different learning experiences to engineering students, they generally lack the required interactive activities and precious face-to-face time between the course instructor and students. Meanwhile, the growth of computer engineering student enrollments coupled with budgetary constraints is challenging institutions to effectively serve their students. Furthermore, the economic reasons cause the universities to consider supplementing departmental personnel resources with part-time adjunct instructors in order to alleviate the excessive academic workload required of the full-time professors. For

computer engineering programs, it is highly desirable to recruit adjunct instructors from nearby engineering communities. These instructors not only bring real-world experiences to the classroom but also enable students develop the technical skills they will need to address future challenges. However, the adjunct instructors from the industry typically have full-time commitments elsewhere and often find it difficult to accommodate typical in-classroom course schedules.

This paper describes the design and development of a hybrid instructional model which was used to fulfill the curriculum requirements of a core engineering course in the computer engineering program at the University of Wisconsin – Stout (UW–Stout). By using this unique hybrid instructional model, the computer engineering program was able to accommodate the demanding work schedule of the adjunct instructor while meeting the learning needs of the students. This research study uses the term *hybrid* to denote the mixing of online course delivery and in-classroom interactive activities. In this hybrid instructional model, the instructional time traditionally spent in the classroom setting is greatly reduced and replaced with online learning activities. The majority of the course content was delivered through online streaming videos supplemented by in-class question-and-answer sessions, continuation of new lectures, hands-on lab exercises, and team project discussions. The hybrid instructional model combines the benefits accrued from the schedule flexibility of online courses while preserving the instructor-student face-to-face time provided in classroom lectures.

Course Development

The course curriculum was designed to provide an introduction to fundamental concepts in the field of computer networks. The design of the curriculum follows the framework shown in Figure 1. In this research study, a *hybrid* instructional model was specifically developed to teach an upper-division undergraduate computer engineering course, CEE 425 *Data Communications and Computer Networking*, at UW–Stout. The objectives of this instructional model aim to enable engineering students in understanding, evaluating, designing, and implementing computer networks. While this class had been a popular course in many engineering programs from other institutions, the class was taught for the first time in the newly developed computer program at UW–Stout[3]. The course instructor was recruited from the engineering industry to design and develop this course for the engineering and technology department. The course primarily targets toward undergraduate upper-division engineering students in learning the topics of data communications and computer networks.

The course provides an introduction to fundamental concepts in the design and implementation of computer communication networks, their protocols, and the associated applications. The course content covers the key theoretical concepts in computer networks shown in Table I. The class has a unique schedule arrangement which consists of weekly two-hour online streaming video sessions to be completed by each student and bi-weekly four-hour in-classroom sessions. Random quizzes were assigned to motivate students to stay on track in completing online videos as well as assessing their basic understanding of the new concepts introduced weekly. These learned concepts are further enforced by homework assignments, hands-on lab exercises in the classroom setting, and a semester-long team project.

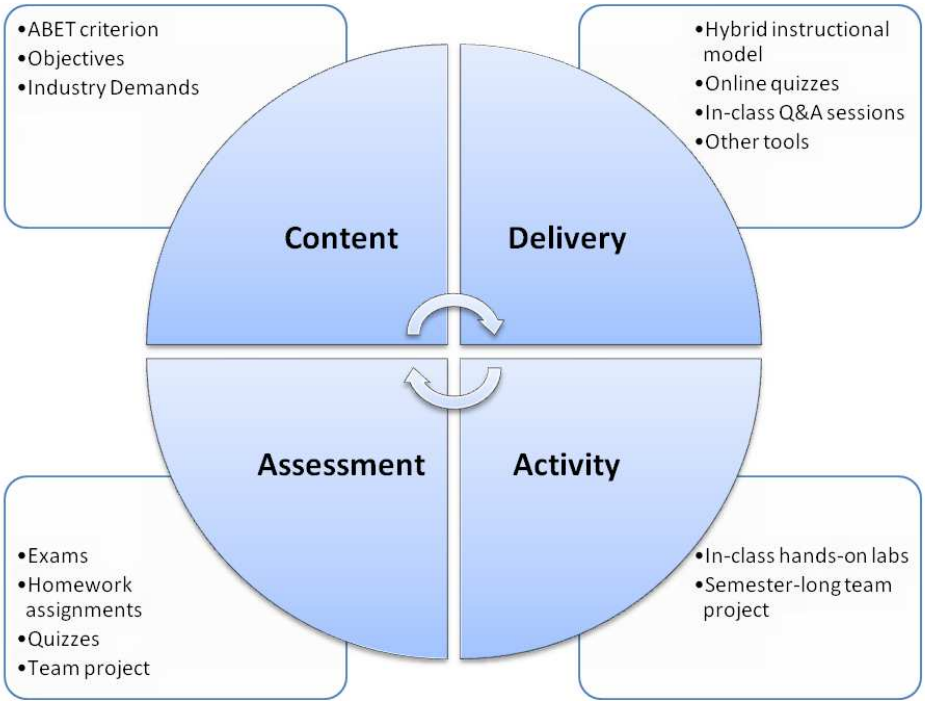

Figure 1. Framework for the design of the curriculum

Table I. Course Topics[4]

1. Introduction to Internet ° Circuit Switching vs. Packet Switching ° Basic Network Performance Metrics ° OSI/Internet Model	**6. Wireless and Mobile Network** ° Wireless Protocol Overview ° CDMA ° CSMA/CA
2. Application Layer ° HTTP, FTP, DNS, SMTP ° Socket Programming Concepts*	**7. Multimedia Networking** ° SIP ° Quality of Service (QoS)
3. Transport Layer ° Reliable Data Transfer ° TCP, UDP* ° Flow/Congestion Control	**8. Network Security** ° Principles of Network Security ° IPSec, SSL, VPN
4. Network Layer ° Routing Principles (LS, DV)* ° Routing Algorithms (RIP, OSPF, BGP) ° Internet Protocol (IP)	**9. Network Management** ° SNMP Operations* ° Management Information Base ° Network Management Systems
5. Data Link Layer ° Error Detection/Correction* ° Multiple Access Protocols* ° MAC, Ethernet, LAN Switches, VLAN	**Topics discussed in the classroom*

The hands-on lab exercises provide great opportunities for students to interact with the course instructor and to ask about the theoretical concepts introduced in the lectures. Furthermore, the instructor leveraged the in-classroom time to review problem-solving homework assignments and to prepare students for exams. Most importantly, the hybrid instructional model also includes a project-based component by requiring a semester-long team project. In the team project, the class is divided into several groups, each group consisting of 2~3 students. It was the intent of the course instructor to allow each team to choose a project which was related to the student's interest. The only requirement for selecting a project was that it must be related to the field of computer networks. This setup serves two purposes: (i) to encourage student creativity, and (ii) to simulate the real-world environment which will help prepare students for future careers in engineering fields. The team project attempts to simulate a real-world engineering project which is somewhat dynamic such that re-defining problems and re-planning resources are often required.

Course Feedback

For this research study, survey data were collected from CEE425 class during the Fall 2012 semester. Some of the survey data were collected from questionnaires while others were gathered from class discussions. Three structured surveys were conducted at the beginning, after the midterm exam, and at the end of the semester, respectively[5]. Student comments from class discussions were also collected throughout the semester to help the instructor enhance and adjust the delivery of course content as needed. Instructor's comments on the team project are also provided.

Data from Questionnaires to Students

Derived from the survey, plots in Figure 2(a)–2(f) provide results on how students rate the questions asked (shown above each plot). In general, students agreed with how the instructor structured and paced the course to provide sufficient time for completing each learning activity of the class, such as online quizzes, lab exercises, homework assignments, and the team project. It is very interesting to observe from Figure 2(d), many students indicated that insufficient instructions were provided for the team project. It shows disparities between teaching and learning goals in this course and, perhaps, other engineering courses in general, because this was the intent of the course instructor to motivate student creativity by providing an open-ended learning opportunity.

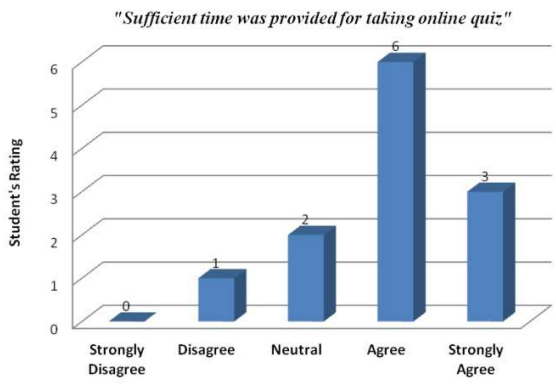

Figure 2 (a)

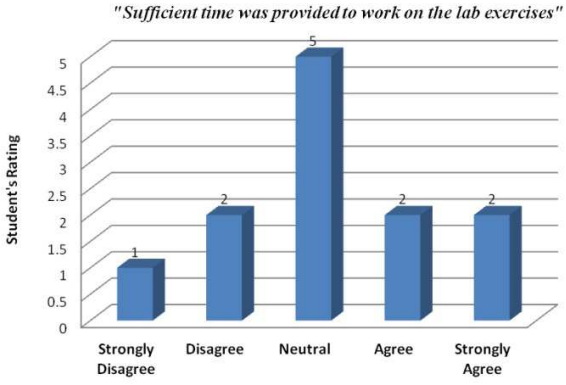

Figure 2 (b)

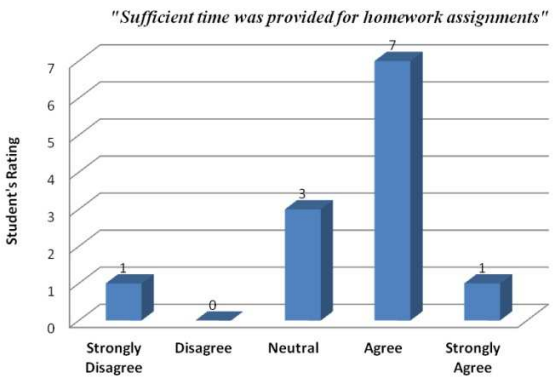

Figure 2 (c)

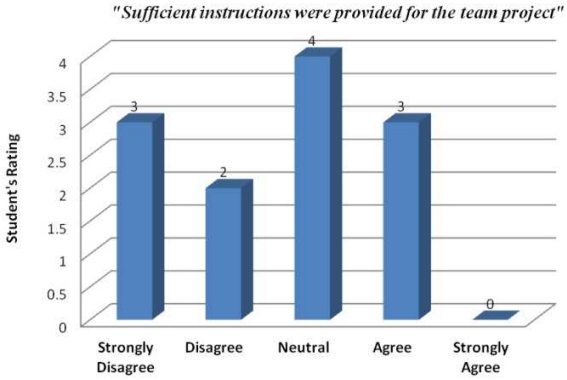

Figure 2 (d)

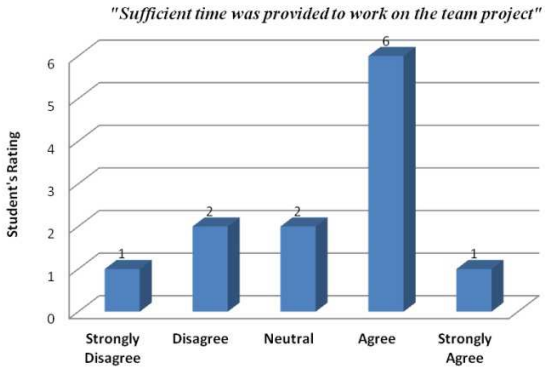

Figure 2 (e)

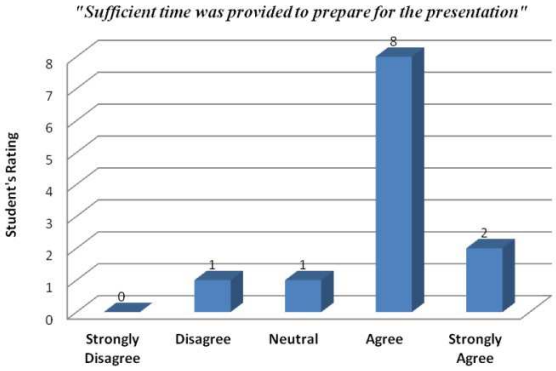

Figure 2 (f)

Figure 2. Students' feedback for the questions asked

Figure 3 provides student ratings of the team project with statements shown in Table II. In the team project evaluation, the entire class indicated that the team project enhanced their learning experiences in computer networks. Students were able to grasp theoretical concepts learned from working on the team project.

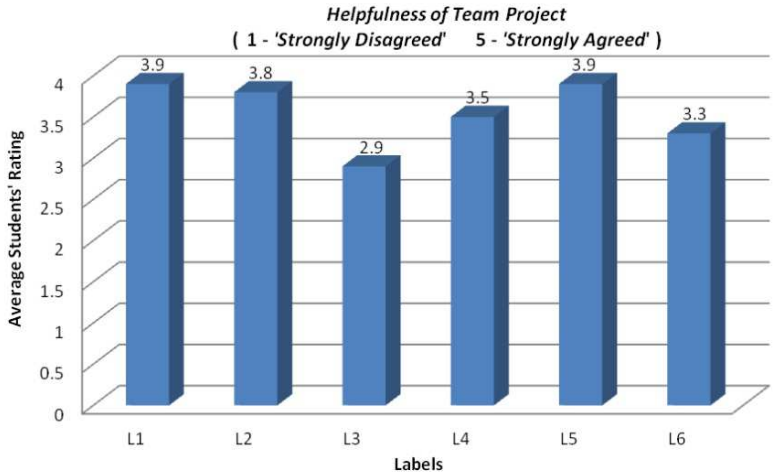

Figure 3. Students' rating of the team project

Table II. Survey Questions shown in Figure 3.

Label	Survey Question
L1	The team project helps me improve my team work skills.
L2	The team project helps me improve my communication skills.
L3	The team project helps me relate what we've learned in the classroom to the real world.
L4	The team project strengthened my conceptual understanding of the course content.
L5	The team project helps me improve my problem solving skills.
L6	The team project helps me appreciate group learning.

Data from Class Discussions

Students provided valuable comments in regard to each course component as shown in Table III. These "just-in-time" comments about the on-going course were significant inputs provided throughout the semester, which helped the course instructor improve the curriculum to meet the learning demands from students continuously.

Table III. Students' comments on each course component

Course Component	Objectives	Comments from Students
Online Videos	Promote self-learning from students	Suggested to rearrange the length of the videos into multiple shorter videos instead of having a single lengthy video.
Quizzes	Motivate students to keep up their learning progress from online videos.	Suggested to reduce the type of questions that require memorization from the online videos.
Homework Assignments	Develop problem solving skill set	Suggested to increase practice time during in-classroom time.
Laboratory Assignments	Develop application skills for learned concepts	Suggested that the instructor should elaborate more technical details about each lab exercises.
Exams	Enhance problem solving skill set	Recognized the exams were mostly from homework assignments, but viewed exams to be difficult.
Team Project	Simulate real world environment	Rated positively for every component of the team project (see Figure 3).

Data from Instructor's Comments (Team Project Only)

Table IV shows the instructor's assessment of student learning outcomes based on the team project. In general students were at first overwhelmed with the intent of the semester-long project due to their initial lack of knowledge of computer networks. The situation seemed to improve as more course content was delivered and students became more familiar with the subject area. While the students' feedbacks about the team project were fairly positive, the quality of the team project deliverables differed dramatically. Some teams were able to complete and meet the project objectives while others failed to do so.

Table IV. Instructor's assessment of students' learning outcomes

Project Deliverables	**Objectives**	**Instructor's assessment of students' learning outcomes**
Pre-proposal Report (Group, individual contributions Plan noted)	Assesses students' creativities in selecting project topics and awareness of current issues in computer networks.	Most of teams selected reasonable project topic to be completed during the semester.
Proposal Report (Each Student)	Assesses preliminary technical approach to the project topic selected.	Most of teams failed to provide technical approach at this stage.
Progress Report (Each Student)	Provides mid-semester project status report.	All teams provided accurate status report. Some teams were clearly behind the schedule at this stage.
Project Presentation (Group, each student must participate)	Provides opportunity for each team member to present their efforts. Demonstrates organizational skills and team efforts.	Contents of the presentation provided distinction between each individual's assigned efforts.
Final Report (Group, individual contributions noted)	Assesses students' abilities as a team to complete the assigned project tasks.	Students require more instructions and/or directions to deliver better final reports.

Conclusion

This paper describes an innovative course development based on a hybrid instructional model using the framework described above. The course feedback is provided to assess the effectiveness of the designed course and improve the development of the course. While there were concerns regarding the lack of on-campus support from the instructor, student comments toward the learning experiences in this course were well received. The design of the curriculum fulfills the requirements similar to traditional in-classroom settings. The course also includes a semester-long team project, which not only developed technical skill sets but also teamwork ability, communications as well as leadership skills. A majority of the students commented positively on the benefits and learning experiences of working on their respective team project. The survey data and students' comments collectively serve as valuable input on how to improve future course offerings in computer networks that apply the hybrid instructional model.

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