Student Perceptions of Online Resources as Predictors of Performance in a Hybrid Classroom: Exploratory Findings from a Large Engineering Economics Course

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Introduction

This paper presents research findings from a full implementation of a hybrid/buffet[1] approach to instruction deployed in a large Engineering Economics course following a successful pilot implementation in a previous semester. The course offered students a buffet of learning resources including online resources, classroom activities, and support resources. The primary online resource was an online learning environment managed by *WileyPLUS* consisting of a digital copy of the textbook with Reading and graded Problem assignments. Reading assignments directed students to specific sections of the digital text. Problem assignments required students to solve end-of-chapter problems and submit numerical answers. Each problem offered automated grading with immediate feedback, while some problems also offered additional support like tutorials or links to text. Students' "buy-in" and usage of the new instructional tools and strategies were critical elements for the success of this hybrid implementation. Therefore, in this study we focused on the students' perceived usefulness, value, and overall impact on their learning of the *WileyPLUS* 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. Studies show some evidence that giving learners an element of control over the online resources they use produces greater learning gains than instructor-directed environments.

In a "hybrid" course, a portion of the activities that would normally take place in the classroom is shifted to an online format. The result is reduced classroom time without reducing 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, 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, as described by Carol Twigg of the National Center for Academic Transformation[11]. In this approach, the hybrid learning environment is customizable for each student, allowing students to choose their preferred approach to the course from a buffet of learning options.

Inspired by these two models, and motivated by increasing course enrollments and reduced classroom space, the instructor sought to redesign an undergraduate engineering economics course. Redesign efforts were supported through grants from the University of Missouri System eLearning initiative and the Missouri University of Science and Technology (Missouri S&T) eFellows program[12]. The University of Missouri System initiative, launched in 2010, sought to expand access to college courses and degree programs by providing resources and training to faculty for course redesign. Similarly, the Missouri S&T eFellows program, established to improve student learning through the implementation of technology, offered course development support as well. This study will present some findings from a full implementation of the redesigned undergraduate engineering economics course that was part of the eFellows program.

Instructional Context

Two large sections of an undergraduate Engineering Economics course were delivered in hybrid/buffet mode during the Fall 2012 semester, following a successful pilot and full implementation in earlier semesters. A thorough discussion of the course structure, components, and preliminary implementation results may be found in Grasman et al.[13] As previously described, a variety of course components were utilized. The course components may be categorized as:

1. Online Resources
   a. *WileyPLUS*, the online learning environment associated with *Principles of Engineering Economic Analysis 5e* by White, Case and Pratt[3], consisting of a digital copy of the text as well as Reading and graded practice Problem assignments.
   b. Instructor-Created Modules, consisting of Introduction videos with learning objectives, Lessons in both PowerPoint™ and video form, and Example problem videos.
2. Classroom Activities
   a. Lessons, consisting of PowerPoint™ presentations with live annotation
   b. In-Class Problem Solving with polling, consisting of examples solved by students and/or the instructor with audience response
3. Support Resources
   a. Problem Solving Help, consisting of tutoring by skilled undergraduate Learning Assistants in a computer lab setting
   b. Live Chat, consisting of real time question and answer sessions facilitated through a chat tool
   c. Discussion Board, consisting of a thread for each Practice problem

In general, students were encouraged to utilize the resources that they found most useful to them as individual learners. Students could choose to participate in the Classroom Activities each class meeting. With this approach, they would be exposed to all fundamental course topics through Lessons and Problem Solving guided by the Instructor in the classroom. Alternately, students could choose to access the Online Resources to review material independently.

Students were not forced to choose an all-classroom or all-online approach and were free to change their mode of participation throughout the semester.

Although some students chose to attend regularly in the classroom while others preferred to review course material online, all students were assessed in the same manner. Course grades were determined by performance on four in-class exams (80% of overall grade) and weekly practice Problem assignments completed in *WileyPLUS* (20% of overall grade). Weekly, ungraded Reading assignments were also completed in *WileyPLUS*. In addition to the online and classroom resources, students were provided both face-to-face and electronic Support Resources. 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 a discussion board.

Since fewer than half of enrolled students participated regularly in the Classroom Activities, much student learning was taking place independently through online resources. The two primary online resources were *WileyPLUS* and Instructor-Created Modules respectively. Students used these two online resources to read assigned topics, watch videos related to specific course objectives and to complete weekly assignments. The *WileyPLUS* online resource will be the primary focus of this study.

WileyPLUS

The textbook used for the course, White, Case and Pratt's *Principles of Engineering Economic Analysis 5e*[14], 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, and could do so in lieu of, or in conjunction with, purchasing a hardcover textbook.

The *Reading* and *Practice Problem* components mentioned above were located in *WileyPLUS*, The *Reading* component was comprised of a specific reading assignment from the digital textbook. Each assignment linked students directly to specific sections of a chapter. The digital text appears almost identical to that of the print text, but also includes links to the Excel files that are used in text examples. 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 rather than a computer screen.

Practice Problem assignments in *WileyPLUS* generally included 8-10 or more problems chosen from the end-of-chapter questions in the text or created by the instructor. Most problems required students to analyze a situation, perform calculations, and report a numerical answer. All students were assigned the same problems, but many questions allowed for algorithmic generation of problem variables. Therefore, while all students were working with the same general problem statement and solution process, their numerical answers were unique. This feature allowed hundreds of students to complete the same assignment without the concern of students sharing answers with friends.

The assessment functionality of *WileyPLUS* automatically checked the student's answer against the correct answer and offered immediate feedback, either correct or incorrect. Students were allowed three attempts to reach the correct answer, and were offered various forms of support with each problem.

Many assignable 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 the specific problem. Further, some problems also offered "GO tutorials" which offered step-by-step 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.

Research Goals

Given the abundance of course components available for student learning, and the innumerable ways in which students may utilize those resources, many qualitative and quantitative studies may be conducted to analyze the redesigned hybrid/buffet course. For this study the research focus is informed by the Community of Inquiry framework that emphasizes the importance of students' interaction with the online content and tasks, known as cognitive presence[15,16] (Garrison 2000, 2007). In this study, we limit 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 study, we used path analysis, a form of Structural Equation Modeling (SEM) that 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[17].

Proposed Path Analysis Model

To test the predictive power of the perception measures associated with *WileyPLUS* on students' course performance we proposed the following exploratory path analysis model.
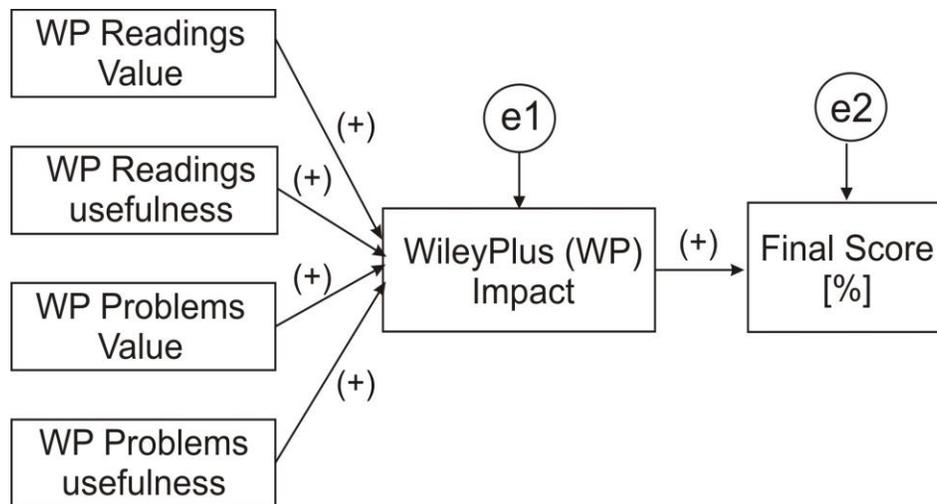
Figure 1. Proposed Path Analysis Model

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 final scores 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[TM], a tool that allowed the instructor to send individual invitations to each student and reminders to only those students that did not participate in the survey by a given time. 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 perceived overall impact of *WileyPLUS* on own learning respectively.

The perceived overall impact resulted from the evaluation of six statements related to the course concepts, quizzes, retention, confidence, time saving and grade and 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 was computed as the average of the scores for these six items.

The exogenous (independent) variables were: a) perceived value of *WileyPLUS* reading assignments, b) perceived usefulness of *WileyPLUS* reading assignments, c) perceived value of *WileyPLUS* graded practice problems and d) perceived usefulness of *WileyPLUS* graded practice problems. To measure the four exogenous variables we used single questions with a five-point evaluation scale for value (1- not at all valuable to 5 - Very valuable: I could not have done without it) and a five-point evaluation scale for usefulness (1- very useless to 5 - very useful). The actual items administered in the online survey are presented in the Appendix.

Results and Discussion

The cases/parameter ratio was ~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 Figure 1.

Results from the Basic Statistical Analysis

Table 1 presents the basic statistics for each of these measured continuous variables at the exit point and includes both the endogenous (dependent) and exogenous (independent) variables.

Table 1. Path Model Analysis: Basic Statistics for Path Variables

| | Variables | Correlations, Means and Standard Deviations | | | | | |
		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 1 clearly show that the items related to the two main types of activities associated with *WileyPLUS* online environment, reading assignments and practice problems, have different weights on students' perceptions on their overall impact on their overall assessment of this environment's impact on their own learning (column E in Table 1).
That is:

- the positive correlations between the perceived impact 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 value and value and usefulness of readings are only in the low to medium range (.33 and respectively . 35, $p < .01$).

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 (column F in Table 1).

Finally, the overall perceived impact of *WileyPUS* has 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 (Figure 1).

Fit and Adequacy of the Overall Model

Figure 2 summarizes the resulted path coefficients and their statistical significance.
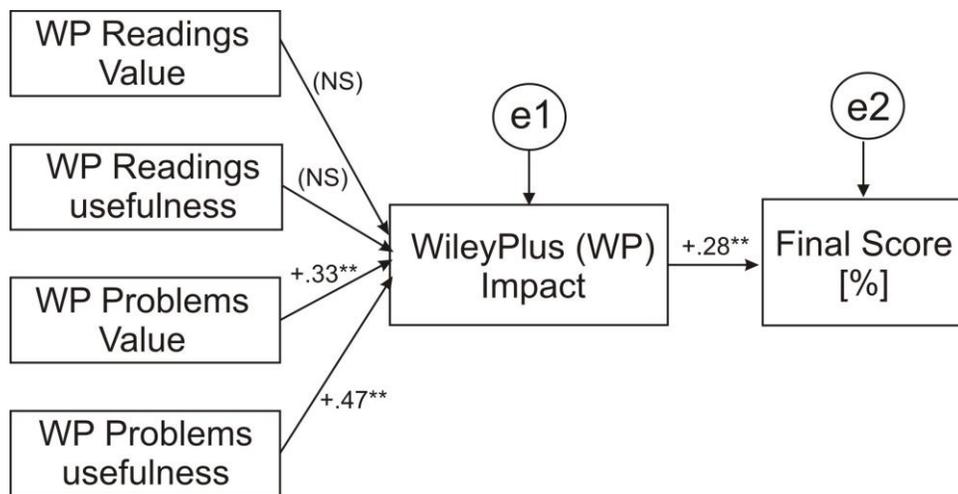

Figure 2. Path Coefficients for the proposed model

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[17,18]. 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[17].

Goodness-of-Fit Measures

All major goodness-of-fit statistics recommended in the literature[17,18] 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[18].

In addition, critical sample size statistic, Holter (p = .05) = 1213 is much higher than 200, a value that is indicative of a model that adequately represents the sample data used[17].

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 overall perceived impact of *WileyPLUS* and the value (+.33, p < .01) and usefulness (+.47, p < .01) of the practice problems clearly show that hands-on online activities are perceived by students as more beneficial for their learning performance when compared to the reading assignments that proved not to be significant predictors in the proposed model (see Figure 2).

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 and Future Research

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 be used 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 will be needed to identify a threshold value for the perceived impact to signal potential at-risk students at a point in the semester where failure can still be avoided.

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 such was the case of *WileyPLUS* online environment provide students with enough meaningful feedback to allow them understand the importance of these activities on their final course performance. Therefore, the instructional process will benefit if the instructors make sure to 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 students' perception related to the practice problems was impacted by the immediate feedback the online system provided in practice problems, while 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 on the course, students are allowed to choose from a variety of learning resources and may have opted to skip the reading assignments.

Further investigation of reading assignment completion rates may indicate a grade incentive is required for students to benefit from the assignment. Additionally, investigation of students' awareness of the valuable Excel files available for each example contained within the text of the readings may be surveyed. These findings will be used to reshape future strategies to increase the impact of online readings.

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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 in the table below.

Rate your level of agreement with the following statements. Using Wiley PLUS…

	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
-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 that you used in this course, indicate its value to you. If you did not use it, indicate that.

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