A Study on Student Perceptions of an Adaptive Learning System in College Algebra and Its Effect on Course Performance

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Abstract: College-level introductory math courses are notorious for students' high rate of failure and lack of mastery. Adaptive learning systems were created to address these problems. However, research on these systems is limited. The purpose of this study was to examine students' satisfaction with the use of an adaptive learning system in an introductory college math course. Additionally, final grades of students who used the system were compared to final grades of students who did not use the system. Results revealed that students who used the system had higher final grades than students who did not use the system. Therefore, it would benefit students if use of the adaptive learning system was continued in introductory math courses.

Introduction

Failure in introductory college math courses is at an all-time high (Boggs, Shore, & Shore, 2004). Failure, as defined by the Department of Mathematics at Allegany College of Maryland, is earning a score of less than 70 percent on a test or other assignment (Boggs et. al., 2004). These courses are also typically general education courses that are required for students to graduate. Therefore, when students are unable to pass the course, they fail to graduate. Introductory math courses emphasize the basics of mathematics and are often heavily populated with students who have not been previously successful in math. Often, students who struggle with a particular mathematical concept in these classes are left behind as their classmates move to the next concept.

Many researchers have argued that introductory math courses often disregard three important principles of good instructional design: engagement, mastery, and taking pre-requisite knowledge into account. However, adaptive learning systems can implement all of these components of an effective course and, thereby, increase student success. Although accessed through the use of a computer, adaptive learning systems can be used effectively in both online and face-to-face courses. Using these systems in either environment allows students to work through content on their own. Then, time communicating online or face-to-face can be spent collaborating and engaging with other students or the instructor for a deeper learning experience.

Most adaptive learning systems promote mastery learning by allowing students to work at their own pace and only permit them to move to the next concept once they have proven mastery of the current one. These systems often work by having students log into a website where they take a pre-test, letting the system detect each student's existing knowledge and learning preferences. These diagnostic steps allow students to discover how much they already know and what content they have yet to learn. The system then creates an individualized learning path, opening new content areas only after the student masters the current topic.

Thus, having students with varying levels of pre-requisite knowledge is no longer a critical issue for courses employing an adaptive learning system. Such courses are not taught at a single level since the system detects each student's current achievement level and then proceeds from there. Students who lack the expected background content can gain that knowledge through remediation in the adaptive learning system (Howard, Remenyi, & Pap, 2006). By being assigned questions based on learner level, students are more likely to be engaged in the content (Clayton, Blumberg, & Auld, 2010) and will not waste time on content that they have already mastered or that is too advanced for them (Walkington, 2013).

Although adaptive learning systems can incorporate each aspect of good course design, the actual impact of using such systems is largely unknown. There is also a lack of research on user evaluation of adaptive systems, especially in mathematics courses where these systems are most needed (Fischman, 2011). The studies that do exist typically involve small numbers of participants. These small-scale studies, which are conducted mostly in

secondary schools rather than in higher education, are qualitative studies that do not offer the statistical analyses that quantitative studies can. Additionally, these existing studies often involve the manipulation of multiple confounding variables, so the effectiveness of using adaptive learning systems remains largely undetermined (Fischman, 2011). Although the concept of these systems works in theory, whether or not they work in practice, particularly in college-level introductory math courses, has yet to be determined.

The Study

This study was designed to examine students' self-reported satisfaction with the use of the adaptive learning system, ALEKS, and how much time they invested in its use. The study also compared the results from students using the system in an online environment with the results from students using the system in a traditional face-to-face environment. To gauge the system's effectiveness, final grades of students who used the system were compared to a control group who did not. The specific research questions investigated were:

1. How satisfied are students in college algebra with ALEKS in their course?
2. Is there a relationship between how satisfied students are with ALEKS and how much time they invest into using the system?
3. Is there a relationship between how satisfied students are with ALEKS and their enjoyment of mathematics?
4. Are there differences in student satisfaction with ALEKS in college algebra between students taking the course online and face-to-face?
5. Are there differences in the distribution of final grades between students who did and did not use ALEKS?

Findings

To examine if there was a relationship between student satisfaction with the adaptive learning system and how much time they invest into using the system, a multivariate correlation test was performed between Items 1 and 2 (measures of the amount of time that students used ALEKS each week) and Items 4 – 11 (measures of student satisfaction with ALEKS). As shown in Tab. 1 below, there was no correlation between either the hours spent or the number of times students logged into the system each week and their perceived satisfaction with ALEKS. However, when the hours the students spent in the system and the number of times they logged in were considered together, the correlation between time invested and satisfaction with the system was significant at $\alpha = .01$ (Tab. 1).

Effect	Hypothesis df	Error df	Sig.
Intercept	8.000	196.000	.000*
Item 1	8.000	196.000	.132
Item 2	8.000	196.000	.303

Note. * indicates that the item is significant at $\alpha = .01$

Table 1: Multivariate Correlation Between Items 1-2 and Items 4 – 11.

A summary of the response frequency for each of the eight Likert-scale items in the survey is below (Fig. 1). This scale ranges from Strongly Disagree to Strongly Agree and describes student opinions about ALEKS.

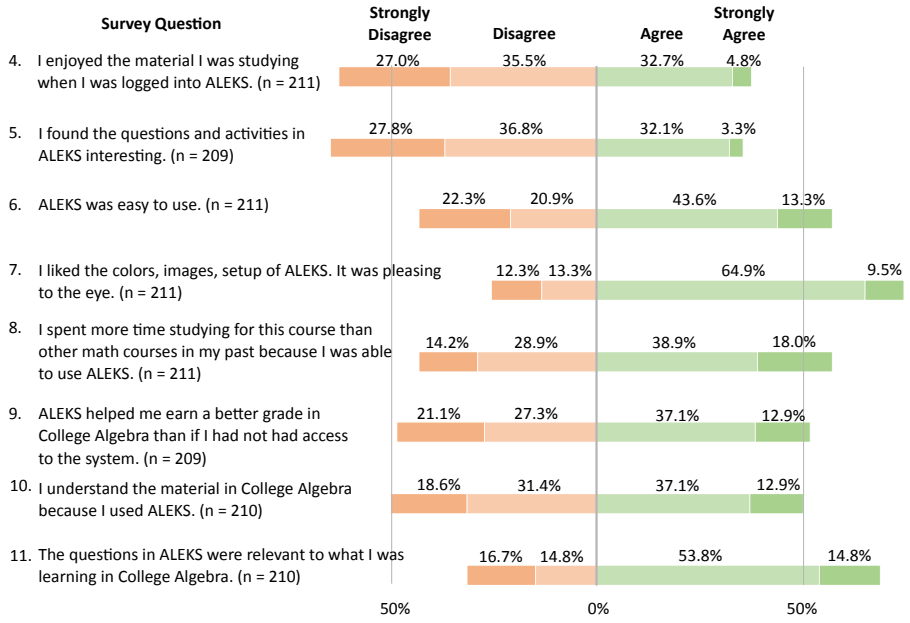

Figure 1: Summary of Student Responses to Survey Items 4 – 11.

By disagreeing or strongly disagreeing with the statements in Items 4 and 5, almost two-thirds of the students indicated that they found the questions and activities in ALEKS neither enjoyable nor interesting. As for ease and pleasure of use, just over half of the students found ALEKS easy to use, while almost three-quarters liked the colors, images, and setup of ALEKS. As for the benefits of using ALEKS (Items 8 – 10), just over half the students felt they spent more time studying because of ALEKS. The number of students who felt that ALEKS helped them earn a better grade or better understand the course material was split almost evenly between those who agreed and those who disagreed. Finally, on relevancy (Item 11), over two-thirds indicated that ALEKS was relevant to what they were learning in their course.

To examine if there was a relationship between student satisfaction with the adaptive learning system and their enjoyment of mathematics, survey Items 4 – 11 (related to satisfaction with ALEKS) were individually correlated with Item 3 (enjoyment of mathematics). These results are shown below (Tab. 2).

	Item 4	**Item 5**	**Item 6**	**Item 7**	**Item 8**	**Item 9**	**Item 10**	**Item 11**
Chi-Square	22.563*	10.394	11.531	3.733	6.378	5.697	8.612	.911
Note. * indicates that the item is significant at $\alpha = .01$								

Table 2: Chi-Square Test for Independence Between Survey Item 3 and Items 4 – 11.

The only significant relationship ($\alpha = .01$) was between Item 3, to what extent students enjoy math, and Item 4, to what extent students enjoyed the material they were studying. This result shows that as students reported to be more satisfied with the adaptive learning system, these same students also reported a higher level of enjoyment with the material they were studying in the system. However, since the other items did not have a significant correlation with their satisfaction of mathematics, students' beliefs about the benefits of the adaptive learning system were shown to not have been affected by their attitudes towards mathematics in general. In other words, how much students like math is correlated with how much they like course content, but it is not correlated with how much they like the adaptive learning system.

An Independent t-test was used to determine if there were any differences in satisfaction with ALEKS among those students taking college algebra online and those taking it face to face. The mean scores for each of the two

groups were compared for each of the eight items (Items 4 – 11), and the results of the corresponding Independent t-test are summarized below (Tab. 3).

		Levene's Test for Equality of Variances		
		F	Sig.	t
Item 4	Equal Variances Assumed	1.988	.160	-1.687
Item 5	Equal Variances Assumed	2.724	.100	-1.679
Item 6	Equal Variances Assumed	2.878	.091	-1.202
Item 7	Equal Variances Assumed	1.059	.305	-1.021
Item 8	Equal Variances Assumed	1.525	.218	-1.401
Item 9	Equal Variances Assumed	.013	.908	-1.402
Item 10	Equal Variances Assumed	.055	.815	-1.177
Item 11	Equal Variances Assumed	1.875	.172	-1.128

Note. * indicates that the item is significant at α = .01

Table 3: Independent t-test on Items 4 – 11 Between Face-to-Face Students and Online Students.

As can be seen in Tab. 3, none of the items between the two groups were significant at α = .01. Therefore, there were no significant differences in student satisfaction with the adaptive learning system between students taking college algebra online and students taking college algebra face to face.

To analyze differences in final grades between students who did and did not use ALEKS, the frequency for each letter grade was first tabulated for both semesters. A comparison of the five letter grades (A – F) for each of the two semesters is below (Fig. 2). As can be seen, there were more As and Bs and fewer Cs, Ds, and Fs during Fall 2014 Semester when ALEKS was used compared to Spring 2013 Semester when ALEKS was not used. In fact, in the semester during which ALEKS was used, there were 13.8% more As and Bs, and 13.6% fewer Cs, Ds, and Fs, with the greatest drop (9.2%) being in the number of Fs.

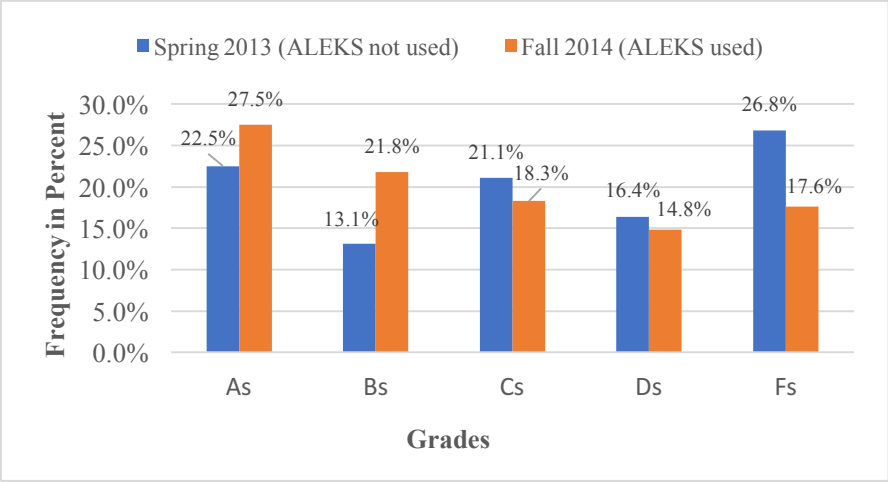

Figure 2: Distribution of Final Letter Grades for Spring 2013 Compared to Fall 2014.

An Independent t-test was then run comparing the mean grades for each semester. The means were found to differ significantly at the α =.01 level, thus confirming that students using the adaptive learning system earned significantly higher grades than students who did not use the adaptive learning system.

The responses to the five open-ended items were meant to supplement or clarify students' thoughts about the

adaptive learning system and how they believed it affected their learning. From the analysis of the first open-ended question (Item 12), it was shown most that students (over 80%) understood that the purpose of the adaptive learning system was not to replace the instructor, but to help them comprehend the course content and to provide practice solving problems. However, the responses to the second question (Item 13) verified that students' opinions split, almost evenly, as to whether they believed that the system was or was not beneficial to their ability to learn the material. From student responses to the third open-ended question (Item 14), it was clear that the issues students had with the system were issues that could be addressed with changes to the system. The most commonly mentioned issues involved dissatisfaction with the number of questions the system assigned to the students and with receiving insufficient explanations to incorrect answers. Only 12.4% of students said that system should be abolished from the course.

Conclusions

This study provided a big picture of students' perceptions about an adaptive learning system in their introductory mathematics course and its effects on their learning. It also explored the difference between final grades of students who used the system with final grades of students who did not use the system. A study during future semesters may provide a greater understanding of what was reported by students, as there may be confounding variables between actual benefits and perceived advantages of an adaptive learning system. Nevertheless, this study found a possible tool, the use of an adaptive learning system, to help improve low pass rates in introductory math courses. The adaptive learning system accomplished this by using engaging material, incorporating mastery learning, and solving issues related to students' lack of pre-requisite knowledge.

According to the results of this study, students' beliefs about mathematics as a subject did not affect their perceptions of how much using an adaptive learning system benefited their success in college algebra. For items in the survey related to satisfaction with the system, the number of Strongly Disagree/Disagree responses was greater than the Strongly Agree/Agree responses. Therefore, overall student satisfaction with the use of the adaptive learning system in their course was low. Nevertheless, students who used the system did significantly better than students who did not use the system. Students who used the system had 5% more As, 8.7% more Bs, and 10.8% fewer failures (Ds and Fs) than students who did not use the system. So, even though students did not agree that using an adaptive learning system was beneficial, its use may be a probable factor for explaining their increased success in an introductory college algebra course.

The significant correlation between the time students spent in the system and the number of times they logged into the system with their satisfaction suggests that as time spent and logins increased together, satisfaction with the use of the system also increased. This result may be because students who logged into the system often only spent a few minutes using it, or those who logged into the system once used it for several hours. For students to be satisfied, they need to use the system often and also for an increased amount of time.

Findings also suggest that the reasons students were not satisfied with the system were related to design issues that could be relatively easy to remedy. The two most common complaints by students were the number of remedial questions the system assigned to the students when they failed to answer a question correctly and the lack of sufficient explanations for incorrect answers. By addressing these complaints with the adaptive learning company, an update to the system was applied before its use the following semester. In fact, the use of the new-and-improved adaptive learning system was expanded to all pre-calculus and trigonometry courses, for which data is currently being analyzed. This will allow researchers to determine if the impact the system had in college algebra is unique to college algebra or applies to all introductory math courses.

References

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