Piloting a Blended Approach to Teaching Statistics in a College of Education: Lessons Learned

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Abstract

This study investigated the performance of graduate students enrolled in introductory statistics courses. The course in Fall 2005 was delivered in a traditional face-to-face manner and the same course in Fall 2006 was blended by using an online commercial tutoring system (ALEKS) and making attendance of several face-to-face classes optional. There was no significant difference in the *t*-test comparing performance in the courses, which used the students' combined score on two mid-terms and the final exam to indicate performance. The ANCOVA analyzing influences on performance in the blended class yielded no significant influence for gender, ethnicity, age, or class type (traditional vs. blended), but a significant influence from students' incoming GRE-Quantitative score. Seven Likert questions on students' perception of blended learning were not correlated with student performance. Three focus groups – comprised of low-, medium-, and high-performing students – revealed three themes and several subthemes and differences based on students' performance level.

Key Words

Blended Learning, Statistics Instruction, ALEKS Software

Introduction

There is perhaps no more difficult subject to teach in a college of education than statistics. The types of students who are drawn to education are often motivated by a desire to work with students, improve schools, and pursue a career in a range of service occupations. Individuals drawn to graduate study in education are often intelligent and dedicated, but not all have a background in mathematical studies. For the teacher of statistics, some of these students may actually exhibit a high level of fear and aversion to the subject, which complicates the learning process. The challenge for any instructor of statistics is to prepare graduate students to understand and critique research studies using a range of statistics and to confidently design a high-quality research study of their own.

This study was motivated by the desire of a statistics professor to test a blended learning approach to teaching statistics. Statistical Methods Applied to Education I – or Stat I – covers the use and interpretation of such topics as frequency distributions, central tendency, Pearson correlation, linear regression, introduction to probability, normal distribution, hypothesis testing and use of computer software in statistical analysis. It is a required course for the 15 master's and doctoral programs in this particular college of education. Therefore, it is taught every term and must address the learning needs of a diverse group of students.

For Fall 2006, Stat I was augmented by a web-based software system called Assessment and LEarning in Knowledge Spaces or ALEKS (http://www.aleks.com). The system is an artificial intelligence-based learning environment that provides assessment of learning, remediates gaps in student learning and preparation, monitors student performance, and provides explanations and feedback. Traditional pedagogical approaches were combined with ALEKS to provide students with a blended class: part online and part face-to-face. Using a mixed-methods study design, this research evaluates how well the approach worked in comparison to a more traditionally taught statistics course, analyzes in depth the influence of blended learning on student performance, and discusses improvements to be made in future statistics courses.

Theoretical Background

Blended Learning

The Sloan-C Consortium adopted the following definition to provide some precision to the term of "blended learning:"

1. Courses that integrate online with traditional face-to-face class activities in a planned, pedagogically valuable manner; and
2. Where a portion (institutionally defined) of face-to-face time is replaced by online activity (Picciano, 2006).

To date, several books and articles on blended learning have focused on how to and when to blend (Bonk & Graham, 2005; Kaleta, Skibba, & Joosten, 2007; Thorne, 2003; Vaughan, 2007). Studies on blended learning have only recently begun to be undertaken by many researchers. The Sloan-C Consortium has recently published a book on blended learning (Picciano & Dziuban, 2007) that focuses on theories and questions on blended learning. Currently, research on blended learning has focused on effectiveness (Vignare, 2007), with some studies finding positive results (Dziuban, Hartman, Moskal, Sorg & Truman, 2004; Graham & Robison, 2007; McCombs & Vakili, 2005) and others questioning whether blended learning is really better than fully online learning (Reasons, Valadares & Slavkin, 2005; Wu & Hiltz, 2004). It does not appear that many studies have been done to understand the specific mechanisms by which blended teaching impacts learning. In a comparison of a traditional versus blended class in accounting, Chen and Jones (2007) found that while both methods produced similar learning outcomes, the students in the blended class felt their analytical skills improved more than students in the traditional class, but traditional class students felt the clarity of instruction was higher. With inconsistent findings such as these, more research is certainly needed to explore what types of learning may be more effective in which setting – face-to-face or online – or how to best combine or integrate the two settings to ensure student learning.

Media Comparison Studies

Media comparison studies comprise the majority of the studies included in the "no significant difference" literature (http://www.nosignificantdifference.org). Russell (1999) prepared several editions of this book which compiled “no significant difference” studies, now totaling 355 studies and growing. These studies often compare end-of-course grades or final exam scores of two courses, one taught in a traditional fashion and the other taught via some technology, either satellite, interactive television, etc. Although it is difficult to conduct experimental studies in educational research, these studies have been criticized as being too broad and poorly designed, rarely matching students or carefully controlling treatments, assuming that using the same instructor to teach both courses would be sufficient. It is argued that, in such a design, too many other variables can intercede to affect the outcome, making such comparisons unable to discriminate the actual influence – if any – of the technology or delivery method.

Despite this criticism, media comparison studies continue to appear in the literature and are undertaken by faculty. Meyer (2004) has argued that media comparison studies serve a useful purpose since the individual instructor has a need for proof that the technology is not harmful and perhaps may even be beneficial for student learning. This was termed “personal journey research,” or research undertaken not for its ability to contribute to the literature or stretch the boundaries of what is known, but for its ability to help individual instructors come to better understand the technology and prove to themselves that it helps students learn. Therefore, it is unlikely that media comparison studies will vanish anytime soon.

In this study, the initial question is to compare the performance of students in the blended learning class using ALEKS with the performance of students in an earlier class not using ALEKS. This was an essential first step for the instructor. Second, the major focus of this study was to collect and analyze students’ perceptions of the blended learning class and how it impacted students’ learning of and attitude towards statistics.

ALEKS

ALEKS was developed by a group of software engineers, mathematicians, and cognitive scientists at the University of California, Irvine and New York University with support from the National Science Foundation. ALEKS is an online tutoring system that takes an artificial intelligence approach to teaching statistics and assessing student learning individually and continuously. It is commercial software that is marketed to K-12 schools, higher education, and private users such as parents or tutors.

ALEKS is based upon a field of study called "Knowledge Space Theory" (Falmagne, Koppen, Villano, Doignon & Johannesen, 1990; Doignon & Falmagne, 1999). Knowledge Space Theory is a mathematical language that describes the ways in which particular elements of knowledge (concepts in Algebra, Mathematics, Accounting, and Statistics, for example) are organized to form distinct knowledge states. For example, Arithmetic is regarded as a domain of roughly one hundred basic concepts, giving rise to a structure of approximately 40,000 knowledge states (ALEKS, n.d.a). Computer algorithms have been developed to construct discipline-specific knowledge structures (known as "Knowledge Spaces") and apply them to assess knowledge states of individuals.

ALEKS does not use multiple choice questions, but instead uses questions like traditional paper and pencil exercises. A student selects a module to learn, reads the online text as well as the examples, and then ALEKS provides a number of practice problems. After a number of modules, an assessment then tests the student's progress by asking 10 to 15 questions. Based on the assessment result, ALEKS develops a profile of the student's knowledge: that is, which topics have been mastered and which have not. In subsequent assessments, ALEKS tests new knowledge but also includes questions from previous modules. If the student fails to show mastery of certain modules, he/she has to repeat them. Therefore, each set of questions is unique, making it impossible to predict which questions will be asked. The student can track his/her learning of the course topics throughout the semester, and so can the instructor.

As for evidence of its effectiveness, some studies indicate that ALEKS improves student learning. In a 2002 study of 256 students in college algebra, Briggs (2007) found that students in three of the four sections of a course using ALEKS outperformed the control groups; furthermore, adopting ALEKS doubled the number of students successfully completing algebra. In a test of ALEKS in behavioral statistics courses (Hu, Luellen, Okwumabua, Xu & Mo, 2007), the performance of African-American students in ALEKS sections closed the gap in performance with Caucasian students which had been in effect in earlier, lecture-based courses, and essentially equalized statistics performance for both groups. The ALEKS website claims an approximate 90% average learning rate. The website also provides testimonials from users, including claims that the percentage of developmental math students moving on to College Algebra increased from 35% to 61% with ALEKS, and that ALEKS classes had a 35% improvement in the number of students passing final exams in financial accounting (ALEKS, n.d.b). Clearly, there is a need for additional research into this product.

Research Questions

This study was designed to address five questions:

1. Are there differences in performance between the blended class and a traditional offering of Stat I?
2. For students in the blended class, are there any relationships between aspects of blended learning and performance?
3. What advantages or disadvantages do students perceive to teaching statistics via ALEKS or by blending Stat I?
4. Is there a relationship between student perceptions of online components, ALEKS, and their performance?
5. How has the experience with this blended course influenced students' perception of online learning?

The unique contribution of this study is its qualitative examination of how blended learning impacts student performance and attitude toward blending as well as its exploration of how changing the format of a class can meet students' learning needs.

Methodology

Blended Stat I

The Stat I course was blended in several ways. First, the ALEKS software was integrated into the Stat I course curriculum. Students were assigned modules in ALEKS corresponding to the topics covered in class each week and were expected to complete the modules before coming to class. This provided an online component that would allow students to take the time needed to learn new concepts, have their learning assessed, and to do so with the infinite patience and 24x7 capabilities of a web-based program.

Second, class attendance was required for only five classes spread across the beginning, middle, and end of the course; attendance at other classes was made optional. If a student felt confident he/she understood the content within the module and text, they could choose not to attend class. However, the instructor was available during traditional class times to discuss the concepts, answer questions, and demonstrate problems. This structure was thought to provide students more flexibility in their learning choices – they could opt for online or traditional instruction – and to do so in a pedagogically sound manner that recognized differences in students' mathematical preparation, aptitude for statistics, and learning styles.

Research Method

This research was conducted using a graduate-level introductory statistics course in the college of education of a mid-south urban university. The college of education enrolls the greatest percentage of graduate students at the university, totaling 1024 students or 24.6% of total graduate enrollment at the university in Fall 2006. Graduate students in the college are racially diverse as were the students included in this study (see Table 1 for the distribution by gender and ethnicity of the college and the sample).

TABLE 1: Demographic Distribution of Graduate Students in College of Education (Fall 2006)

Ethnicity	College of Education (Fall 2006)						Sample (Stat I in Fall 05 & 06)					
	Female		Male		Total		Female		Male		Total	
Asian	7	0.7%	0	0.0%	7	0.7%	2	2.3%	1	1.2%	3	3.5%
African American	296	28.9%	79	7.7%	375	36.6%	15	17.4%	7	8.1%	22	25.6%
Hispanic	4	0.4%	3	0.3%	7	0.7%						
White	442	43.2%	158	15.4%	600	58.6%	38	44.2%	18	20.9%	56	65.1%
American Indian	1	0.1%	0	0.0%	1	0.1%						
Foreign	19	1.9%	15	1.5%	34	3.3%	2	2.3%	3	3.5%	5	5.8%
Total	769	75.1%	255	24.9%	1024	100.0%	57	66.3%	29	33.7%	86	100.0%

These students are pursuing master's or doctoral degrees in teaching, instruction and curriculum, instructional design and technology, reading, early childhood education, or special education, human movement science and clinical nutrition, educational psychology and research, counseling psychology, school administration and supervision, leadership and policy studies, and higher and adult education. Stat I is offered every semester, often in multiple sections, and has only one prerequisite course, a master's level course titled, "Introduction to Educational Research."

The blended version of Stat I was taught Fall 2006 and included 41 students in two sections. A traditional version of Stat I offered Fall 2005 that included 45 students was chosen for this study; this offering of Stat I was chosen as the comparison because students from the two semesters were alike in terms of gender ($\chi^2 = 2.10$, $p = 0.15$) and race ($\chi^2 = 1.64$, $p = 0.44$). They also shared similar attitudes, because when asked for their reason for taking the course at the beginning of the course, all students responded "it is required" in both semesters. The instructor for both courses was the same as were all exams. Approval was gained from the institution's Institutional Review Board for this study. Students signed informed consent forms if they agreed to participate in the study.

Data Collection and Analysis

Data were collected at three points in the course; these will be described in reverse chronological order. First, student performance was calculated by summing scores on the first and second mid-terms and the final exam; this composite score was used as the dependent variable measuring student performance. Because the exams for both offerings of Stat I (in Fall 2005 and Fall 2006) were exactly the same, the results were considered comparable. Demographic information about students (gender, ethnicity, and age) from both courses was obtained from the Institutional Research Office as well as the students' incoming GRE-quantitative scores. These data were analyzed using ANCOVA to answer research question 1. Because of the relatively small size of the sample, $\alpha = 0.05$ was chosen as the level of significance for hypothesis tests.

Second, 28 students in the Fall 2006 blended class completed a three-page survey immediately before the final exam that included several Likert questions about blended learning, coded

"strongly disagree," "disagree," "neutral," "agree," and "strongly agree." The seven questions were: (1) "After learning the required topics in ALEKS, it becomes easier to read and understand the chapters in the textbook," (2) "I wish ALEKS matched better with the book chapters," (3) "I attend optional classes," (4) "ALEKS helps my understanding of the lectures in the required-attendance classes," (5) "I really think I would do better in this class if it were taught in traditional classroom format," (6) "Overall, I enjoy online learning," and (7) "I think the class format is working, but changes are needed to make the ALEKS program a better fit." Participation in the survey was optional and survey results were sealed and given to the instructor only after the course was finished and the final course grade was assigned.
The relationship of these Likert items to the students' performance in the class was evaluated using Pearson's correlation and used to answer research question 2.

Third, right before the end of the course, a qualitative researcher met with three focus groups to elicit expanded comments on the blended learning format and ALEKS. The three groups were defined by their cumulative scores on the first and second mid-terms, thereby forming low-, medium-, and high-performing groups. These sessions were video recorded and then transcribed for analysis. Analysis followed standard procedures for qualitative research (Maxwell, 1996), including the identification of themes and then a determination of whether themes were consistent or inconsistent across individuals or groups. Four students from each performance group were invited to these focus groups, but only two or three students volunteered and participated in each session. Their comments helped answer research questions 3 and 4.

Finally, the three-page survey mentioned earlier also included three open-ended questions; answers to one question ("How did the class format influence your attitude toward online learning?") were analyzed for consistency in themes and used to answer research question 5.

Limitations

This study was limited in three ways. First, it included only 41 students in the blended learning portion of the analysis. The sample is relatively small, but qualitative and quantitative findings were cross-validated to improve the validity of this study. Second, it represented the instructor's first exploration into blended learning, and while much was learned during the process and many aspects of the blended course will be changed in future offerings, it would be inappropriate to assume this situation would be replicated by others. Therefore, generalizing results from this study should be done with caution. Last, several students were allowed to discontinue working with ALEKS after the second mid-term exam (or approximately two-thirds into the course) because of their difficulty to move forward with an overwhelming number of modules to be relearned. This change could influence the final results of the study, but was deemed important to be responsive to student needs at a critical time in the class.

Results

Differences in Performance: Blended vs. Traditional

Research Question 1 asked, "Are there differences in performance between the blended class and a traditional offering of Stat I?" Table 2 presents the results from the *t*-test comparing student performance in the blended class to that of students in a traditional class. With a highest possible score of 160 from the combined three exams (two midterms and one final), the table indicates that the blended class was seven points higher than the traditional class, but this difference was not statistically significant.

TABLE 2: *t*-Test of Student Performance, Blended versus Traditional Class

Group Statistics				*t* test			
Year	N	Mean	Std. Dev.	Mean Difference	*t*	*p.* (2-tailed)	95CI
Fall 2005	45	123.34	24.14	-6.90	-1.30	0.20	(-17.43, 3.63)
Fall 2006	41	130.24	24.96				

In order to control potentially confounding variables, student's gender, ethnicity (African American versus others), age, and incoming quantitative GRE score were incorporated into the analysis. An ANCOVA analysis was conducted (Table 3) in which total exam score was the dependent variable; independent variables included gender, ethnicity, and class type (traditional vs. blended), and age and GRE-Quantitative score were the covariates. Age was found non-significant as a covariate and removed from the ANCOVA model to save a degree of freedom. The rerun of ANCOVA model without age showed that gender (F =0.56, p = 0.46), race (F

=2.19, *p* = 0.12), and class type (*F* =0.07, *p* = 0.80) were not statistically significant influences on student performance, but the student's incoming quantitative score on the GRE was. After the GRE-Quantitative score was controlled for, student performance in the two class formats lacked statistical difference. The underlying assumptions of ANCOVA were also checked for homogeneity of variance, linearity, and homogeneity of regression. Homogeneity of variance was confirmed (*F* =0.874, *p* = 0.57), and GRE-Quantitative score as the covariate was linearly related to the dependent variable and had no interaction effects with the independent variables. Thus, this result was deemed valid; it captured the student's basic ability or preparation in math, which in turn influenced performance in statistics.

TABLE 3: ANCOVA of Influences on Student Performance

Source	Type III SS	*df*	MS	*F*	*p*
Intercept	8110.39	1	8110.39	24.77	0.00
Gender	182.01	1	182.01	0.56	0.46
Race	1436.61	2	718.30	2.19	0.12
Class Type	21.86	1	21.86	0.07	0.80
GRE-Quantitative	11957.61	1	11957.61	36.52	0.00
Error	23574.75	72	327.43		
Total	46850.86	77			

(a) R^2 = 0.498 (Adjusted R^2 = 0.456)

Blended Learning's Relationship to Performance

Research Question 2 asked, "For students in the blended class, are there any relationships between aspects of blended learning and performance?" Table 4 presents the Pearson correlations for the Likert items dealing with blended learning and student performance in the class. None of these Pearson correlations was close to significance. The non-significance may be related to insufficient statistical power due to small sample size; in any case, these Pearson correlations must be discarded from further analysis.

TABLE 4: Pearson Correlation between Blended Learning Questions and Performance (n=28)

Item	Pearson Correlation	*p*
"After learning the required topics in ALEKS, it becomes easier to read and understand the chapters in the textbook."	0.093	0.638
"I wish ALEKS matched better with the book chapters."	0.092	0.641
"I attend optional classes."	0.054	0.783
"ALEKS helps my understanding of the lectures in the required-attendance classes."	-0.143	0.467
"I really think I would do better in this class if it were taught in traditional classroom format."	-0.145	0.462
"Overall, I enjoy online learning."	0.063	0.751
"I think the class format is working, but changes are needed to make the ALEKS program a better fit."	0.093	0.639

Advantages and Disadvantages to ALEKS

Research Questions 3 and 4 were combined for this analysis. Research Question 3 asked, "What advantages or disadvantages do students perceive to teaching statistics via ALEKS or by blending Stat I?" and Research Question 4 asked, "Is there a relationship between student perceptions of ALEKS and their performance?" Focus group transcripts were analyzed to answer these questions, which resulted in three main themes -- *ALEKS*, *students*, and *instruction* -- and several sub-themes. However, some themes were inconsistent based on the performance level (low, medium, high) of the student. The following discussion treats each theme and sub-theme by frequency of occurrence, and notes differences based on student performance.

ALEKS. Most comments were about *ALEKS* and included five sub-themes: assessments, alignment, time, repetition, and working the system. The *assessments* were criticized for being too many and too frequent, adding topics on missed questions, and not specifying what was missed or misunderstood. A comment from a medium-performing student stated the problem this way: “At one point I was down to like 3 or 4 [topics]. Then I had an assessment. It jumped up to like 27 [topics].” This student’s complaint (echoed by others) was that topics already learned were included in assessments, and this was both unexpected and unwelcome. The usual and time-honored approach to education is to deal with a topic, learn it, and go forward, only to return to the topic on a mid-term or final exam. ALEKS’ recursive approach to testing was not a boon for some students. In fact, the word most commonly applied to the assessments was “frustrating.” The second complaint arose when ALEKS warned the student “if you miss one more we’ll try something else.” The students in the group joked that ALEKS was telling the student “you’re a moron.” Students who are insecure may require more emotional support during learning, something that may be difficult for a computer program to do.

A second sub-theme dealt with *alignment* of the textbook used in the course and ALEKS. Almost all of the participants in the focus groups commented on this issue, but the groups had different perceptions. The low- and medium-performing groups were more likely to stress misalignment of the text and ALEKS. This comment was illustrative: “The book and ALEKS…use different terms for things.” However, an individual in the high-performing group had a different view: “ALEKS and then the textbook really worked well together…reinforced the concepts.” Perhaps the students view alignment differently: one group focusing on an exact match of terms and examples, the other group focusing on how the two forms can be mutually reinforcing or beneficial. This interpretation requires further investigation.

A third sub-theme was about *time*. Although warned by the instructor at the beginning of the course to study approximately 9 hours per week outside of class, several students in the low- and medium-performing groups mentioned the amount of time it took to work in ALEKS, especially the assessments. The more difficulty they had learning the material, the longer it took, and this was perceived to be an excessive demand on the students’ time.

A fourth sub-theme was the role of *repetition*. As one individual in the low-performing group said, “The nice thing about [ALEKS] was you did repetitiously go through it. And so you saw it and saw it and saw it.” This individual perhaps understood the importance of repetition in the abstract, but not when facing an assessment that might take several hours to finish.

A fifth sub-theme was how some students *worked the system*. They would print off a lesson in ALEKS, and then log off to read it. By logging off, they would lessen the time online, delaying the assessment that would "pop up" every 10 hours. This should not surprise us, because if there are ways to work the system, students will find them.

Students. The students commented on their own role as well. Two sub-themes arose: *attitudes* and *math skills*. For the sub-theme of *attitudes*, they stressed a student's responsibility to come to class, to come prepared, and to bring textbooks to class. One student "fell behind in ALEKS," which was stressful but also indicated a lack of responsibility for completing weekly assignments. Another attitude mentioned was fear. A student in the high-performing group stated, "I think a lot of people are just afraid of statistics." Another attitude that was found valuable for one student was looking at math as a "puzzle-solving exercise."

Math skills were deemed important by many students, irrespective of performance group. But as one low-performing student put it: "My worst subject is math. Math has always been a challenge to me." Generally, the students who had taken higher-level math courses and/or an undergraduate statistics course felt better about taking statistics at the graduate level. "I had to have an undergraduate stats class to take a graduate research methods class and it was very similar to the stuff that we're learning here." There was also some evidence of a particular barrier to understanding math, i.e., trouble understanding formulas. "I like ALEKS more…the book is more formulas and math and ALEKS has examples…if I see the examples without the formula…I got it. But if I see the formula…it confuses me." These comments may be particularly helpful in developing specific curricular changes that could solve these problems.

Instruction. The students in the focus groups were also asked about the instructor and the instructional techniques chosen for the class. Two sub-themes emerged that may be particularly relevant for blended statistics: *modeling* and *attendance*. *Modeling* referred to two interrelated instructional tactics: working problems out on the board and showing the work. "I definitely get a lot more out of seeing somebody…work it out on the board and…explaining as they go." One of the criticisms of ALEKS was "there's no way to show your work…So if I'm feeding it the right answer then it assumes I'm doing all the steps." By attending class and watching the instructor either show the steps or critique the steps taken by the students, students saw how problems could be done correctly and have their missteps and misunderstandings corrected.

Attendance, especially at the optional classes, was a more complicated topic. Students at all performance levels liked having optional classes. However, attending the optional classes became more important to the students in the low- and medium-performing groups. What was interesting about this was not that those who were struggling opted to attend these classes, but some of the reasons mentioned for why attendance mattered. Certainly, seeing problems worked out on the board was important, as has already been mentioned. But it was also important because the other students asked questions that had not yet occurred to the student: "When other students ask questions, then I'm like, 'I could've asked that.' But then since they asked it, [the instructor] answered it and I'm writing it down." Another student added, "[hearing the] dialogue back and forth…then getting to actually ask a question the way you need to…you can't do that on the computer." In other words, it took attending class with other students and a good instructor and watching the interaction among them to ask a really good question.

These themes and sub-themes indicate that students found advantages and disadvantages to blending using ALEKS. There is consistent evidence that students in the high-performing group saw the experience differently from peers in the low- and medium-performing groups. Performance levels made the experiences of students different, from frustration to appreciation and struggle to ease.

Influence on Perceptions

Research Question 5 asked, "Has the experience with this blended course influenced students' perception of online learning?" The results are interesting and can be summarized as "I like online, but…" This interesting twist became apparent when the responses to the open-ended question on the survey were incorporated into the analysis. The question asked was, "How did the class format influence your attitude toward online learning?" As phrased, the question was not a direct assessment of ALEKS, but answers would clearly be influenced by feelings generated by the ALEKS experience.

Of the 28 students responding to this open-ended question, eight expressed negative opinions about online learning and two expressed no opinion, but the remainder – 18 students – expressed positive opinions. One might think this result odd in comparison to the often intense negative comments garnered during the focus groups, but in fact, many of the comments that were clearly supportive of online learning contained a "but." The "buts" sound familiar, however. They liked online learning, but for the "assessments" (four mentions), a lack of alignment between the text and ALEKS (four mentions), too much repetition (one mention), and a lack of Internet access at home (one mention). The relative consistency with the results from the focus groups tended to confirm that despite low numbers of participants in the focus groups, the analysis of the groups' comments captured the issues that concerned all of the students in the blended class. In conclusion, despite some difficulties with ALEKS, these students liked online learning. This is an interesting endorsement from experienced -- and critical -- consumers.

Discussion and Recommendations

This research represents the first time the instructor attempted to teach Stat I in a blended learning context and to evaluate this teaching approach both quantitatively and qualitatively. Much was learned that can guide the revision of the course and provide better understanding of how the format of a class influences student learning. First and most clearly, math skills and preparation for statistics seemed to make a difference in performance, as evidenced by the comments in the focus groups and the influence on student performance of the students' incoming GRE-Quantitative scores. This argues for the need for some preparatory units on essential math skills or mathematical concepts or better attention to the GRE-Quantitative score when admitting new graduate students.

Second, in the blended class, the online component was clearly important. While most students had a positive attitude towards online learning and the flexibility of blended learning, many suffered setbacks because they did not appreciate the learning theory behind ALEKS, including its emphasis on mastery learning which required the repetition of earlier concepts. Also, based on student comments, there needs to be a good alignment of the text and online system, including direct connections between approaches and language. The consistency between the two components – face-to-face and online -- of blended courses warrants more attention as more classes experiment with various commercial software packages such as ALEKS.

ALEKS and similar commercial software learning systems may also need to consider adjusting their approach. Students may need better explanations of what was missed in an assessment as well as less frequent assessments with fewer items. At least for students who are already struggling with learning statistics, they might do better with more regular but smaller, discrete assessments. And it may be worthwhile for commercial vendors to align their software to work closely with an existing textbook that is widely used, since this seemed to be a problem for many of the Stat I students.

What is there to make of the lack of relationship between the Likert items on various aspects of blended learning and student performance? Certainly any conclusions must be tentative as there were few (n=28) responses to the survey, and this might affect the reliability of the results. But it is likely that there was no relationship, and that blending as was done in this class had little effect on performance. Put another way, perhaps quantitative ability and skill as captured in the GRE-Quantitative score is more critical to learning a subject like statistics than experimenting with the instructional format. That is an assertion that should clearly be tested in a future study. On the other hand, given the systematic variations that emerged from the students at different performance levels in regards to blended learning and ALEKS, future research ought to explore how to modify the elements of blended learning and adjust instructional approaches to meet the needs of students at different levels.

The larger issue that remains open is whether uses of software such as ALEKS can help improve the understanding of statistics for students who may be math-averse or do not possess strong preparation in math. This situation is common in education, as was noted in the introduction, because the majority of students specialize in instruction, psychology, or their primary field of study. Since students with problematic attitudes toward math or inadequate quantitative skills comprise a portion of the students in many fields, how can blending be used strategically to address holes in the preparation or understanding of students? Certainly, merely adding online components to make a blended course may not improve student learning, unless it is done in a thoughtful and strategic manner that addresses specific student learning needs. Can blending do this so that students gain confidence rather than question their abilities or feel like a moron? If blending can address this problem, then it will have proven its worth to students wherever and whatever they study.

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