Comparison of Hybrid vs. Traditional Pedagogical Approach in a Computer Engineering Course

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***Abstract*— This paper compares student learning outcomes from two different pedagogical approaches: hybrid vs. traditional in-classroom teaching method. The study applies a previously developed framework in order to assess the learned curriculum for the same upper division computer engineering course. It also analyzes how it is aligned with the intended curriculum. The same computer engineering course was taught by two different instructors during two different semesters. Both instructors are considered subject matter experts and have extensive technical background as well as many years of practical engineering experiences. Both classes employed the same textbook, delivered similar set of course topics, required similar homework and laboratory assignments as well as including a semester-long team project. A key difference is the use of online lectures. Based on students' survey responses and final grade results, this study compares their development in content knowledge and cognitive abilities to determine the effectiveness of each pedagogical approach. The study provides an interest in finding ways to truly utilize Internet technology to improve student learning, particularly their development of cognitive abilities. The study also seeks the impact of the Internet technology on lecturing styles and in-classroom dynamics. Furthermore, this study helps gaining insights into pedagogical approaches concerning teaching and learning along the technological dimension.**

Index Terms—Computer Networks, Engineering Education, Instructional Model, Hybrid, Pedagogical Approach

Introduction

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 system [1]. Internet technologies play a significant role in the recent development of engineering education. By leveraging the benefits of online training and traditional in-classroom training, hybrid instructional approaches have gained increasing support for various reasons [2]. Proponents seize the opportunity to effectively integrate live classroom activities with online learning and instructions in order to maximize teaching and learning potential. The setup enables students to learn course content ahead prior to attending the class in-person. This also allows the course instructors to efficiently control over time, place, and pace. Several challenges remain in such course settings. In a previous study [3], the authors had applied a framework to examine the level of fidelity of implementation of a hybrid instructional model for an upper division computer engineering course. The framework includes three components of Intended Curriculum, Implemented Curriculum, and Learned Curriculum. The study identified the driving forces behind the intended curriculum, including needs of society and workforce development, rapid advancement of content topics, and values and beliefs of the subject area. The study recognized factors that influence the implemented curriculum, which encompass instructors' pedagogical and content knowledge as well as their perceived student needs. Factors such as limited availability of the instructor and intellectual openness of students' can be constraints for the curriculum implementation. The current study primarily compares the outcomes between the two types of teaching methods.

I. Methodology

A. Curriculum Development

The curriculum for the computer engineering course was previously designed when the course was first introduced to the computer engineering program [4][4][2]. The course curriculum provides an introduction to fundamental concepts in the field of data communications and computer networks [5]. Survey questions designed and responses collected for this study were based on an upper division undergraduate computer engineering course, *CEE-425 Data Communications and Computer Networking*, at University of Wisconsin—Stout. The course provides an introduction to fundamental concepts in the design and implementation of data communication networks, their protocols, and the associated applications. The lecture materials are based on examples primarily from modern Internet technologies. The objectives of this course aim to enable engineering students in understanding, evaluating, designing and implementation of computer networks. Derived from the course syllabus which is based on a computer networks textbook [5], the course content covers a list of topics shown in Table I.

B. Pedagogical Approaches

The hybrid method was initially designed to accommodate a part-time adjunct instructor recruited from the industry due to University's budgetary constraints [3]. The course setup for the hybrid method was previously described in other studies [3][4]. In the hybrid method, the students receive most of lecture materials online, then the class is met once every two week for in-class discussions and hands-on labs. In the traditional in-classroom method, the class is an instructor led which held regularly twice a week. The course was first developed and taught in Fall 2012 semester using hybrid method and in Fall 2013 semester using traditional in-classroom method. While the course was taught by two different adjunct instructors, they both have similar technical background in the computer networking field.

Table I. Computer Networks Course Topics [5]

Introduction to Internet ◦ Circuit Switching vs. Packet Switching ◦ Basic Network Performance Metrics ◦ OSI/Internet Model	**Data Link Layer** ◦ Error Detection/Correction ◦ Multiple Access Protocols ◦ MAC, Ethernet, LAN Switches, VLAN
Application Layer ◦ HTTP, FTP, DNS, SMTP ◦ Socket Programming Concepts	**Wireless Network** ◦ Wireless Protocol Overview ◦ CSMA/CA
Transport Layer ◦ Reliable Data Transfer ◦ TCP, UDP ◦ Flow/Congestion Control	**Multimedia Networking** ◦ Quality of Service (QoS) ◦ Session Initiation Protocol
Network Layer ◦ Routing Principles (LS, DV) ◦ Routing Algorithms (RIP, OSPF, BGP) ◦ Internet Protocol (IP)	**Network Management** ◦ SNMP Operations ◦ Management Information Base ◦ Network Management Systems

The course structure, lecture materials, assignments, and project topics are very similar between two different semesters. Furthermore, the course grading criteria are identical between two different pedagogical approaches. Table *II* shows the course grading criteria from the course syllabus.

Table II. Course Grading Criteria

Homework	15%
Lab	15%
Midterm Exam #1	20%
Midterm Exam #2	20%
Final Exam	30%

II. Results and Assessment

The outcomes of the study are presented herein by comparing the two teaching methods based on the survey data collected and final grade results. Survey questions were identical and same method of collecting the survey data was administrated between the two classes. Table *III* describes the first set of the survey questions. Comparisons of the results are shown in Figure 1. While both classes received good overall ratings (*i.e.* > 3 or better, except for P3 question) in all survey questions, the results indicated that traditional in-classroom method appears to be more favored by the group of computer engineering students. Collected survey data were insufficient to further analyze the gap illustrated in P3 question.

Table III. Questionnaires for Pedological Approaches

Label	Question
P1	The instructor makes students aware of the content and skills to be learned in the course.
P2	The instructor understands students' learning difficulties in this class.
P3	The instructor uses various techniques to teach new and difficult concepts.
P4	The instructor provides adequate instructions and encourages students to explore their own ways of learning
P5	The instructor makes the course content interesting to learn.
P6	The instructor demonstrates willingness to help students' learning.

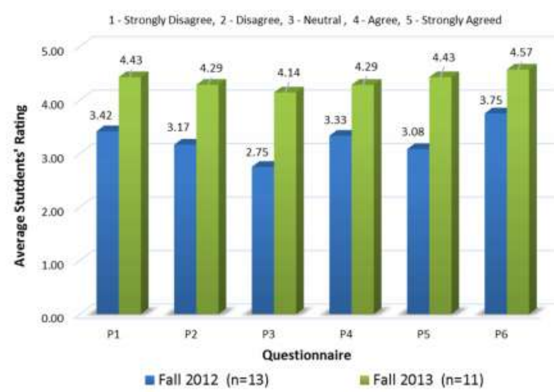

Figure 1. Students' Rating for Different Pedological Approaches

Table *IV* describes the second set of survey questions. Comparisons of the results are shown in Figure 2. In the team project evaluation, both classes indicated that team project did enhance their learning experiences in the field of data communications and computer networks. The ratings from both classes are mostly correlated to each other (*i.e.* < 0.5 between the two values, except for Q3 question). The correlation reflects that students were able to grasp theoretical concepts learned from working on the team project, independent of how each instructional method took place. The large gap in Q3 question could be related to students not fully grasp theoretical concepts before starting to work on the team project in the hybrid instructional method. More analysis may be required to provide more insights.

Table IV. Questionnaires for Team Project

Label	Question
Q1	The team project helps me improve my team work skills.
Q2	The team project helps me improve my communication skills.
Q3	The team project helps me relate what we've learned in the classroom to the real world.
Q4	The team project strengthened my conceptual understanding of the course content.
Q5	The team project helps me improve my problem-solving skills.
Q6	The project helps me appreciate group learning.

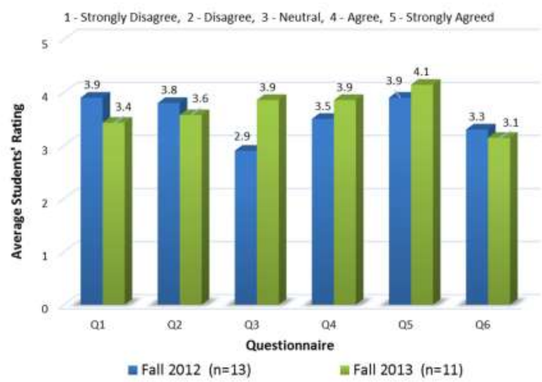

Figure 2. Students' Rating of the Team Project

Figure 3 compares the final letter grade distribution between the two classes. It needs to be pointed out that the failing grade in Fall 2012 was an outlier in the data set since it was assigned to a special case, where a particular student decided not to show up to the class after few weeks into the semester. The student also did not drop the class either. In general, students from both classes performed reasonably well (*i.e.* B or better). This also illustrates that students are able to perform reasonably well independent of the two pedagogical approaches.

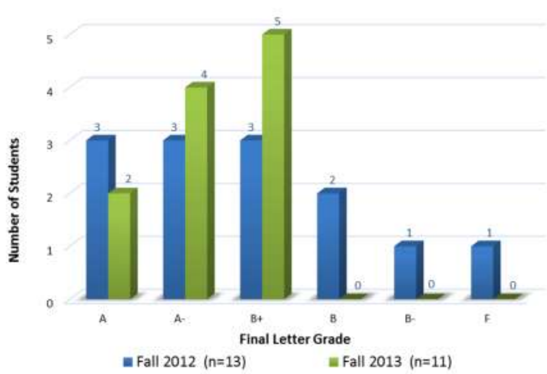

Figure 3. Comparison of Students Final Grades

Figure *4* illustrates the learning outcomes from two pedagogical approaches based on survey questions shown in Table *V*. It is interesting to see that two different groups of students have different perspectives on the learning outcomes for concepts R4, R5, R6, R9, R12, and R14 (*i.e.* > 3 difference). Since the course content is nearly identical, different instructional styles between two different instructors may contributed to students' learning outcomes.

Table V. Questionnaires for Learning Outcomes

Question: "*Please tell us what you have learned in this course. Choose all that apply:*"

Label	Concepts Learned
R1	Fundamental concepts in data communications and computer networks
R2	Fundamental computer algorithms and how they are applied to computer networks
R3	Math representations in computer science and computer engineering
R4	Basic data structure principles applied to compute networks
R5	Data manipulations in computers
R6	Modular design for partitioning a system into components
R7	Computer system architecture and its organization
R8	Underlying physics of signals and data communications
R9	Understanding usage of tools to diagnose network problems
R10	Computer network topology
R11	Computer networking terminology
R12	Devices used in the computer networks and their functions
R13	OSI network layers vs. Internet layers
R14	Fundamental concepts in wireless networks
R15	Fundamental concepts in network management

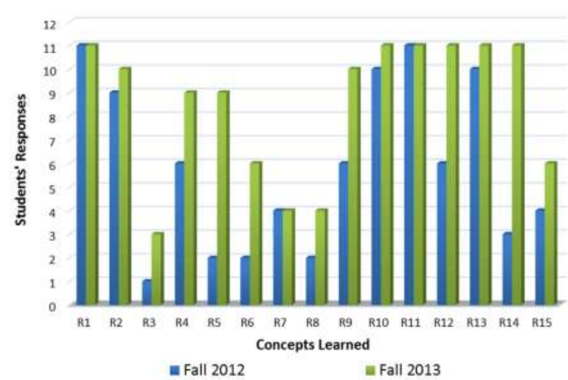

Figure 4. Comparison of Learning Outcomes

III. Conclusion

This paper compares hybrid and traditional pedagogical approach based on a computer engineering course (*i.e.* computer networks). The course feedback is compared to assess the effectiveness of the designed course and improve the development of the course. The design of the hybrid method does fulfill similar requirements to the traditional in-classroom settings.

The study showed that students from both classes perform reasonably well. However, students still prefer traditional instructional method over the hybrid method.

While we strongly believe that blending learning of a hybrid instructional model for computer engineering courses is a natural way to merge the implemented and learned curriculum into the intended curriculum, we find that if learning activity is not carefully planned, students may not be as interested in the hybrid instructional method. The transition from traditional instructional method to hybrid or completely online method needs to be carefully planned in the future.

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