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Strategies to Enhance Learning in a Large Engineering Economics Course: Including Students' Perceived Values in the Instructional Redesign Process

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Strategies to Enhance Learning in a Large Engineering Economics Course: Including Students' Perceived Values in the Instructional Redesign Process

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Abstract – **Purposeful implementation of technology in instructional design presents opportunities to increase institutional efficiency while simultaneously improving instructional quality. This paper presents findings from the implementation of a hybrid/buffet approach in an undergraduate Engineering Economics large course. A Design-Based Research (DBR) approach informed the instructional redesign and measured its effectiveness through multiple iterations, or macro-cycles, of implementation. Overall, pedagogical structure and specific technology solutions applied to each course component are described, as well as preliminary measures of effectiveness and student perception from a pilot offering of the hybrid/buffet course. Encouraged by positive preliminary results, a second implementation informed further study of students' perceived usefulness, value, and overall impact on their learning of *WileyPLUS* online tools and their predictive power on students' overall course performance. These two DBR macro-cycles created a baseline to analyze the impact of future strategies to improve student learning in this course.**

Index Terms – **blended learning, engineering economics, instructional design, student perceptions, design-based research**

Introduction

The current forces of increasing student enrollments, limited classroom space, and increased budget constraints have led many to rethink the way courses are offered, especially those with significant enrollment each semester. Advances in technologies that may support learning provide opportunities to increase efficiency while maintaining quality. This paper presents findings from the implementation of a hybrid/buffet approach[1] in an undergraduate Engineering Economy large course along with pedagogical structure and specific technology solutions used in this course. This study discusses students' perceived usefulness, value, and overall impact on their learning of *WileyPLUS* online tools and their predictive power on students' overall course performance.

MOTIVATION OF THE STUDY

Many research studies have attempted to quantify the effects of delivery mode on the effectiveness of instructional process. Their focus ranged from direct comparisons of traditional and online modes[2,3,4,5,6] to more in depth analyses of the impact of the teaching strategies[7] or stakeholders' perceptions[8,9] for online delivery modes. Among these, the U.S. Department of Education synthesized the results of over 50 such experiments in a meta-analysis of research results that covered both online and blended-format educational models[5]. This meta-analysis study found that online students performed modestly better than those learning with traditional face-to-face instruction. Yet, instruction combining online and face-to-face elements (hybrid instruction) yielded an advantage over purely online instruction.

In a "hybrid" course, a portion of the activities that would normally take place in the classroom shifts to an online format. The result is reduced classroom seating time without a reduction in the content of the course. Hybrid course delivery (also commonly referred to as *blended learning*[10]) reduces demand for university classroom space and promises accessible, cost-effective, efficient and standardized instruction, especially for high enrollment courses.

From the student perspective, hybrid delivery has the potential to increase scheduling flexibility while maintaining some face-to-face interactions with faculty and fellow classmates. A variant of the hybrid classroom is the "buffet" model[11]. In this hybrid approach, the learning environment is customizable for each student or group of students, allowing them to choose the preferred instructional approach from a "buffet" of instructional options.

Inspired by these two models, and motivated by both increasing course enrollments and reduced classroom space, the instructor sought to redesign an undergraduate engineering economics course to address these instructional needs. Two grants from the University of Missouri System eLearning initiative and the Missouri University of Science and Technology (Missouri S&T) eFellows program[12] supported these redesign efforts.

By providing resources and training to faculty for course redesign, the eLearning initiative sought to expand access to college courses and degree programs while the eFellows program focused on improving student learning through the implementation of technology.

This study will present the pedagogical structure and specific technology tools implemented in new hybrid/buffet design as well as preliminary outcomes from the pilot of the new course design. Further, this study will summarize the research findings relating to student perception from a full implementation of the redesigned undergraduate engineering economics course.

INSTRUCTIONAL CONTEXT

During the spring 2011 semester, two large pilot sections of an undergraduate Engineering Economics course were offered in a hybrid/buffet mode. Since at the time of the pilot implementation the course had only two sections, all students taking the course participated in the hybrid/buffet instructional mode. Following the pilot implementation, the course was again taught by the same instructor in fall 2011 with minimal modifications to the pilot offering. The remaining portion of this section presents a thorough discussion of the course structure and components. The course included three major instructional components that supported its hybrid/buffet mode:

1. Online Resources
   a. Instructor-created content, consisting of short *Introduction* videos with learning objectives, video *Lessons* of narrated PowerPoint™ slides, and *Example Problem* videos.
   b. The online learning environment, *WileyPLUS,* associated with *Principles of Engineering Economic Analysis 5e* textbook,[13] and consisting of a digital copy of the text as well as *Reading* and graded *Practice Problem* assignments.
2. Classroom Activities
   a. Live lectures, consisting of PowerPoint™ *Lessons* annotated in real time and projected to a viewing screen
   b. In-class problem solving, consisting of examples solved by students and/or the instructor and assessed with audience response devices (clickers).
3. Support Resources
   a. Problem Solving Help sessions, consisting of tutoring by skilled Undergraduate Learning Assistants in a computer lab setting.
   b. Live Chat with the instructor, consisting of real time question and answer sessions facilitated through a chat tool.
   c. Discussion Board support forums with individual threads for each practice problem.

In general, students were encouraged to utilize the resources they found most useful to them as individual learners. Students could choose to participate in the live Classroom Activities each class meeting that exposed them to all fundamental course topics through Lessons and Problem Solving guided by the Instructor during the classroom time. Alternately, students could choose to access the Online Resources to review the same material independently. Students were free to change at any time their mode of engagement throughout the semester. In addition to the online and classroom resources, students benefited from both live and electronic Support Resources. For example, those students with questions about specific problems or issues with general topics could receive individual assistance in Problem Solving Help sessions or ask questions via online chat or through a dedicated discussion board forum.

Although some students chose to attend regularly the live classroom, others preferred to review course material online. However, regardless of their choice of participation, all students participated in the same type of assessment. That is, course grades were determined by students' performance on: (a) four in-class exams (80% of overall grade) and (b) weekly practice Problem assignments completed in *WileyPLUS* (20% of overall grade). In addition, on a weekly basis the instructor suggested non-graded *Reading* assignments in *WileyPLUS*.

Online Resources

The hybrid/buffet course offered extensive Online Resources that students could access at any time throughout the semester. The Online Resources consisted of both Instructor-Created Content and part of the *WileyPLUS* online environment. As the new hybrid/buffet course was developed, the instructor reorganized and divided the course content based on actionable learning objectives. These actionable learning objectives formed topic-related Modules, with each of them covering approximately 8-10 learning objectives. For each Module, a comprehensive set of resources prepared students to achieve the associated learning objectives. Students were generally responsible for one Module each week, and materials were presented in Blackboard's™ standard module format (see Fig. 1).

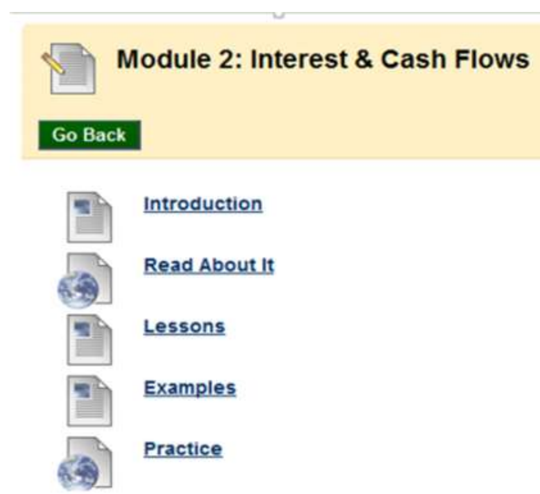

Figure 1. Structure of a sample online Module

As shown in Fig. 1, each Module within Blackboard™ contained the same common components: *Introduction*, *Read About It*, *Lessons*, *Examples*, and *Practice*. Each *Read About It* and *Practice* component contained a link to the appropriate *WileyPLUS* site, where those resources were hosted.

Those components will be discussed in the next section while the *Instructor-Created Content*, including *Introduction, Lessons,* and *Example Problem* components are shortly described in this section.

While Blackboard™ housed all online modules, the WileyPLUS content was hosted in its own environment. In other words, students could click on a module link in Blackboard to access a Reading in *WileyPLUS*, but a separate login was required to access the WileyPLUS content. New partnerships between developers of learning management systems and publishers promise to allow integrated solutions in the near future.

Instructor-Created Content. The *Introduction* component of each Module offered students a summary of all learning objectives and a short (3-5 minute) video of the instructor explaining the significance of the module topics and relating those topics to previous topics and/or engineering practice. Students were encouraged to refer to the learning objectives as they read the recommended text and prepared for the assessments.

The *Lessons* component contained brief video lectures for each significant topic. The instructor used Camtasia® to create videos based on voice-over PowerPoint slides. Most video Lessons followed a similar format, presenting equations, theory and a worked example. While it is difficult to convey the nature of the video lessons in a written format, the screen capture presented in Fig. 2 may help to clarify the nature of activities recorded in these videos.

The design of the underlying PowerPoint™ presentation allowed space for the instructor to animate the presentation by writing on-the-fly notes on the slides as the Lesson progressed. This approach mimicked the act of writing on the board in a traditional classroom and kept students both engaged and alert during the virtual lecture. Additionally, the slides were prepared with color-coded buttons on the bottom, offering a visual cue on the topic being discussed at any given point in the video (see Fig. 2). This feature allowed students to replay a section or search for a specific topic or example within each video without the need to search the entire video or replay it entirely.

The *Examples* component of each Module presented solved example problems. Some traditional pencil and paper problem solutions were prepared, scanned, and uploaded in Blackboard™. However, multiple video solutions were prepared for each Module as well. The video solutions used the same strategy as the one discussed in the preparation of the *Lessons*. The video solutions often demonstrated multiple solution methods for each problem.

For instance, a video may first display a "by hand" solution written on a virtual whiteboard. The same problem was also solved using factor tables, when the video displays the table on the screen while the narration explains which column and row to use. Further, the video captured the keystrokes required to solve the same problem using Excel functions. Students were able to replay entire videos or only sections of them, as needed.

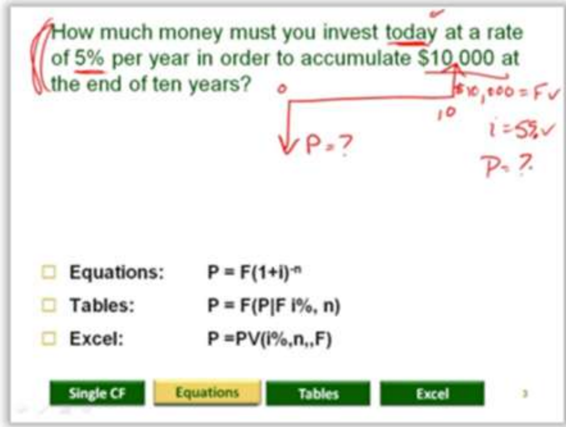

Figure 2. Sample *Lesson* screen capture

WileyPLUS Online Environment. The textbook used for the course, White, Case and Pratt's *Principles of Engineering Economic Analysis 5e*[13], offered significant digital resources through the corresponding *WileyPLUS* site. In general, the *WileyPLUS* site delivers a full digital version of the textbook as well as assessment tools. Students in the hybrid/buffet course were required to purchase access to the *WileyPLUS* site as it hosted two major online Module components, the *Reading* and the *Practice Problems*. However, they could do so in lieu of, or in conjunction with, purchasing a print copy of the textbook.

The *Reading* component was comprised of specific reading assignments from the digital textbook. Each reading assignment offered a direct link to specific sections of a chapter. The digital text and printed text were identical but, as an added benefit, the digital version included links to the Excel files used in examples discussed in that chapter. The weekly reading assignments were *not required but encouraged*, and students could print sections of the digital textbook if they preferred to read on paper.

Practice Problem assignments in *WileyPLUS* generally included eight or more problems, either chosen from the textbook or created by the instructor. Most problems required students to analyze a situation, perform calculations, and report a numerical answer. While the instructor assigned the same problems to all students, many of these problems allowed for algorithmic generation of their variables. Therefore, while all students were working with the same general problem statement and solution process, their numerical answers were unique. This feature allowed for hundreds of students to complete the same assignment without the concern of shared answers. The assessment functionality of *WileyPLUS* automatically checked the student's answer against the correct answer and offered immediate feedback, either correct or incorrect. Students had three attempts to reach the correct answer, and got various forms of support for each problem.

For example, many problems within the *WileyPLUS* system offered a "link to text" support, allowing students to click directly to the section of the digital textbook that discussed the material relevant to that problem. Further, some problems also included a "GO Tutorials" link that offered systematic guidance on the solution process for the problem. Students could practice solving the problem using the tutorial and then return to their original problem statement to apply the process. Additionally, some problems offered "video solutions" linked directly to the practice problem.

Classroom Activities

As a complement to the online resources (Blackboard™ and *WileyPLUS*), students could attend live classroom sessions each week. The Lessons presented in the classroom were the same as the Lessons offered in video format on Blackboard™. However, the Lessons were live in the classroom and the PowerPoint™ slides were annotated by writing on a podium tablet PC screen projected for students to view. During these live sessions, students had the opportunity to ask questions, take notes on printed PowerPoint™ handouts, or simply focus on the discussions. The Lessons were generally short, approximately 5-15 minutes, and included theoretical elements, specific equations and often a brief worked example.

In addition to live Lessons, classroom sessions included in-class problem solving activities with real-time feedback generated from live polling using Poll Everywhere[14]. While similar in practice to the use of personal response devices, or "clickers", in the classroom, the students were able to use this pooling tool and respond to questions using mobile devices or laptops. For instance, students could text, tweet with Twitter or use any web browser to submit their response. The instructor could also prepare polling questions in advance or create them in real time in the classroom. The anonymous poll responses were projected for the class to view. Occasionally students responded to opinion questions, allowing the instructor immediate perspective on the clarity of a topic or the perceived difficulty of an assignment.

Support Resources

In an attempt to ensure all students had access to the resources they needed to succeed, they had access to additional Support Resources throughout the semester. For example, for about six hours per week students could use Problem Solving Help offered in a computer lab setting. For these sessions, at least one knowledgeable Undergraduate Learning Assistant was available to answer student questions and/or assist with the solution. Students had also the opportunity to participate in Live Chat sessions with an Undergraduate Learning Assistant. Chat sessions were available approximately six hours per week in the evenings, at a time when many students typically worked on their homework. Students could open a chat window on their computer and correspond by typing to get real time answers to questions. Further, a Discussion Board with individual threads for each Practice problem was available on Blackboard™.

The instructor often posted tips and hints for historically challenging problems, and students were encouraged to view these before beginning Practice assignments. Students were required to post their questions to the Discussion Board, rather than emailing the Instructor directly. In that manner, either the instructor or a fellow student could respond to the question and all students in the course would have access to the answer.

OVERARCHING RESEARCH METHODOLOGY

The complexity of transition from a traditional face-to-face instructional process to the proposed hybrid/buffet model required multiple iterations of design-implementation-redesign cycles. To increase the effectiveness of this iterative process, research-driven monitoring elements were included in this process, following the overall recommendations proposed by the Design-Based Research literature. Design-Based Research (DBR) emerged in the Learning Science field, with the main focus on moving the research on learning and instructional design into the educational context where they actually take place[15,16,17]. DBR can be viewed as a collaborative process that integrates course design, course implementation and educational research in a synergic activity that is beneficial both for the practitioners and researchers[18,19].

From a procedural perspective, DBR is implemented through a series of steps called macro-cycles, each of these steps integrating a certain instructional design (e.g. course, online module, tutorial) to be deployed, a research program that will measure the effectiveness of that design and the implementation of that design in a given educational context. Typically, the educational research used to monitor the effectiveness of the instructional design in each macro-cycle focuses on a combination of cognitive (e.g. student performance) and affective (e.g. attitude, perceptions, beliefs) factors that are important for the educational process under design. The research findings from a certain macro-cycle along with additional ad-hoc information collected during the implementation phase: (a) serve as input for the redesign of the instructional process and (b) direct the needed changes in the research process to address the changes in the associated instructional design[17, 18].

The remaining part of this study presents the results from the first two DBR implementation cycles for the described hybrid/buffed mode of the undergraduate Engineering Economics course that is the object of this research.

FIRST IMPLEMENTATION: PRELIMINARY STUDENT FEEDBACK

After an initial pilot hybrid/buffet section was offered in spring 2011 semester, the first full implementation that also used a detailed student survey was administered in fall 2011 semester.

During this first full implementation, the instructor relied for feedback on the overall performance results and an anonymous survey distributed online through Qualtrics™.

To ensure the anonymity of respondents, the survey collected only general demographic information not linked to individual students. Participation in the survey was voluntary and not rewarded with points toward their final grade. Out of 259 enrolled students during this first implementation, 71 (27%) completed the survey.

Measured Effectiveness

To determine the impact of the hybrid/buffet model on student learning we assessed several major outcomes. As the hybrid/buffet course covered all sections on campus, no control group was available to compare learning within a given semester. Therefore, baseline performance data from an offering of the course in the traditional format in fall 2010 was compared to data collected from the hybrid/buffet sections.

For this step in the study, along with the overall grade for the course, we analyzed student performance on eight questions contained in the final exam. These eight questions covered fundamental learning objectives of the course. The same instructor taught all traditional and hybrid/buffet sections, and all exams were delivered in pencil and paper format.

To test the homogeneity of the two groups at the entry point, we compared students' average ACT score and respectively their high school core GPA. The two groups were homogeneous, with the average ACT mean score varying from 26.8 for fall 2010 (traditional offering) to 26.7 for fall 2011 (hybrid/buffet offering). The high school GPA mean was 3.5, identical for both groups.

The analysis of final course letter grades provided the first global view of the impact of the new instructional mode. Fig. 3 synthesizes the grade distributions for traditional and hybrid delivery methods.

While there were no significant shifts found in the upper grades, it is important to note that the percentage of students who were unsuccessful in the course, letter grade of D or F or withdrawing before the semester finished, did not increase with the shift to hybrid delivery.

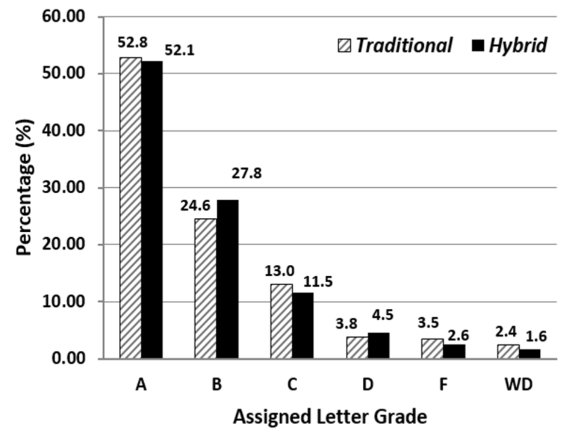

Figure 3. Final Course Grade Distribution Comparison by Delivery Mode

Therefore, though students in hybrid sections were not required to attend in the classroom their overall course performance did not deteriorate.

Students' grades associated with the eight exam questions covering the major learning objective of the course provided a more detailed view of the impact of the delivery mode.

The percentage of students who successfully demonstrated the learning objective (i.e. answered the exam question correctly) was calculated for students in the traditional course offered fall 2010 and the hybrid course in fall 2011.

Fig. 4 synthesizes the difference in performance (hybrid minus traditional) for each learning objective covered in the target course.

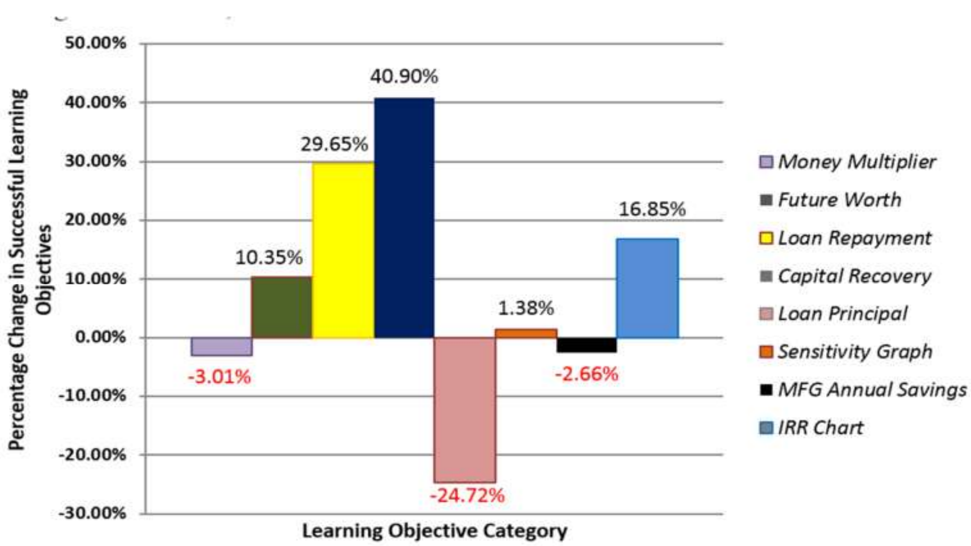

Figure 4. Gain/Losses in Student Performance for Major Learning Objectives

As shown in Fig. 4, for five out of the eight objectives analyzed, students from hybrid sections showed a learning gain over students from the traditional sections. For example, the learning objectives related to loan repayment and calculation of capital recovery cost showed gains between 30% and 40%. Three other learning objectives showed some modest gains and two learning objectives showed small losses. The learning objective showing a major loss (about 25%) is the one related to Loan Principal (see Fig. 4).

The question that measured this learning objective required students to calculate, without the use of a spreadsheet, the remaining principal on a loan immediately after making a specific payment. In the traditional sections, the instructor demonstrated this calculation in the classroom on a chalkboard and students were required to repeat the calculation by hand on a homework submitted on paper. However, in the hybrid sections, the emphasis was placed on spreadsheet solutions, especially for loan calculations. Further, students in hybrid sections completed their Practice problems on a computer with ready access to spreadsheet tools and were encouraged to use them, a context that was not available at the exam. Therefore, it is logical to assume that students in the hybrid course may have lost some of the ability to solve this problem using pencil and paper. However, an assessment of their ability to solve using a spreadsheet would likely yield comparable or improved performance relative to the traditional teaching approach.

Basic Descriptors of Students' Perceptions

Students' self-reported expected letter grade for the course, indicated in an exit survey, provided a second perspective on the impact of the course delivery mode. Table 1 shows the expected grade distribution of students compared to the actual overall assigned grade distribution for students who chose to participate in the survey.

While the respondent pool may contain proportionately more A and B students than the course as a whole, the survey results remain relevant and represent a reasonable distribution of students' opinion for the overall course.

TABLE 1

ACTUAL VERSUS EXPECTED COURSE GRADE

	A&B	*C*	*D&F*
Actual Overall Class Grades (N = 259)	81.08%	11.58%	7.34%
Expected Class Grades (N = 71)	92.96%	4.23%	2.82%

Since this hybrid/buffed model was deployed in a heavily face-to-face instructional environment, the researchers were interested to see if students still preferred the live, classroom-based sessions and also if this choice in the offered buffet model had a significant impact on their self-reported expected course performance. Table 2 summarizes the self-reported live attendance by the expected course letter grade for the students that participated in the exit survey.

TABLE 2

SELF-REPORTED LIVE ATTENDANCE (N = 71)

Indicate the category that represents in-class attendance	*Expected Grade*		
	A&B	*C*	*D&F*
Nearly every time class met	30%	33%	-
40-80% of class meetings	12%	33%	-
20-40% of class meetings	13%	-	100%
Only as required, for the first week of class	45%	34%	-

From the data summarized in Table 2, it is clear that for highly motivated students (A and B grades) classroom attendance was not a critical factor to success in the course. However, those who expected to be unsuccessful (D and F grades) may have benefited from an increased attendance. Since at the time of this implementation we had to rely on self-reported data coming from a relatively small sample of students, the potential impact of live attendance will benefit from additional, more structured analysis in future work related to this course.

The final set of basic information collected in this first implementation was focusing on students' perceived value of various learning resourced deployed in the hybrid course. To assess this perception students were asked to indicate the value of each of the offered resources using a 5-point Likert scale. Three resources clearly stand out in terms of their perceived value for students' learning.

First, 93% of participating students indicated *Examples* worked by the instructor and posted online as being *valuable* or *very valuable*. The *Practice* problems available in *WileyPLUS* followed, with 91% of students considering this resource as *valuable* or *very valuable*.

Finally, *Lessons* recorded or presented by the instructor placed third, with 88% of students considering them *valuable* or *very valuable*. These findings clearly showed that students strongly valued instructional resources directly tied to the activities that engaged them in the learning process.

SECOND IMPLEMENTATION: STUDENT PERCEPTIONS OF ONLINE RESOURCES

The encouraging results from the data collected during the first DBR macro-cycle convinced the instructor to get more structured feedback. Therefore, in the implementation of the second DBR macro-cycle, the course exit survey became a formal course feedback from students and was therefore rewarded with bonus points toward their final grade. This new strategy allowed the researchers to collect perception and attitude information connected to students' final performance in the course.

Research Goals for the Second Implementation

Given the abundance of course components available for student learning, and the multiple ways in which students may utilize those resources, the analysis of the redesigned hybrid/buffet course can inform several qualitative and quantitative studies.

For this second part of the study, the research focus is informed by the Community of Inquiry (COI) framework that emphasizes the importance of students' interaction with the online content and tasks, known as cognitive presence[20,21]. We limited our analysis to the students' perceptions of the online resources in *WileyPLUS* since these perceptions are informed by students' experiences from extensive use of these online resources in the online part of the course.

In this exploratory study, we focused on two major research goals related to students' perceptions of the role of the major online activities and tools as follows:

1) To identify if students' perceived usefulness and perceived value of major online instructional tools and strategies are factors that impact their overall perceived impact of *WileyPLUS*, the online environment used in the target course, and
2) To verify if the perceived overall impact of the online *WileyPLUS* environment on own learning has a predictive power on students' overall course performance.

Research Methodology

To focus on the research goals of this part of the study, we used path analysis, a form of Structural Equation Modeling (SEM). This type of analysis allows specifying a priori, for inferential purposes, the relation between students' final score, perceived impact and its four major determinants, perceived value of reading assignments, perceived value of practice problems, usefulness of reading assignments and usefulness of practice problems respectively[22].

Proposed Path Analysis Model. To test the predictive power of the perception measures associated with *WileyPLUS* on students' course performance we proposed the exploratory path analysis model presented in Fig. 5.

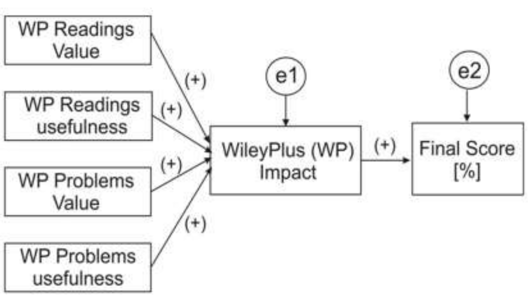

Figure 5. Proposed Path Analysis Model

Based on their role in the instructional process, we expected that the four proposed factors, perceived value and usefulness of reading assignments and practice problem respectively, to have a positive correlation (+) with the overall perceived impact of *WileyPLUS*.

In addition, we expected to also have a positive correlation (+) between the overall perceived impact of *WileyPLUS* and students' final score in the course.

Participants. Of the 227 students enrolled in the course at the time of this study, 129 participated and provided input for all variables considered in the proposed path analysis model. Most of the students were male (77%) and their educational level was split at comparable proportions in seniors, juniors and sophomores.

Research Procedure and Instruments

We collected students' perceptions with an online survey administered at the end of the semester using Qualtrics™. Students' participation was voluntary and rewarded with bonus participation points that were stimulating, but did not have a significant impact on students' final score in the course. The endogenous (dependent) variables used in this study were students' final percentage score, and the student perceived overall impact of *WileyPLUS* on own learning respectively.

The perceived overall impact of *WileyPLUS* resulted from the evaluation of six statements related to the course concepts, quizzes, retention, confidence, time saving and grade. These statements were evaluated with a five-point Likert scale (1- strongly disagree to 5 - strongly agree). We tested the internal reliability of the six statements used to measure perceived overall impact and found that Cronbach's alpha was .96, a value clearly above .70, the accepted indicator of a good internal reliability for a scale. Therefore, we treated the six questions as a scale. The final value for the perceived overall impact resulted as the average of the six items score.

The exogenous (independent) variables were: a) perceived value of *WileyPLUS* reading assignments, b) perceived usefulness of *WileyPLUS* reading assignments, c) perceived value of *WileyPLUS* practice problems and d) perceived usefulness of *WileyPLUS* practice problems.

To measure the four exogenous variables we used single questions with a five-point evaluation scale for value and usefulness (see the Appendix presents the actual items administered in the online survey).

Path Analysis Results and Discussions

The cases/parameter ratio was around 21:1, significantly higher than the minimal value of 5:1 recommended in the literature. AMOS (v.19) was the software platform used to test the proposed path model presented in Fig. 5.

Results from the Basic Statistical Analysis. Table 3 presents the basic statistics (means, standard deviations and correlations) for each of these measured continuous variables at the exit point and includes both the endogenous (dependent) and exogenous (independent) variables.

TABLE 3

PATH MODEL ANALYSIS: BASIC STATISTICS FOR PATH VARIABLES

		Correlations, Means and Standard Deviations					
	Variables	A	B	C	D	E	F
A.	Perceived value of readings	-	.58**	.37**	.39**	.33**	.16
B.	Perceived usefulness of readings			.21*	.34**	.35**	.11
C.	Perceived value of problems				.61**	.59**	.22*
D.	Perceived usefulness of problems					.68**	.18*
E.	Perceived impact of WileyPLUS						.34**
F.	Final score [%]						-
	Mean	3.10	2.89	4.03	4.16	3.65	89.21
	SD	1.17	1.21	.88	.91	.95	7.59

Notes: * $p < .05$ (2-tailed); ** $p < .01$ (2-tailed)

The correlations shown in Table 3 clearly show that the items related to the two main types of activities associated with *WileyPLUS* online environment (see column E in Table 3) as follows:

- The positive correlations between the perceived impact of *WileyPLUS* and perceived value and usefulness of *problems* are in the high range (.59 and respectively .68, $p < .01$) while
- The positive correlations between the perceived impact of *WileyPLUS* and value and usefulness of *readings* are only in the low to medium range (.33 and .35 respectively, $p < .01$).

In addition, while the two problem-related perception variables have a significant but low positive correlation with the final score (lower than .30), the two reading-related perception variables have no statistically significant correlation to the final score (see column F in Table 3).

Finally, the overall perceived impact of *WileyPUS* showed a statistically significant moderate positive correlation with the final score (.34, $p < .01$). The correlational analysis results therefore confirm the nature and the sign of the links proposed in the path analysis model (see Fig. 5).

Fit and Adequacy of the Overall Model. Fig. 6 summarizes the resulted path coefficients and their statistical significance.

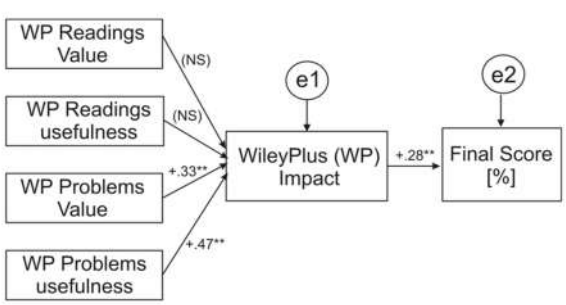

Figure 6. Path Coefficients for the proposed model

The minimum discrepancy measured by chi-square was not significant (χ^2 (4) = 1.00, p = .91) which indicates that there is an adequate close fit between the hypothesized model and the perfect fit model[22,23]. The adequacy of fit is also strengthened by the value of the ratio of the minimum discrepancy to the degrees of freedom, CDMIN/DF = .25, which is smaller than 2.0 as recommended in the literature[22].

All major goodness-of-fit statistics recommended in the literature[22,23] indicated a good fit for the proposed models, as follows:

a) Normed fit index, NFI = .99 is higher than .90, the recommended critical value;

b) Comparative fit index, CFI = .99, higher than .95, the recommended value, and

c) Root mean square error of approximation, RMSEA = .001, smaller than .06, a value recommended by the literature[23].

In addition, the critical sample size statistic as measured with Holter (p = .05) = 1213 was much higher than 200, a value that is indicative of a model that adequately represents the sample data used[22].

Significance of the Results from the Proposed Path Analysis Model. The significance and signs of the paths analyzed in the proposed model clearly map the findings from the correlational analysis previously discussed. That is, the two positive and statistically significant paths between the value and usefulness of the practice problems and the overall perceived impact of *WileyPLUS* clearly shows that hands-on online activities are perceived by students as more beneficial for their learning (see Fig. 6).

Finally, the model indicated a statistically significant path between students' overall perception of the impact of online tool (*WileyPLUS*) and their final performance in the course (+.28, $p < .01$).

This result strengthens the proposition that *well implemented and meaningful online tools and instructional tasks* provide students with enough feedback to allow them form valid perceptions on their value and usefulness.

Conclusions Derived from the Second Implementation

There are several limitations associated with the findings of this study. First, one major limitation was its exploratory nature that did not allowed for a retest of the proposed model. Second, the contextual nature of the course, a science and engineering-oriented instructional environment, as well as the relatively small sample size suggests caution when trying to replicate or extrapolate the findings of this study. Considering these limitations, three major findings resulted from the analysis of path coefficients.

First, the overall perceived impact of *WileyPLUS* proved to be a statistically significant predictor of students' performance, as measured with final scores in the course. This finding suggests that *the impact scale developed for this study can serve as a monitoring tool in the second part of the semester* after students gain sufficient experience using the online instructional tools provided by *WileyPLUS.* Further research should focus on identifying a threshold value for the perceived impact to signal potential at-risk students at a point in the semester where the instructor can act and help the student avoid failure in the course.

Second, the path coefficients for the perceived value and usefulness of practice problems in *WileyPLUS* were, as predicted, statistically significant. That is, the perception factors associated with practice problems are significant predictors for the overall perceived impact of *WileyPLUS.*

This suggests that hands-on activities and tasks built around specific online tools, as was the case with the *WileyPLUS* online environment, provide students with enough meaningful feedback to allow them to understand the importance of these activities on their final course performance.

Therefore, the instructional process will benefit if the instructors will closely monitor students' perceptions of those online activities and tasks that require hands-on applications of major course concepts.

Finally, we found that the value and usefulness measures associated with *WileyPLUS* readings were not statistically significant predictors of perceived impact. Our assumption is that the immediate feedback the online system provided for practice problems affected students' perception related to the practice problems, while online readings did not offer the benefit of any immediate feedback. Further, reading assignments were not a factor in students' grade while problems made up 20% of the overall course grade. Given the hybrid/buffet design of the course, students could choose from a variety of learning resources and may have opted to skip the reading assignments.

OVERALL CONCLUSIONS AND FUTURE WORK

Following initial pilot offerings of a hybrid/buffet undergraduate engineering economics course with large enrollments, preliminary feedback indicated the approach to be generally successful. With continued implementations over multiple semesters, student success rates and learning outcomes remain acceptable.

However, monitoring and analysis of student perceptions and course data can create opportunities for incremental improvement in the course offering.

These first two design-based research (DBR) macro-cycles helped us to create a baseline to analyze the impact of future strategies to improve student learning in this course. For example, as indicated in the detailed study of student perceptions of the online *WileyPLUS* resources conducted during the implementation of the second macro-cycle, the value and usefulness of reading assignments was limited.

As currently implemented, reading assignments showed no impact on student grades. Further investigation of reading assignment completion rates may indicate that a grade incentive could stimulate students to benefit from the reading assignments. For example, implementation of a low-stakes reading quiz may be adequate to encourage students to explore the reading assignments. Currently, only limited interaction with the digital text was available in the form of Excel files associated with text example problems.

Recent developments in the *WileyPLUS* product allow for increased interaction and feedback with readings. Specifically, new interactive text features include: key terms in the digital text link to the definition, lesson videos for key topics play from a link in the digital text, and select example problems link to video solutions.

Investigation of students' awareness of the valuable Excel files and new interactive features within the digital text of the readings can be part of the next stage of the implementation of this DBR study.

Student perception of value and usefulness of the new approach to readings may be compared to the existing approach. The findings from this first set of implementations will inform future strategies to increase the impact of online readings on students' overall performance in the course.

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APPENDIX

ENDOGENOUS VARIABLES

Final percentage score in the course (Final Score) determined from official course records.

Perceived overall impact of WileyPLUS (WileyPLUS Impact) determined as average of scores of the six survey questions presented below.

Rate your level of agreement with the following statements [1-Strongly Disagree…5-Strongly Agree].

Using Wiley PLUS…

- Helped me develop a better understanding of the concepts
- Helped me to better prepare for quizzes
- Helped me to better retain the material
- Made me feel more confident in my ability to learn the material for the course
- Helped me save time studying
- Helped me get a better grade in this course

EXOGENOUS VARIABLES

Overall, rate the usefulness of the Practice problems (weekly graded assignments in Wiley PLUS) to your learning:

Very useful (1)
Useful (2)
Neutral (3)
Useless (4)
Very useless (5)

Overall, rate the usefulness of the Reading assignments in Wiley PLUS to your learning.

Very useful (1)
Useful (2)
Neutral (3)
Useless (4)
Very useless (5)

For each of the following resources that you used in this course, indicate its value to you. If you did not use it, indicate that.

Module "Read About It" (text readings in Wiley Plus)
Module "Practice" (problems in Wiley Plus)

Did not use this (1)
Not at all valuable; I could have done without it (2)
Not valuable (3)
Neutral; it was nice to have (4)
Valuable (5)
Very valuable; I could not have done without it (6)