Integrating Online Instructional Tools in a Large Engineering Course: An Exploratory Study

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Abstract

During the past two years a Mechanics of Material course was offered with two enrollment options for lectures: a) face-to-face attendance in classroom; and b) online participation, either live or delayed (recorded) via streamed recorded lectures. Two online instructional tools were introduced to support the described format of this course. First tool, the Webex[11] online conferencing tool was used for the synchronous online delivery of the lectures as alternative to the face-to-face participation in the course. The second tool, called MecMovies[7] was an online environment that combines worked examples, drill exercises, and assignment problems to be solved by the students.

This paper presents the results of a longitudinal study that followed two consecutive semesters, Spring Semester of 2006-2007 and respectively Fall Semester of 2007-2008. Due to the novelty of this approach for both the instructor and students, the overall research questions were exploratory: How did the inclusion of the two online instructional tools impact students' attitude and behavior? How did these changes impact students' classroom performance? The findings of these studies suggest that students in this type of environment are attracted by the flexibility and convenience of online learning. Anyway, most of students tend to overestimate their ability to self-regulate their own learning process so that they became effective learners. Making students aware of this trap by providing them with empirical findings proved to be a first step in closing the gap between the performance outcomes of the two extreme attendance groups, mainly face-to-face and respectively mainly taped lectures.

Introduction

Class sizes in lower division engineering are getting larger, as is the diversity of learning needs to be addressed by the instructors. In this context including distance students, increasing student retention in lower division courses, or addressing the scarcity of on-campus classroom space are some examples of factors that define the complexity of the instructional process. Computer-mediated instructional tools and especially online tools have proven helpful to faculty in reaching larger numbers of students both in traditional[9] and blended-learning environments[8]. However, the process of integrating the tools into classroom activities is not a trivial task. It requires a systemic effort that includes the direct participants in the instructional process as well as organizational entities charged with the deployment and maintenance of infrastructure. When looking at the instructional process as a mediated activity[5, 3], tools play a significant mediating role in the production of instructional outcomes. That is, tools as mediators define how the participants, both students and instructors, engage in classroom activities to sustain meaningful learning as the outcome of the instructional process.

In this context, the mediating role of technology-driven tools on the structure of the instructional process generates both contradictions and synergies[6]. Instructors tend to resist using online instructional tools mainly because they seem very impersonal. Instructors also feel they lose control over the instructional process when using these tools. The personal contact with students in face-to-face classroom settings is important for instructors because it allows them to: (a) build a community with a certain level of trust; and (b) get quick feedback related to instructional issues and then promptly react to avoid anxiety and complaints from students. In online environments these two factors often require more planning and active engagement. The instructor will also need to master in a relatively short time the skills associated with the effective use of online instructional tools to address these challenges.

From a synergic perspective, online instructional tools facilitate communication process with large groups of students and also engage more students in informal activities such as review sessions and office hours[4]. The synchronous online instructional tools available today offer voice and video tools which makes the online instruction much like the face-to-face instruction. Live sessions can be recorded and archived for reference by the student or instructor.

For many students the most attractive features of online instructional tools are their flexibility and convenience. Not being required to be at a given location and/or at a given time to be part of the instructional process allows for more flexibility in personal and professional time management. By taking advantage of these features students can enroll in courses that have a scheduling conflict and avoid potential delays in the completion of their degree. Students can participate more freely in extra curricular activities, job interviews, and take care of personal and family matters. They can miss class when they need to miss, and be able to view the archived lectures from anywhere they can get an internet connection.

Some students tend to resist online instructional tools due to the lack of personal contact with the instructor, who is seen as the motivator that helps keep them engaged in the course. Another factor that generates student resistance to online tools is the lack of scheduling structure, a factor very often linked to the success of task completion. A flexible schedule requires that students have the self discipline to watch the lectures in a timely manner and keep up with the coursework. Students also have to deal with distractions, such as television and friends, when watching the lectures on-line. These distractions are not present in a face-to-face lecture, which makes it easier for students to focus on the material presented.

In summary, the primary advantages of online instruction are flexibility and convenience of being able to view the lectures, review sessions and office hours from any location that has an internet connection. Sessions can be archived and made available to the students to be viewed at a later time. The primary disadvantage of online instruction is the lack of structure in the class. Some students need the structure of a face-to-face lecture to motivate them to keep up with the course material. Instructors need to talk with students about proper use of the technology, and help them identify their needs and the best method to receive the instruction.

Instructional Context

A Mechanics of Material course with an enrollment of 80 to 150 on-campus students was offered with two enrollment options for lectures: (a) face-to-face attendance in classroom; (b) online live participation; and (c) delayed (recorded) via streamed recorded lectures. Students were free to choose any combination of the options for viewing the class. They were to choose the option(s) they felt would be most effective for own learning style, schedule, and other commitments. The two most popular choices were to view the class face-to-face and to view it delayed (recorded), but there was a significant minority who chose to view the lectures live online.

The majority (80%) of the homework consisted of traditional problems assigned from the textbook. Approximately 20% of the homework was assigned from an online learning environment developed for this course. Review sessions for the exams and office-hour-type help with the homework were all conducted live online, and most of the students in the classes participated in at least some of those sessions.

Two online instructional tools were introduced to support the described format of this course. The Webex[11] online conferencing tool was used for the synchronous online delivery of the lectures as alternative to the face-to-face participation in the course. This tool also allowed the instructor to tape lectures and make them available to all students to be used for review or as replacement of synchronous participation in the course. Webex was also used to conduct the review sessions and office hour sessions for the course. The second tool, called MecMovies[7] is an online environment that combines worked examples, drill exercises, and assignment problems to be solved by the students. The focus of this environment is to scaffold the application of various concepts in the Mechanics of Materials through example problems. Built-in interactive factors such as concept checkpoints and transfer problems offer learners the opportunity to test their understanding and receive quick feedback. Another important feature of this environment is its use of animated illustrations and three-dimensional renderings to help learners develop a mental image of the distribution of stresses and strains within the solid body for the given contextual situation.

The complexity generated by the integration of these online instructional tools in classroom settings requires a long-term commitment from the instructor, and an analysis of the impact of the tools on the learning process. Due to the novelty of this approach for both the instructor and students, the overall research questions were exploratory: How did the inclusion of the two online instructional tools impact students' attitude and behavior? How did these changes impact their classroom performance?

Methods and Methodologies

This longitudinal study followed two consecutive semesters, the Spring Semester of 2007 (SP07) and the Fall Semester of 2007 (F07). Of the 88 students enrolled during the SP07 semester, 76 returned complete data and after eliminating outliers, a sample of 74 students was retained for this study. For the F07 semester, of the 140 students enrolled in the course, 122 returned complete data and after eliminating outliers a sample of 115 students were retained for this study.

Measures and Procedures

Two categories of measures were used for this study. The first category included measures of students' performance. Scores for homework, final exam, and final grade were collected from Blackboard and transformed into percentages of maximal score for each of the three measures. These measures were collected for both semesters covered in this study. The second category of measures targeted students' attitude and perception related to the online instructional tools used in the course and were collected through exit surveys.

For the SP07 semester, one attitudinal and one behavioral measure were used. The attitudinal measure was a categorical one (yes/no) indicating students' recommendation whether to keep MecMovies in the future, or to substitute more homework problems from the book in place of the MecMovies assignments. The second one, *attendance behavior* was a self-reported behavioral measure that was calculated as the weighted sum of students' self-reported percentages of use of each of the three modes of lecture: face-to-face, Webex live, and Webex taped (or archived). The students were asked to choose percentages for the three modes that totaled 100%. In analyzing the data for *attendance behavior*, the weights were *5* for face-to-face since it requires both time and space commitment to participate, *3* for Webex live as it requires only time commitment to participate, and *1* for Webex taped as it requires no time or space commitment to participate. The result was a continuous variable with a range from *1* for students using 100% percent Webex taped lectures, to *5* for students participating 100% in face-to-face lectures.

Based on the findings from the previous semester, for F07 semester we kept the attendance type measure, dropped the MecMovies measure, and included a measure of students' self-efficacy adapted from the validated scale of Self-Efficacy for Learning with Self-Paced, Online Training[2]. The attendance type was a self-reported measure potentially biased by the tendency of students to offer acceptable answers. A strong negative correlation between the attendance type and self-efficacy then would be an acceptable indicator of a low bias risk for the attendance measure. That is, a high level of self-efficacy for learning with online instructional tools should correlate to the attendance score moving toward participation in mostly or all Webex taped lectures.

Seven self-efficacy questions in the survey were evaluated with a 5-point Likert-type agreement scale with 1 – totally disagree and 5 – totally agree were used in evaluating the questions. One of the seven questions was reverse coded. The Cronbach's alpha for the seven items was 0.86, above 0.7 - the typical acceptance value for an internally reliable scale. The measure of students' self-efficacy for learning with online tools resulted as a mean of the seven scores with a minimum of *1* for low self-regulation levels and a maximum of *5* for high self-regulation levels.

Design, Results, and Interpretation

For each of the two semesters that provided the context of this study, a short presentation of the descriptive results will be followed by correlational, ANOVA, or regression analysis as appropriate.

Spring Semester 2007

A one-way ANOVA and two linear regressions were used for this first study. These three designs looked at various aspects of the interplay of the performance, attitudinal, and behavioral factors that played a role in student learning process when online instructional tools were used. The continuous variables for this first study were homework score, final exam score, and attendance behavior. Table 1 presents the means, standard deviations and Pearson correlations for the continuous variables used in the first part of the study.

Table 1
Means, Standard Deviations, and Pearson Correlations for continuous variables

	M	**SD**	**1**	**2**	**3**
1. Homework score	91.01	14.40	-	.29*	.15
2. Final exam	57.86	17.48		-	.18
3. Attendance behavior	2.71	1.51			-

Note: *p < .05;

In addition, students' attitude toward the MecMovies (the online environment used for homework assignments) was used as the categorical variable in this study.

Attitude toward MecMovies

The exploratory question for this part of the study was to see if the difference in students' attitudes toward MecMovies, the online environment used for about 20% of homework assignments is reflected in their performance in homework grade. Results were analyzed using a one-way ANOVA, between-groups design. For this analysis the homework score was the dependent variable while the attitude toward MecMovies served as the independent variable.

The results showed a relatively equal split between students supporting the use of MecMovies for homework assignments, N = 43, and those against it, N = 31. The analysis revealed a significant effect for the attitude toward MecMovies, $F(1,72) = 6.2$, $p < 0.05$. The subjects in the group supporting the use of MecMovies for homework assignments had significantly higher scores for homework, M = 91.43 (SD = 12.53), than the group not supporting the use of this online environment for homework assignments, M = 82.26 (SD = 15.65).

The impact of attendance behavior

The exploratory question for this part of the study was: Did the nature of attendance behavior students had chosen to engage in, varying from *mainly face-to-face* to *mainly Webex taped* have an impact on their performance in the course? For this analysis, final exam score was the dependent variable, homework score was the independent variable, and attendance behavior was the moderating variable. The focus was on the potential moderating effect the behavioral variable might have on the relationship between the final exam score and its predictor. The final exam was selected as dependent variable for this part of the study both because of its significant role in the final grade and its strictly controlled environment.

The bivariate correlations presented in Table 1 above revealed one significant predictor for the final exam, the homework score ($r = 0.29$) significant at $p < 0.05$. In a first step the final exam score was then regressed on the homework score. The resulted equation accounted for 8% of the variance in the final exam score, $F(1,72) = 6.41$, $p < 0.05$, adjusted $R^2 = 0.69$. In a second step, the interaction between the attendance behavior and the homework score was introduced as predictor and mean centered values were used to evaluate a regression analysis (Table 2).

Table 2
Summary of Regression Analysis for 2006-2007 dataset

	Beta Weights	
Predictor	*Beta*	*t*
Homework score (A)	0.30	2.72**
Attendance behavior (B)	0.07	0.59
A * B	0.31	2.82**
Model Summary	$R^2 = 0.19$, $p < 0.01$	

Note: N = 74. **p < 0.01

In this second step, the interaction term between attendance behavior and homework explained a significant increase in final exam score, ? $R^2 = 0.11$, $F(2,70) = 4.78$, $p < 0.05$. Thus, attendance behavior was a significant moderator of the relationship between homework score and final exam score (Figure 1).

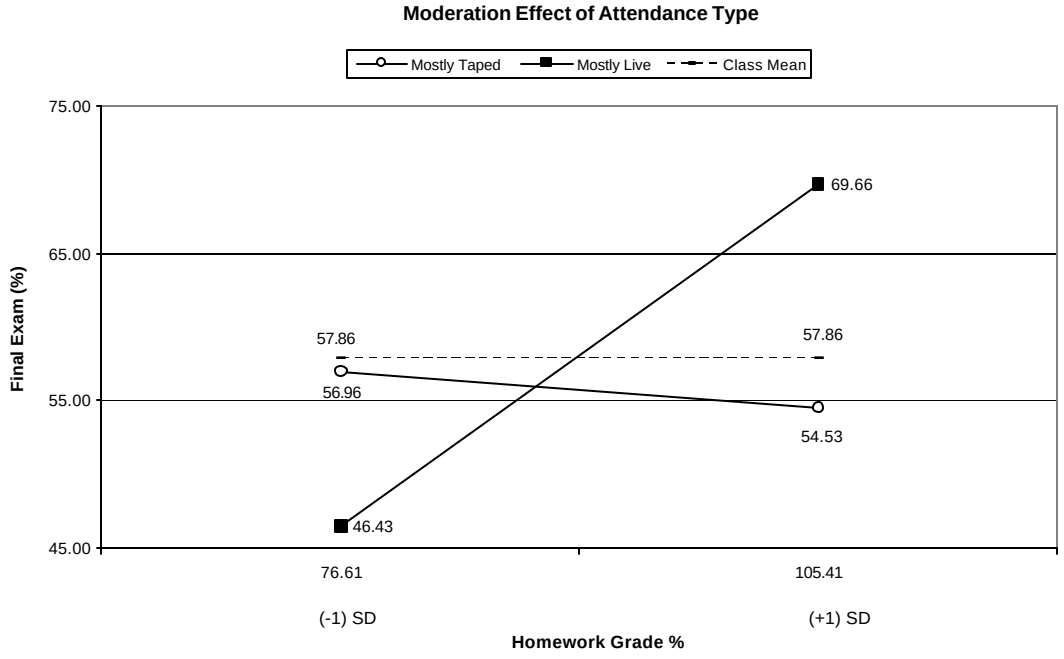


Figure 1. Moderation effect of attendance type on homework scores

The unstandardized simple slope of final exam 1 *SD* above the mean of attendance behavior was + 0.81, and the unstandardized simple slope for final exam 1 *SD* below the mean of attendance behavior was - 0.08 (see Figure 1). The simple slope analysis[1] indicated that the positive slope of the final exam 1 SD above the mean of attendance behavior was statistically significant, $t(70) = 3.76$, $p < 0.05$, while the negative slope of the final exam 1 SD below the mean of attendance behavior was not statistically significant.

Discussions and Implications

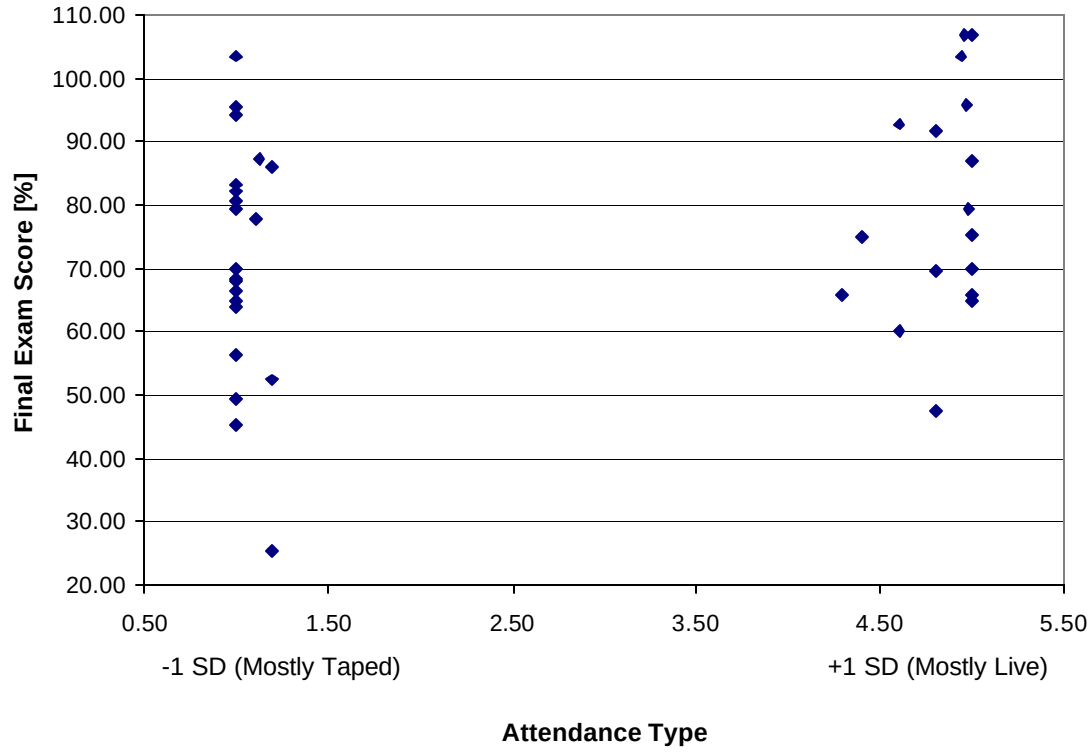
The first finding of this part of the study indicated a relatively equal split between students in favor of sustaining the use of MecMovies for homework problems and those who would rather have more homework problems from the book and no MecMovies. However, the significantly higher homework score mean for the group sustaining the use of this online environment (MecMovies) strengthened the instructor's decision to keep the current homework structure with about 20% of assignments to be done in MecMovies.

The second finding of this study was rather surprising as it suggested that for those students that used mostly the online Webex taped lectures, their performance in the final exam was near the mean regardless of their homework score. In contrast for those students that used mostly live lectures, either face-to-face or a combination of face-to-face and Webex live lectures the performance in the final exam significantly increased with their homework score (see Figure 1).

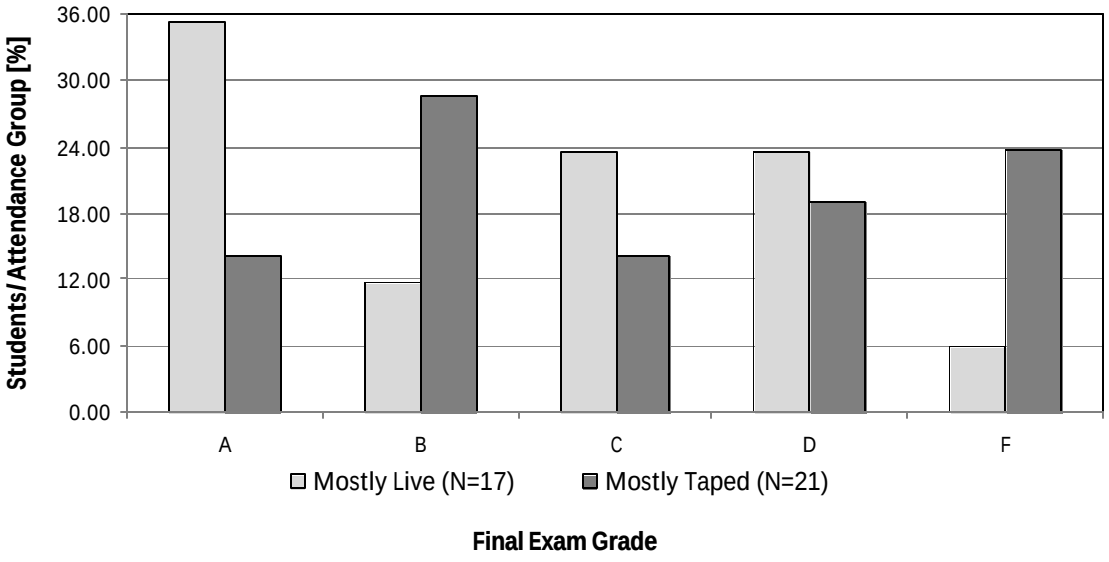
A more qualitative analysis of the relationship between students' choice of attendance type and their performance in the final exam for the two groups showed that: a) students in both groups have final exam grades that spread across the entire spectrum of the grading scale (Figure 2a) but the mainly Webex taped group tend to have more subjects toward middle and lower grades; and b) students in mostly live lectures group had more A's, and less C's than the students in the mostly taped lectures group (Figure 2b).

Two possible explanations were found for the interaction between attendance behavior and homework score when examining student performance in the final exam. First, lectures were the main method used to introduce various concepts and concept-application contexts for the problems analyzed in the course. The lectures included example problems that were similar to those assigned for homework. Being more prone to disturbance, taped lectures had then the potential to reduce students' engagement in the learning process with negative impact on their performance outcome on the final exam. That is, students that engaged in mostly Webex taped lectures overestimated their ability to pursue meaningful learning using this online instructional tool.

Second, students had the opportunity to increase their homework score by solving homework problems for which they had not fully mastered the conceptual issues either by: a) pairing with other students that had mastered these conceptual issues; or b) by passive participation in online office hours where they got some of their homework answers from the interaction between other active participants and the instructor. These two possible explanations drove the instructional intervention and the research process for the following semester.



a)



b)

Figure 2. Influence of attendance on performance for the attendance dyad poles (SP07):
a) Scatter plot of final exam scores by attendance type for mostly taped and live groups;
b) Distribution of mostly taped and live groups by grade.

Fall Semester of 2007

From an instructional perspective the main change in the implementation of the online environments for this second semester was the instructor's decision to warn the students deciding to use mostly the Webex taped lectures about the need to fully engage in this activity. At the midterm, the instructor sent an e-mail warning students about the potential trap of not paying enough attention to the taped lectures and having an attachment of the scatter plot diagram of last semester's exam scores by the type of attendance. From a research perspective, the survey administered at the end of this semester included the scale for self-efficacy for learning with online environments described in the measures section above.

Three one one-way ANOVAs, one linear regression, and one correlational analysis were used for this second study. The main focus was as on the interplay of the performance and behavioral factors that played a role in student learning with the Webex online conferencing tool.

The continuous variables for this second study were homework score, final exam score, attendance type, and self-efficacy for learning with online tools. Table 3 presents the means, standard deviations and Pearson correlations for the continuous variables used in this part of the study. In addition one categorical variable, the semesters when the two studies were conducted, was used.

Table 3
Means, Standard Deviations, and Pearson Correlations for continuous variables

	M	**SD**	**1**	**2**	**3**	**4**
1. Homework score	92.50	13.06	-	0.33**	0.08	-0.01
2. Final exam	61.10	14.90		-	0.15	-0.05
3. Attendance behavior	2.45	1.61			-	-0.49**
4. Self-efficacy	3.96	0.74				-

Note: **p < 0.01

Self-efficacy for learning with online tools and self-reported attendance behavior

Pearson's correlation between the attendance type, M = 2.45 (SD = 1.61), and the self-efficacy for learning with online tools, M = 3.96 (SD = 0.74), was $r(115) = -0.49$, $p < 0.01$ (see Table 3). It indicates the existence of a significant but moderate correlation between the two variables. On one hand, this result supports the hypothesis that students' attendance behavior is driven by their self-confidence in personal ability to learn with online instructional tools. That is, the higher their self-efficacy for learning with online tools, the lower their attendance behavior score and then the higher the probability they will engage in mostly online live and taped lectures. On the other hand, this significant negative correlation is an indicator of a low bias in students' self-reported attendance behavior.

The impact of attendance type

The second research question for this study was: Does student behavior remain the same as reflected by the moderating role of the attendance type on the relationship between homework grade and final exam? Following the procedure in the first study, the final exam score was regressed on the homework score.

Table 4
Summary of Regression Analysis for 2007-2008 dataset

	Beta Weights	
Predictor	*Beta*	*t*
Homework score (A)	0.32	3.58**
Attendance type (B)	0.12	1.38
A * B	0.07	0.81
Model Summary	$R^2 = 0.13$, $p < 0.01$	

Note: N = 115. **p < 0.01

The resulted equation accounted for 10.8% of the variance in final exam score, $F(1,113) = 13.68$, $p < 0.05$, adjusted $R^2 = 0.10$. In the second step, the interaction between the attendance type and the homework score was introduced as predictor and mean centered values were used to evaluate this new regression analysis (see Table 4 above).

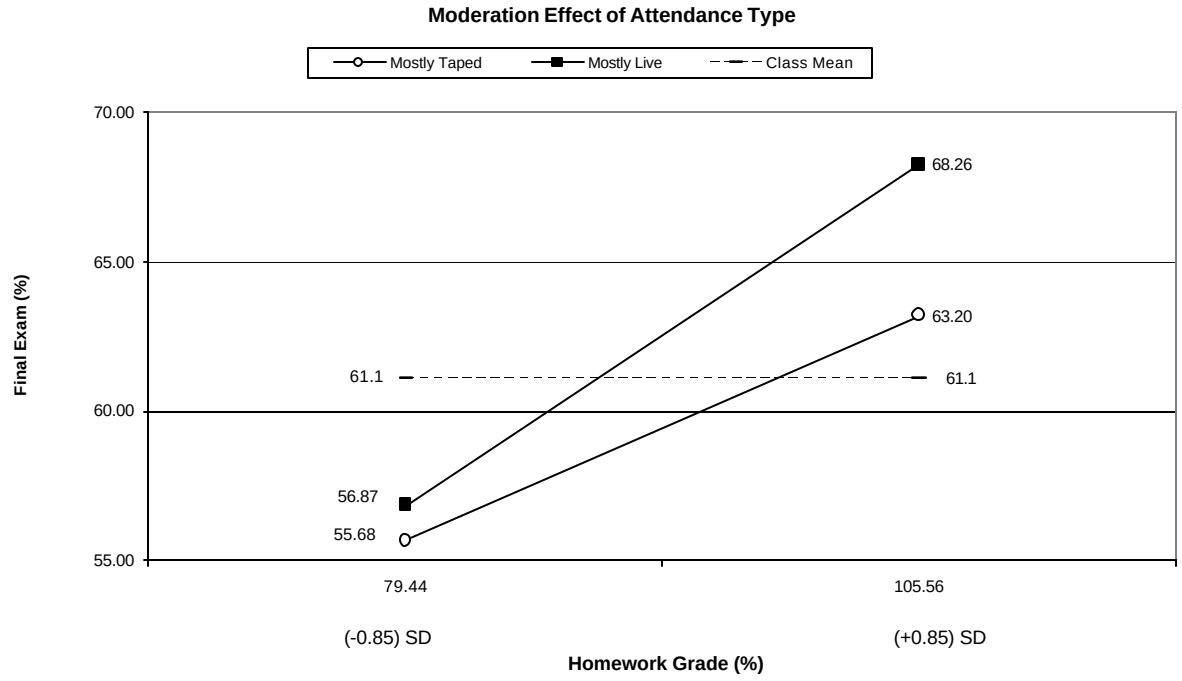
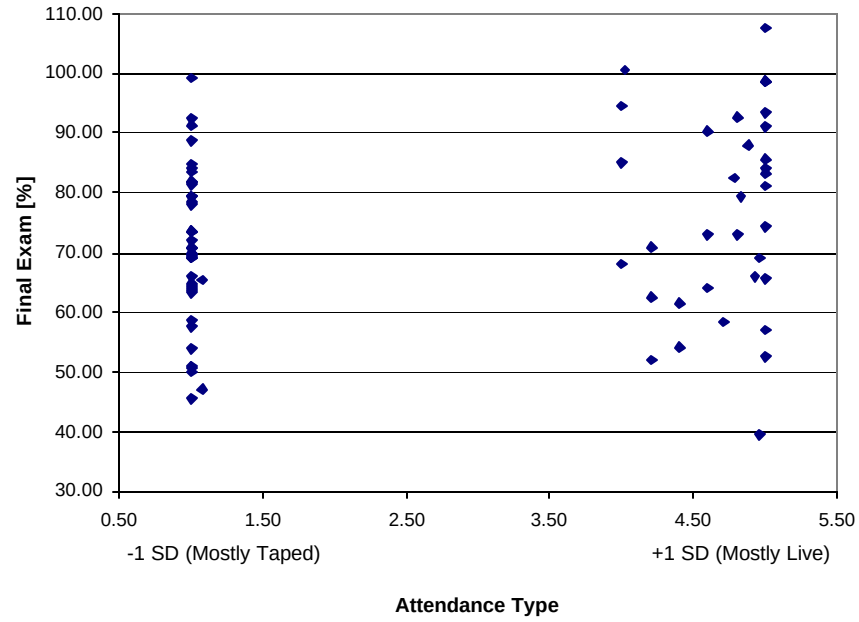
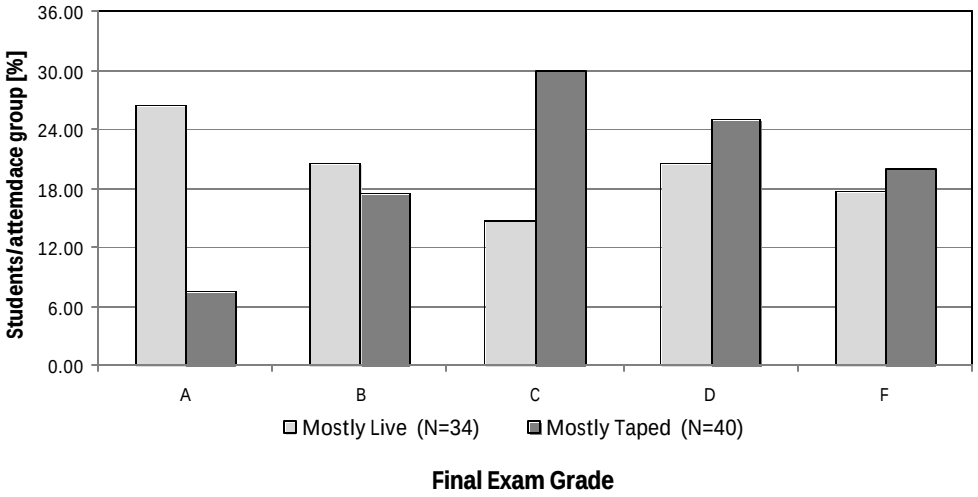


Figure 3. The relationship between homework scores and final exam by attendance type

However, in the second step the interaction term was not statistically significant. Thus, for this group of students the attendance type was not a significant moderator of the relationship between homework score and final exam score (see Figure 3). The simple slope analysis indicated that the slope of the final exam 0.85 SD above the mean of attendance type was statistically significant, $t(111) = 2.14$, $p < 0.05$, while the slope of the final exam 0.85 SD below the mean of attendance type was not statistically significant. As compared to the previous semester this semester's results show: a) a more uniform distribution of the grades for the entire spectrum of the grading scale for both face-to-face and Webex groups (Figure 4a); and b) a much closer distribution of D's and C's for the two groups (Figure 4b).



a)



b)

Figure 4. Influence of attendance on performance for the attendance dyad poles (F07): a) Scatter plot of final exam scores by attendance type for mostly taped and live groups; b) Distribution of mostly taped and live groups by grade.

Students' changes in performance outcomes and behavior

The exploratory question generated by the results of the first question in this study was: Are there significant changes from last semester in students' performance or attendance behavior that can explain the change in the moderating effect of attendance type on the relationship between the homework and final exam score? Results were analyzed using three one-way ANOVA, between-group designs having homework score, final exam score, and attendance type as dependent variables and year in school as independent variable. The analysis revealed no significant effect for the year for the two performance outcome variables as well as for the attendance behavior variable. That is: homework, M = 92.50 (SD = 13.06), and final exam, M = 61.10 (SD = 14.90) mean scores for the Fall 2007 class were not significantly higher than homework, M = 91.01 (SD = 14.40), and respectively a final exam, M = 57.86 (SD = 17.48) mean scores for the Spring 2007 class; the tendency of students' attendance behavior to move toward mostly Webex taped lectures in the Fall 2007 semester, M = 2.45 (SD = 1.61) was not significantly different from the same behavior tendency in Spring 2007 semester, M = 2.71 (SD = 1.51).

Discussions and Implications

The first finding of this second study indicated that the self-reported attendance behavior measure is an acceptable proxy for students' self-efficacy for learning with online tools. Attendance behavior then served in this study as an indicator of students' confidence in their own ability to learn from online lectures. The fact that this confidence was not backed up by their level of academic performance can be explained by the fact that these students were on-campus students mostly exposed to face-to-face lectures as main instructional tool. That is, these students had few or no prior experience with learning in an environment that requires high levels of self-control and personal commitment to overcome the potential distractions that are specific for online learning[2]. This finding is further supported by both: a) the change in the moderating impact of the attendance behavior in this study as compared to previous semester's study; and b) the second semester's differences between the performance outcomes of students following mostly live lectures and those following mostly online taped lectures.

Making students aware of the gap between their confidence in own ability to learn with online tools and their actual low academic performance at midterm can explain the shift in the slope of the final exam scores from a negative one (no warning at midterm) to a positive one (warning at midterm). Therefore, the midterm warning was a good fist step in improving the academic performance of those students that engaged in online instruction. However, more measures are needed to help students reach the levels of self-regulation skills needed for meaningful learning with online instructional tools.

Conclusions

The implementation of online instructional tools is a multi-faceted action that impacts and is impacted by the needs of students, the needs of instructors, and the contextual constrains of the instructional context in which they are implemented. This longitudinal study found some exploratory answers to: a) the relationships between the instructor's decision to enforce or leave open the use of two online instructional tools, students' attitude toward or behavior with these tools; and b) the impact of these relationships on students' performance outcomes.

When student behavior with a given online instructional tool was constrained (e.g. the use of MecMovies was required for 20% of the homework), students' attitudes were split between keeping and dropping the use of this tool for future homework assignments. However, the analysis of performance outcomes indicated that students supporting the future use of this tool performed significantly better on homework assignments than their colleagues not supporting the use of this tool. When the usage of the online instructional tool was not subjected to formal constraints, students' attendance behavior clustered in three categories with the majority forming a dyad with one end on the mostly face-to-face attendance and the other end to the mostly Webex taped attendance of lectures.

Finally, it has to be mentioned that the educational environment that served as the context for this study required face-to-face attendance for most of the courses across campus. The findings of these studies suggest that students in this type of environment are attracted by the flexibility and convenience of online learning, but most of them tend to overestimate their ability to self-regulate their own learning process so that they become effective learners. Making students aware of this trap by providing them with empirical research findings is a first step in closing the gap between the performance outcomes of the two attendance groups: mainly face-to-face and mainly taped lectures. Anyway, to fully use the benefits of such instructional tools more targeted measures toward improving self-regulation skills with online instructional tools need to be developed, tested, and deployed.

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