AC 2008-1710: DIFFERENCES IN TEACHING AND LEARNING OUTCOMES IN FACE-TO-FACE, ONLINE AND HYBRID MODES OF ENERGY CONSERVATION COURSE

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Differences in Teaching and Learning Outcomes in face-to-face, Online and Hybrid Modes of Energy and Environment Courses

Abstract

The Energy Conservation and Environmental Protection (EGEE 102) course has been offered at The Pennsylvania State University since the fall of 2001 as a face to face class to over 6,000 students. This course was later developed as an online course under the University's "Courseware Initiative" and has been offered to approximately 400-600 students each semester since fall 2005. Online content significantly engaged students through Flash animations, enabling students to learn concepts through automated interactivity. Under "Blended Learning Initiative" of The Pennsylvania State University, this course was also selected and adapted for hybrid learning and teaching in spring of 2006. This class meets once a week face-to-face, and the rest of the interaction is online. . The same instructor taught this course in each of the three modes: face to face, online, and hybrid The goal of this blended method is to combine the best of both face-to-face and online modes and was offered for the first time in spring of 2007 to about 100 students. In fall 2007, it was offered to 130 students.

This paper discusses the learning experiences, performance differences, and feedback from the students in all three modes. The results showed that the average quiz scores for online and face-to-face sections were identical. Students in the Hybrid section scored slightly higher (2.8%) than those in the online and face-to-face sections. The average scores for the midterm and the final exams for all sections were almost similar, indicating no significant differences in performance. The perceptions of the students about the courses, however proved definite differences-despite similar academic performances. A greater number of students in the online and Hybrid sections felt that the course was challenging compared to the face-to-face class. In addition, more Online and Hybrid students felt that the course was "medium difficulty" and/or "heavy load" compared to face-to-face students. The results also suggest that the online students felt that they were learning on their own and the instructor's role ~~is~~ was less significant in their learning process. The data clearly show that, as a result of taking this course, the interest in energy conservation and environmental protection has grown in all of the students, irrespective of the format or learning mode that was used.

Introduction

The amalgamation of technologically advanced students and widespread availability of high speed internet use has generated an explosive increase in the online courses in the last 15 years. The number of online courses offered increased almost five fold (from 26,000 to 127,000 courses) between 1995 and 2001[1]. There is also an increasing trend in the number of hybrid or blended learning courses. Studies have shown that students who engage in online learning perform-as well as students in a face-to face environment[2]. However, literature comparing all three formats (Online, Hybrid and traditional face-to-face) is scarce.

Objective of this Study

The objective of this study is to examine the students' learning experiences, performance differences, feedback in all three modes (online, hybrid and face-to-face). The uniqueness of this study is that the same instructor developed the materials and provided instruction for all three modes.

Methodology

The Department of Energy and Mineral Engineering initiated a drive to promote energy education to the general student population of the University. Two energy-related courses were developed in 2001: Energy and the Environment (EGEE 101) and Energy Conservation and Environmental Protection (EGEE 102.) This paper mainly describes the results from the Energy Conservation and Environmental Protection course. The main objectives of this course are to provide basic understanding and appreciation of energy efficiency and environmental concepts, to educate students on the basic operating principles of day-to-day energy conversion devices, to discuss various options to increase energy efficiency, to examine ways to save energy and money, and to explore approaches to maintain and protect the environment**.**
There is a prescribed text book for this course [3]. Most of the reference materials and lecture slides are posted on the web and are delivered via the course management program: A New Global Learning Environment (ANGEL). ANGEL was developed by Cyber Learning and was adopted as the course management system by The Pennsylvania State University.

Instructional Design

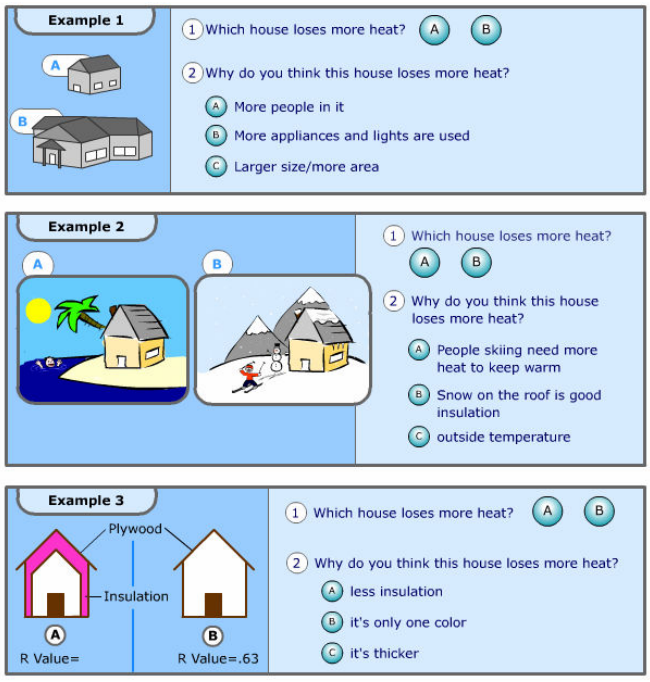

Figure 1. A screen shot of interactive activity to teach heat transfer.

The face-to-face sections of this course have been popular due to the warmth, enthusiasm, and humor of the instructor. Thus, reduced student motivation was a major concern when converting this course from a face-to-face environment to a totally online environment; the students would no longer be benefiting from the instructor's immediacy behaviors[4]. To overcome this obstacle, the instructor's presence and personality were included in the course through a caricature that appeared periodically in the online lessons; simulations and audio explanations were also incorporated. The caricature was not stagnant or one-dimensional by any means; rather, he was dressed in different outfits, placed in various situations, and he often used dialogue bubbles to stress important points or elicit the students' curiosity. The instructor also made his presence

felt by both narrating all animations and worked examples, and appearing in a number of videos. An example of an interactive activity is shown in Figure 1.

The online lessons were text-based with embedded activities, animations, videos, and worked examples. The content in each lesson was divided into small sections, and text design strategies were used to assist the student in selecting, organizing, and integrating information[5]. Specifically, objectives were listed at the beginning, titles and subtitles followed, important terms were bolded, and lists were bulleted. In addition, a series of icons were used to draw students' attention to interactive features.

Besides online lessons, students also completed four simulations. All simulations included the caricature of the instructor and were highly interactive (Figure 2). The simulations presented the students with practical, real-world situations where the knowledge they attained in the course could be put to use, such as calculating the cost savings from adding additional insulation to a house. The activities helped to motivate the students to *want* to learn the material because they could truly see and appreciate its relevance to their future role of ~~a~~ home owner. The simulations, which were graded, also assessed the students' abilities to transfer the knowledge they had gained from completing the online lessons to their everyday lives.

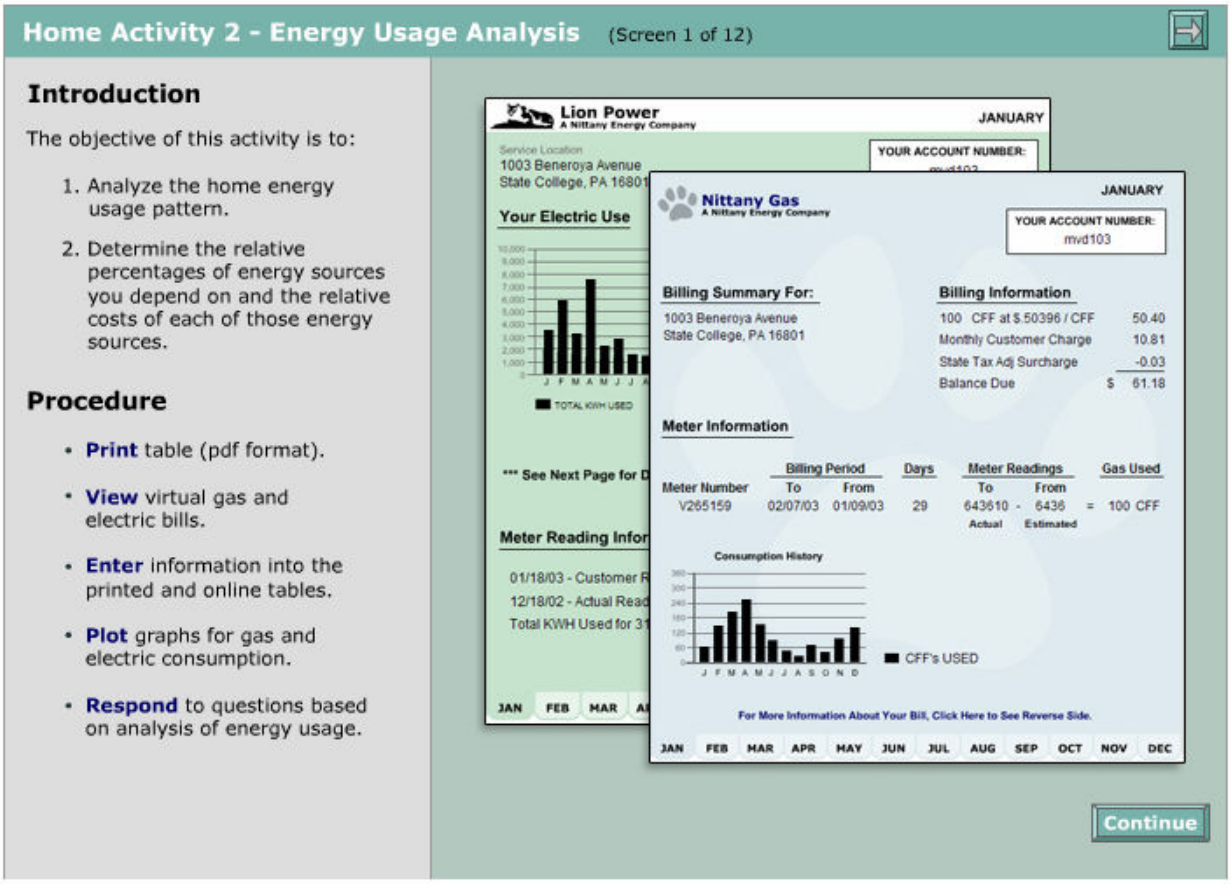

Figure 2 A screenshot of an interactive Home Activity showing student specific data

The "hybrid" section is conducted using a combination of online materials and a weekly face-to-face meeting. Online resources include lecture materials, online activities, quizzes, and exams. After the students go through online material, they fill out a feedback survey indicating the concepts in which they had difficulty or needed more practice. After going though the feedback surveys, the instructor explained those ambiguous concepts in the following class. The weekly face-to-face meeting utilizes small group exercises to help students master the more challenging course concepts. The class time is also used to go through additional practice problems.

Demographics:

The student population demographics by semester standing, and gender for fall 2007 are compared in Table 1. The data on the distribution of student population enrolled by majors show that this course is subscribed by students in 71 majors. Students within this course are in the Colleges of Arts, Liberal Arts, Business Administration, and Communications. In a given semester, the number of majors represented varies between 40 and 71. The maximum number of students from a single major varied between 13 and 21%, with an average enrollment of 3.2-8.0 students. This highlights the diversity of the class population. However, majors with *significant* enrollment in this course are from Communications (COMM), Business Administration (BA), and Division of Undergraduate Studies (DUS). Students from DUS have not yet decided on their majors.

Table 1. Demographics of student population in Fall 07

	Face-to-face	Online	Hybrid
Semester Standing			
1	114	27	33
2	15	32	10
3	96	270	40
4	27	56	11
5	43	87	17
6	18	43	10
7	20	39	4
8	4	17	0
9	2	7	1
N/A	3	3	
Gender			
Female	166 (48.3%)	232 (42.7%)	61 (45.9%)
Male	177 (51.7%)	358 (57.3%)	72 (54.1%)
Majors			
Total	62	71	40
Average per major	5.3	8	3.2
Dominant Majors	COMM, DUS, BA	DUS, BA COMM	BA, DUS, COMM

Data in Table 1 show that about 65-73% of the students taking this class is made up of freshmen or sophomores. There 27-35% students from junior and senior years. The table also shows that

the face-to-face mode is the preferred mode for freshmen and the online course has a significant number of sophomores. The female population is highest in the face to face section, slightly lower in the hybrid section, and lowest in the online section. These students are from a variety of non-engineering majors and generally report having a "phobia" towards math and science.

Assessment of Student learning

This course was graded based on individual achievement. Online students finished ten lessons at a scheduled pace, took quizzes, completed the Flash simulation "Home Activities," took mid-term and final exams, and participated electronically on the message board. The hybrid class completed the same assignments, but also participated in weekly face-to-face class meetings and in-class (as opposed to online) postings, similar to the face-to-face students.

Course grades are determined as follows:

1. Class Participation (5% of course grade):
   Hybrid class students are required to attend one weekly, 75 minute face-to-face class session. The students engage in small group activities designed to help them master challenging concepts. The time is also used to address any questions that students may have that have not already been addressed online.
   Online students are required to contribute to "Class Participation Message Boards," one for each unit, located on ANGEL. A total of six postings and six replies are required to earn full credit.
   Face-to-face students are required to participate in several in-class activities (demonstrations, worksheets, small group discussions, one minute papers or puzzles, etc.) during the semester. Participation in 80% of those activities is counted toward the overall class participation grade.
2. Quizzes (16% of course grade):
   After each lesson, online and hybrid students take a quiz on the material covered in that lesson. A total of ten quizzes are administered and the best eight scores are considered for the final grade. Face-to-face students take a total of six quizzes, with four quizzes used for the final grade.
3. Home Activities (12% of course grade):
   All students are required to complete three "Home Activities" during that semester. Home Activities are interactive simulations that students apply concepts from the online lessons to a real world environment.
   Home Activity 1: Residential Energy Conservation
   Home Activity 2: Energy Usage Analysis
   Home Activity 3: Insulation and Energy Conservation
   These activities were described in detail elsewhere[6]
4. Exams (55% of course grade):
   There are three course exams—two mid-term exams (15% each) and a final exam (25%). The final exam is comprehensive. All students take the exams face-to-face on campus in the evening. The exams were computer based for all the students.
5. Final Project (12% of course grade): Students are required to complete an online Project that is similar in nature to the Home Activities. The Project consists of three parts:
   Part 1: Appliances

Part 2: Lighting
Part 3: Insulation.

Results and Discussion

The student learning performance was evaluated using the rubric previously described. The results are shown in Table 2. The timed quizzes consisted of 12-15 multiple choice questions drawn randomly from a pool of questions. All test questions are chosen from the same pool for each class section. The quizzes are computer-graded. Table 2 shows that the average quiz scores for online and face-to-face sections were identical. Students in the Hybrid section scored slightly higher (2.8%) compared to the online and face-to-face sections. However, considering quizzes count for only 16% of the final grade, a 2.8% differential is not significant.

All students complete three Home Activities. The goal of these simulations is to engage students using animations and to challenge students to calculate their energy consumption, analyze their energy consumption patterns and utility bills, understand the economics of insulation addition, and conduct an energy audit on a virtual home.

Table 2. Assessment of Student Performance for all three modes of instruction

Semester	Format	Quizzes Average	Home Activities Average	Mid-term Exams Average	Course Project Average	Final Exam Average	Item Analysis – Numerical Problems
Fall 07	Online	77.95	88.54	74.28	88.34	82.68	77.50
	Hybrid	80.21	85.38	75.90	89.04	83.79	77.90
	Face-to-face	77.96	89.35	75.42	88.54	83.20	77.39

Each of the students worked with a unique data set for each of these activities. The data sets for energy consumption of appliances or monthly energy bills for each student are generated using Perl scripts and are retained in the MySQL database. These student specific datasets are delivered through the Flash simulations. The students complete the required activity and submit their results via the Flash interface. The submitted values are automatically compared with the student-specific data sets and the correct numerical answers as calculated by the PHP script.
These activities are graded by different Teaching Assistants for each section. The scores reflect moderate differences due to some subjective grading involved in Home Activity explanations.
Midterm exams are administered similar to quizzes. Each exam consists of about 50±5 questions. These questions are drawn from a pool of questions and all sections take the same exams. However, for the numerical problems, Hybrid sections students are required to solve the problems and enter the answer as a fill-in–the–blank. They have to show their work in a descriptive text area in order to prove that they understand the concepts behind the mathematics. If the entered answer is wrong, the TAs look at the explanation of the procedure and award partial credit if the explanation merits it. The same multiple choice questions are given to both

online and face-to-face students. The average scores for all sections are almost similar, indicating no significant differences in performance.
For the final exam, all the questions, including numerical problems, are multiple choice. Looking at the data, it can be observed that the scores are almost identical for each section. To look at the quantitative problem solving skills, an item analysis is performed on the numerical questions. It can also be noted that the mean numeral scores are practically identical for all sections.

Student Feedback:

The Pennsylvania State University's Schreyer's Institute for Teaching Excellence offers a standardized mid-semester feedback instrument called the Students' Evaluation of Educational Quality (SEEQ). Table 3 shows the summary of student feedback. For the questions in Table 3, students were given the choice of selecting "very poor," which is assigned a numerical value of 1, "poor" with a value of 2, "medium" with a value of 3, "good" with a value of 4, and "very good" with a value of 5. There is also a choice of "N/A" for students who feel that the question was not applicable for a section or course. The reported mean is the mean of applicable choices.

The results (Table 3) indicate that there are differences between students' perceptions on both learning and the instructor according to the format in which they learned. Overall, the students gave a positive feedback about the course and the instruction. Although the student learning performance (mean) in all the three formats is almost identical, the Students Evaluation of Educational Quality shows some differences. Face-to-face students rated highest compared to online and hybrid students when asked whether they learned something which they consider valuable. Similar observations were made in regards to the question on whether they learned and understood the subject materials. It should however be noted that the exam scores were almost identical. Four questions regarding the students' encouragement to participate in the class discussions, invitation to share their ideas, and encouragement to ask questions garnered minimal differences; each section gave high ratings for these questions. The mean response to the question on the value of reading materials/texts was almost identical for face-to-face, online and hybrid sections, (4.08, 3.93, and 4.0, respectively) indicating the importance of reading materials and texts. Questions on the fairness and appropriateness of methods used to evaluate student work garnered almost similar responses from the face-to-face and Hybrid sections (4.16 and 4.16, respectively). However, a fewer proportion of online students agreed to that statement (3.65).

Table 4 shows the students' feedback on the role of the instructor. For most of the questions on the instructor's role, the online students' ratings were lower compared to Hybrid and face-to-face students. It is interesting to note that 20-25% of students responded that these questions regarding the instructor were not applicable to the online course. This suggests that the online students felt that they were learning on their own and the instructor's role was less significant in their learning process.

Figure 3 shows the feedback in response to the statement "Course difficulty, relative to other courses, is…" Most of the students (65-70%), regardless of the learning format, felt that the course was of medium difficulty. Zero students from the face-to-face and Hybrid formats thought it was very easy; only 3% of the students in the online format thought it was too easy. However,

a greater number of students (15-18%) in the hybrid and face-to-face sections felt it was easy compared to 8% of the online students. A higher number of students (up to 20%) in the online and Hybrid sections felt that the course was hard compared to 6% in the face-to-face class. Figure 4 shows feedback on the course workload (relative to other courses). From Figure 4, it is clear that face-to-face students felt the course load was light to medium difficulty. However, more Online and Hybrid students felt that it was medium difficulty and/or heavy load.

Figure 5 is a plot of responses to the question of pace of the course. It is very interesting to note that more Face-to-face students felt that the course went at a faster pace compared to Online and Hybrid. At the same time, some *(consider using a percentage instead of the ambiguous word "some.")* face-to-face and online students felt that the course was conducted at a slow pace. There is a much wider distribution in the pace for the face-to-face section. This highlights the advantage of online courses – students can spend as much time as they need without having to sit in a face-to-face format, which may present them with either *too much* time or *not enough* time (quality of time over quantity).

Figure 6 highlights the impact of this course on the students' interests in the subject matter. ~~It~~ This course, EGEE 102, can be considered an impetus for students to become life-long learners. The figure clearly shows that as a result of taking this course, the interest in this subject has grown in all the students, irrespective of the format or learning mode. This is a very important outcome for this study. It is worth noting that the students enrolled in the Online version of the course have a *slightly* lower interest (2.45 versus 2.75 for face-to-face students and 2.95 for hybrid students) in the subject prior to taking the course. This is understandable due to the fact that approximately 92% of students have taken this course just to satisfy their General Education requirement in the online and face-to-face sections, while only 5-6% have enrolled because of their personal interest in the subject matter. The Hybrid section reports that 81% of the students took this class for the General Education requirement and 13% due to personal interest. Face-to-face and Online students showed the most significant enhancement in their interest as a result of this course. Although the interest level was slightly higher to start with for Hybrid students, the interest level at the end of the course was not as high as the other sections.

Table 3 Student feedback for all the three modes of instruction

Question	Face-to-Face			Online			Hybrid		
	N/A*	Mean	Std Deviation	N/A*	Mean	Std Deviation	N/A*	Mean	Std Deviation
You find the course intellectually challenging and stimulating.	0	4.054	0.7049	0	3.809	0.7193		4.161	0.7787
You have learned something which you consider valuable.	0	4.645	0.5876	0	4.207	0.8568	0	4.29	0.6925
Your interest in the subject has increased as a consequence of this course.	0	3.945	0.9412	0	3.738	0.9199	0	3.709	1.039
You have learned and understood the subject materials in this course.	0	3.945	0.8802	0	3.642	0.8592	0	3.806	0.7924
Students are encouraged to express their own ideas and/or question the instructor.	0	4.324	0.7473	1	4.036	0.9222	0	4.266	0.9802
Students are encouraged to participate in class discussions.	0	4.297	0.9679	9	4.12	0.8692	0	4.193	1.0138
Students are invited to share their ideas and knowledge	0	4.459	0.8364	1	4.17	0.8285	0	4.29	1.0064
Students are encouraged to ask questions and are given meaningful answers	0	4.486	0.6507	1	4.121	0.8223	0	4.387	0.7154
Course materials are well prepared and carefully explained	0	4.405	0.6855	0	4	0.8695	0	4.2	0.8051
Proposed objectives agree with those actually taught so you know where the course is going	0	4.297	0.661	1	3.925	0.8771	0	4.2	0.7143
Feedback on examinations/graded materials is valuable	0	3.783	1.1089	1	3.59	1.1047	0	4.129	1.0244
Methods of evaluating student work are fair and appropriate	0	4.162	0.7642	1	3.65	1.0052	0	4.161	0.9694
Examinations/graded materials test course content as emphasized by instructor.	0	4.243	0.796	1	3.506	1.0285	0	4.032	0.9826
Required readings /texts are valuable.	0	4.083	0.8742	4	3.937	0.9048	0	4	0.8563
Readings, homeworks, etc., contribute to appreciation and understanding of the subject	0	4.351	0.7155	1	4.109	0.867	0	4.258	0.7732

Table 4 Student feedback for all the three modes of instruction on Instructor's role

Question	Face to Face			Online			Hybrid		
	N/A*	Mean#	Std Deviation	N/A*	Mean#	Std Deviation	N/A*	Mean#	Std Deviation
Instructor is enthusiastic about teaching the course.	0	4.864	0.5355	4	4.45	0.7274	0	4.774	0.6169
Instructor is dynamic and energetic in conducting the course	0	4.783	0.7123	6	4.179	0.7853	0	4.677	0.7017
Instructor enhances presentations with the use of humor.	0	4.891	0.3148	7	3.935	1.0044	0	4.612	0.7154
Instructor's style of presentation holds your interest during class	0	4.351	0.7893	19	3.671	1.0925	0	4.096	0.9782
Instructor's explanations are clear.	0	4.216	0.6296	0	3.783	0.8271	0	4.066	0.8276
Instructor gives lectures that facilitate taking notes	0	4.108	0.875	21	3.769	1.027	3	3.633	1.129
Instructor is friendly towards individual students	0	4.621	0.5452	28	3.933	1.0061	0	4.483	0.6256
Instructor makes students feel welcome in seeking help/advice in or outside of class	0	4.756	0.4947	22	3.907	0.9307	0	4.533	0.6814
How does this course compare with other courses you have had at Penn State?	0	4.162	0.8979	0	3.638	0.9445	0	4.032	0.9122
How does this instructor compare with other instructors you have had at Penn State?	0	4.702	0.661	2	3.902	0.9109	0	4.483	

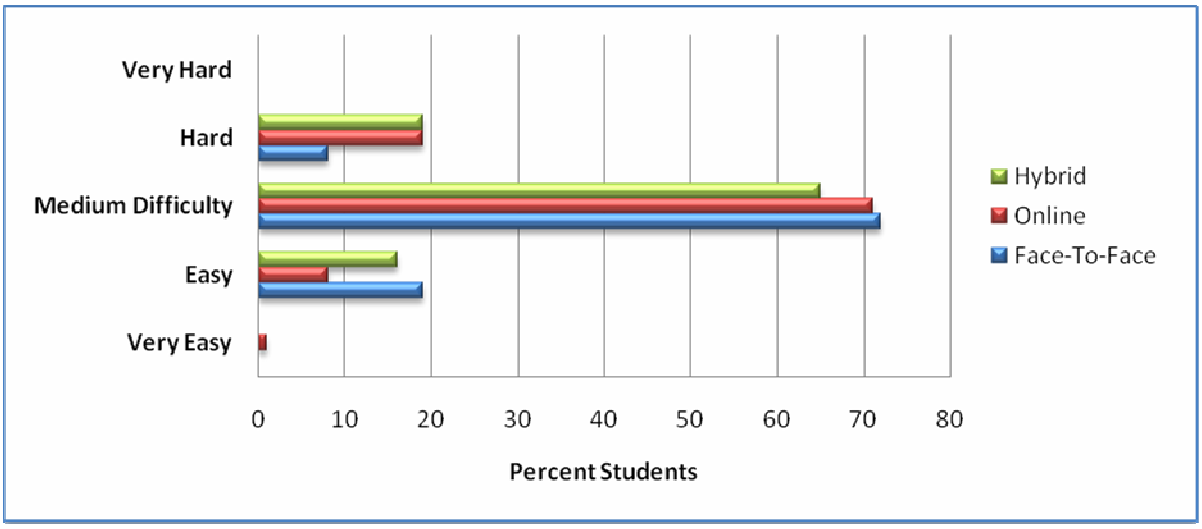

Figure 3 Student Feed Back on Course Difficulty

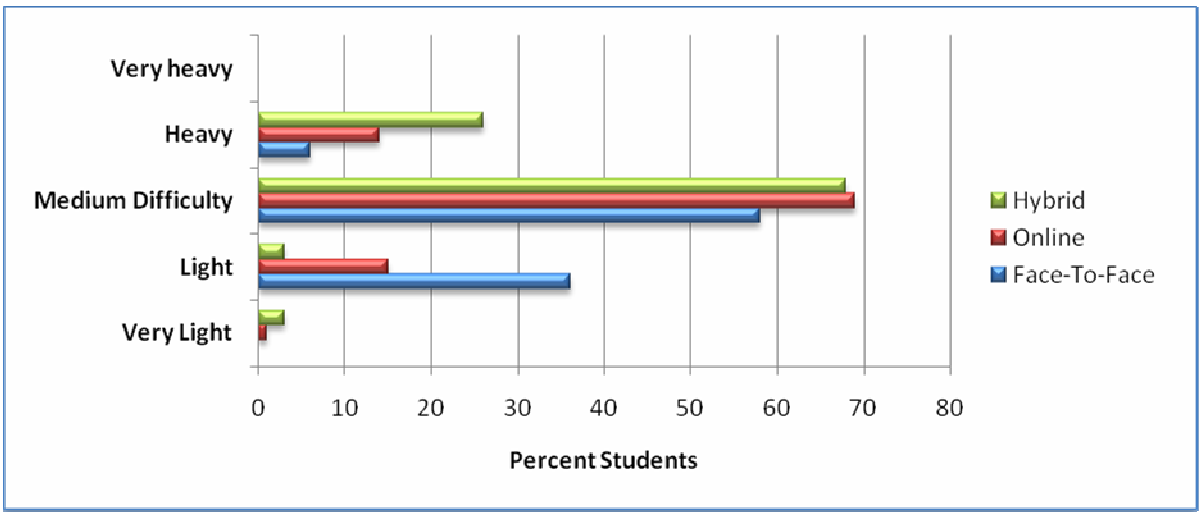

Figure 4 Student Feed back on Course Load

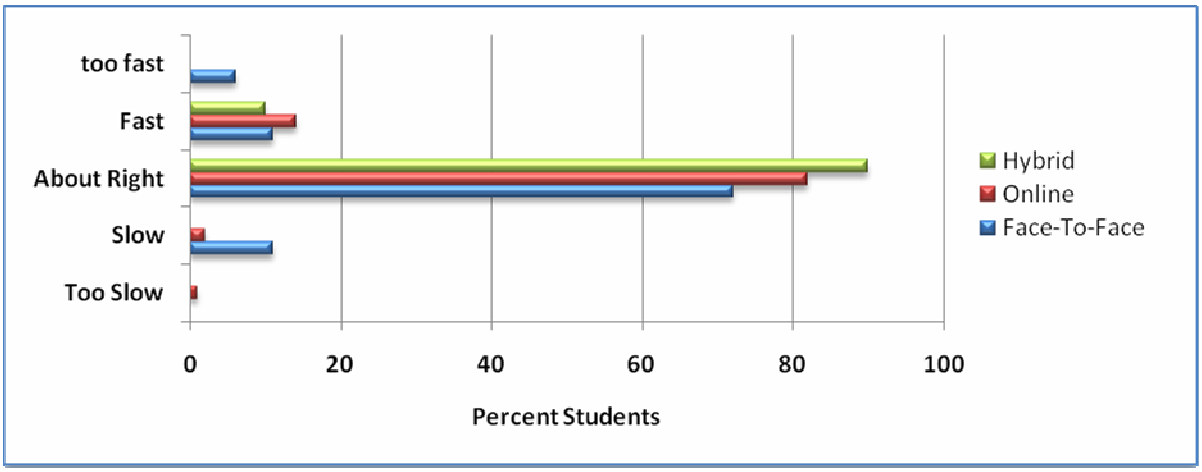

Figure 5 Student Feed Back on the Pace of the Course

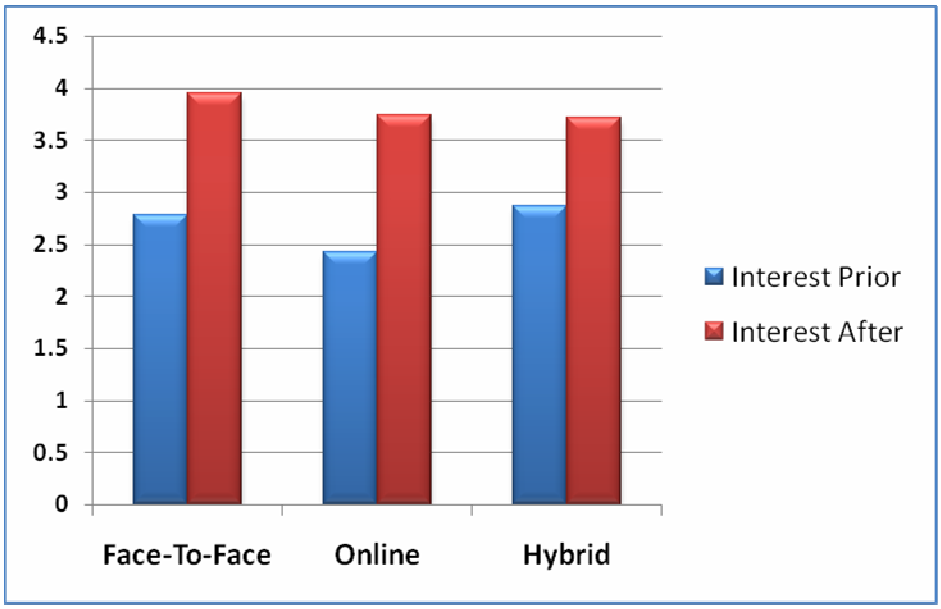

Figure 6 Students' feedback on their interest prior to and after taking the course

Conclusions

This study examined the students' learning experiences, performance differences, and feedback on learning experiences in all the three modes (online, hybrid and face-to-face) taught by the same instructor. The study included 343 students in the face-to-face class, 590 students in the Online section, and 133 students in the Hybrid section of an Energy Conservation and Environmental Protection course (EGEE 102).

The results as evaluated by quizzes, midterm exams, home activities, project, and a final exam indicated that the overall learning performance is similar within the statistical error limits. The results showed that the average quiz scores for online and face-to-face sections were identical. Students in Hybrid section scored slightly higher (2.8%) compared to the online and face-to-face sections. The average scores for the midterm and the final exams for all sections were almost

similar, indicating no significant differences in performance. However, some slight variations in scores were observed for Home Activities and the Projects. These minor differences are attributed to subjective grading involved in these sections due to different Teaching Assistants grading each section.
The perception of the students about the course, however, showed some differences although their performance is similar. A greater number of students in the online and Hybrid sections felt that the course was challenging compared to the face-to-face students. More Online and Hybrid students also felt that the course was medium difficulty and/or heavy load compared to face-to-face. The results also suggest that the online students felt that they were learning on their own and the instructor's role ~~is~~ was less significant in their learning process. The data clearly show that as a result of taking this course, the interest in this subject has grown in all students, irrespective of the format or learning mode. This is a very important outcome for this study.

Acknowledgments

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