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An Examination of the Effectiveness of Online Adaptive Learning Technologies

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Abstract

Business faculty are trying to find new and innovative ways to enhance the learning of their students. The need to develop metacognitive as well as technical skills has grown as the business and accounting professions have become more dynamic. One tool that purports to aid in alleviating deficiencies in metacognition, as well as improving those skills, is an online adaptive learning technology (OALT). Our study examines the impact that an OALT has on attributes associated with student learning, including students' perceptions of preparation, engagement, and information retention.

Our findings suggest that an OALT has a nonlinear impact on students' perceptions, with both higher performing and lower performing peers indicating lower perceived benefits than their peers. Furthermore, for students who do feel that the OALT improved their level of preparation, their perception of engagement in classroom activities and interest in the course topics are similarly improved. These findings should help business faculty better understand the impact that an OALT can have on classroom activities and student learning.

Introduction

For years, institutions of higher learning have shifted resources toward improving the effectiveness and efficiency of their teaching. While the process has been strongly encouraged by accrediting bodies (e.g., The Association to Advance Collegiate Schools of Business and the Higher Learning Commission), there has also been pressure from many university stakeholders (e.g., parents, employers, politicians) to improve student learning and measure outcomes. Faculty not only seek to design new degree programs and add new content to current classes, but they pursue ways to improve the learning process. Faculty and experts in teaching and learning centers realize, however, that their approaches to course design are not independent of the students taking their courses. Students have different learning styles; some may learn best in a passive environment, while others are more likely to succeed in a highly interactive, active-learning environment (Young and Fry, 2008). Though course design and content are important, student participation in the learning process is critical. As these students leave colleges and universities

and begin their careers, professional organizations, such as the American Institute of Certified Professional Accountants (AICPA), stress the importance of lifelog learning and continued professional education. Students must learn how to learn (metacognition) and course design, course supplements, and faculty assistance can help them build those skills.

Studies have found a positive relationship with metacognition and academic performance. Some of these performance measures are overall grades in a class (Dull and Scheifer 2009), the calibration error of a student's expectation of performance, and the magnitude of that error (Ravenscroft et al. 2012). The consensus is that students who have high metacognition (i.e., students who had a greater overall awareness of knowing about what they know) tend to have higher exam scores and be less surprised by the outcome. In contrast, those students who were unaware about what they knew tended to score lower on exams and be more surprised by the outcome. While these studies highlight the importance of metacognition in academic performance, they do not reflect the effect of metacognitive feedback on the individual. In these studies, the measurement and reporting of the metacognitive scores were completed via survey, independent of normal classroom activities and unknown to the individual student.

The role of information technology in business education continues to grow and evolve, providing faculty with many options to assist in student learning. Online adaptive learning technologies (OALT), and how they can positively influence the student learning process, have attracted a great deal of interest. Many textbooks now offer these technologies, which espouse benefits such as improved metacognition, through more effective study habits, and improved academic performance. With an OALT, students can receive immediate feedback about their metacognitive performance and have an opportunity to alter their study habits and activities in response to those scores. Furthermore, the adaptive learning technology will treat students differently based on their responses, prompting students with lesser metacognitive skills to study and learn differently to overcome their shortcomings. While high metacognition has been shown to be associated with improved academic performance in some academic settings, there are still questions as to whether an OALT can help improve metacognition and lead to the improved learning outcomes frequently associated with high metacognition.

Studies (Kealy et al. 2005, Jones and Fields, 2001) have found that supplemental instruction can aid in student performance by improving critical thinking skills and learning strategies, which are both important components of metacognition. However, can an OALT cause students to alter their learning processes and impact academic performance? In this study we examine how LearnSmart®, an OALT, impacts student preparation for class and exams, engagement in classroom discussions and activities, and knowledge retention. In addition, we examine how preparation, engagement, and retention is ultimately related to classroom performance.

Because our study is based on a specific OALT, LearnSmart®, it is useful to provide a brief introduction to McGraw-Hill's product. There are three heavily marketed elements to this suite: Connect, SmartBook, and LearnSmart®. Connect is the umbrella under which the other products are used. Connect can be used to simply provide access to end-of-the-chapter questions, assign static online homework problems, or can be used in a more integrated approach, as is described in this study. SmartBook begins as an E-text but allows instructors to export highlighted content to students. SmartBook also is interactive as driven by the LearnSmart® adaptive engine. LearnSmart® can be used to query students about their understanding prior to in class coverage, for example, to highlight knowledge gaps and provide students with structure so that they better absorb lecture materials. LearnSmart® creates a unique learning path for each student by asking questions and asking about the students' confidence in those questions. The Recharge feature is a post-class coverage tool that uses proprietary algorithms, data from LearnSmart® probes, and data from SmartBook content review to predict when a learner is about to forget something. Recharge is used to review content that has already been read in previous chapters and targets concepts that the user may have been struggling with or is likely to forget as part of a targeted reinforcement.

While the results were not conclusive related to actual classroom performance, our tests did reveal some important observations related to the use of an OALT. The first important finding was that B students tended to feel that LearnSmart® provided more benefits associated with preparation, engagement, and retention; while A students and

C students tended to have a lower perceived benefit.[1] While the A students' lower perceived benefits may be expected due to their pre-existing academic skills, the perceived lower value to the C students would suggest that there may be another factor contributing besides metacognitive skills. It could be suggested that student effort and motivation may also be impacting this relationship. The second important finding was that a student's feeling of whether the OALT improved their preparation was strongly related to their perceived improvement in engagement and information retention. Faculty members want their students to be interested in the course material being covered, and there was a strong relationship between a student's feeling of preparation and his/her interest in the topics of the course. The third important contribution of this study was the examination of the mediating relationship of the engagement factor between a student's preparation and information retention. While perceived preparation did have a positive relationship with engagement, our study was inconclusive as to engagement as a mediating influence on the relationship between preparation and performance. As we try to better understand how students learn, faculty and academicians need to examine the relationships between preparation, engagement, and performance, as well as how student effort and motivation can impact those relationships.

Literature Review

To be successful in today's business world, it is important for graduates to possess the skills necessary to be successful learners not only in the classroom but also as working professionals. Professional organizations (AICPA, 2010) have advocated that success depends on its members' ability to assess and regulate their own learning in a rapidly changing business environment. This self-regulated learning heavily involves metacognition, which is the process of understanding how one thinks, learns, reasons, and solves problems (Ravenscroft et al., 2012). Metacognition is derived from meta, which means "beyond," and cognition, which means "intellectual process," therefore metacognition is "beyond cognition" (Onyekuru and Njoku, 2017). Metacognition is the understanding of one's learning processes and using this knowledge to enrich one's learning. Metacognition has therefore been referred to as "knowing about knowing" (Dull and Scheifer, 2009) or "thinking about your thinking" (Flavell 1979), and many researchers view it as important in meeting the needs of today's business graduates.

Metacognition has been identified as having two components: knowledge of cognition and regulation of cognition (Bruning et al. 1995). Knowledge of cognition can be summarized as (1) knowing what factors affect our performance, (2) knowing different strategies for learning, and (3) knowing when or why to use a particular strategy. Regulation of cognition can be summarized as (1) planning – allocating resources, selecting goals, and using prior knowledge, (2) regulating – monitoring and self-testing, making predictions or pausing while reading, and (3) evaluation – appraising the results, evaluating the learning processes used, re-evaluating goals, and revising predictions.

Fostering and cultivating metacognition in students is becoming more imperative due to technological advances and changes in socioeconomic forces. In fact, the World Economic Forum estimates that 65% of the next generation's jobs have not yet been created. Thus, a large part of the educational process needs to focus on upskilling students in addition to providing substantive, technical material. Helping a student develop metacognitive skills should be a driving force in education as it helps provide students with skills that can translate to dynamic environments. The relationship between metacognition and student performance has been studied extensively and there is a great deal of research that shows a positive correlation (Duff and McKinstry 2007; Hall et al. 2004; Lucas and Mladenovic 2004; Schliefer and Dull 2009; Zhao and Mo 2016).

While there has been significant research performed on the relationship between metacognition and student performance, research on metacognition and preparation and engagement has been more limited. In assessing the relationship between metacognitive skills and preparation, Ravenscroft et al. (2012) examined calibration errors for students with high and low metacognitive skills. The study found that students with low metacognitive, due to their

[11] In this paper we define A students as those having a pre-course cumulative GPA of greater than 3.5, B students as those with a GPA greater than 2.5, but less than 3.5, and C students as those with a GPA less than 2.5.

lack of self-awareness of their technical skills, underperformed relative to their expectations. This has been referred to as the "unskilled and unaware" effect (Kruger and Dunning, 1999). These students also possessed a larger deviation in actual versus expected performance. Perhaps their low metacognitive skills, that is, they were unaware of how little they knew, resulted in an overall lack of preparation. The other interesting finding is that high metacognitive skill students tended to perform better than their individual expectations. These high performing students may have actually been overly critical of their performance, needlessly spending more time and effort on preparation than what was actually necessary. However, the high metacognitive students did possess a much smaller measurement error. So even though they did tend to underestimate their level of performance, the high metacognitive students did a better job of self-analysis when assessing how prepared they were.

In a 1994 study, Schraw and Dennison noted a difference between adult students and traditional undergraduate students. Their study suggested that the difference rested within their metacognitive regulation skills, but not so much in their metacognitive knowledge skills. The findings in Young and Fry (2008) buttress this point with similar findings between graduate and undergraduate students. They specifically looked at knowledge of cognition and regulation of cognition. Both studies found that the more experienced students had higher levels of metacognitive regulation skills. This is consistent with Ravenscroft et al. (2012) if one assumes that a more seasoned student will have a better grasp on his/her own regulation.

Young and Fry (2008) further breakdown the calibration errors into local and global levels. Local monitoring is the difference between the actual answer of a test question and the students' judgment of how well they answered the question, whereas, global monitoring is the difference between the overall test score and the students' judgment of how they did on the test. It is believed that local monitoring is a measure of ongoing metacognitive regulation, while global monitoring is a measure of cumulative metacognitive regulation (Nietfeld, et al 2005). In a traditional classroom setting, as Nietfield notes, attempting to measure metacognitive regulation at local and global levels is difficult and places additional stress on students. We used a series of surveys in conjunction with a course-embedded OALT to limit stress on our students and limit any negative impacts our research might have on the learning environment.

If OALT systems are designed to help students better "learn how to learn," we could expect that all students should be able to benefit and become more prepared for their classes. However, it is also expected that students who are high performers are likely to possess more metacognitive skills than lower performers, thus seeing less benefit from an OALT. This leads to our first two hypotheses:

(1) Do students feel more prepared for class?

H1: Students will perceive that an OALT will help them feel more prepared.

H2: Lower performing students will perceive that an OALT helps them feel more prepared relative to higher performing students.

McGraw Hill promotes one of the primary benefits of its OALT, LearnSmart®, as aiding students in "having a solid foundation of concepts that will be covered" in class, allowing the students to be more involved in classroom activities (McGraw Hill, 2015). This level of engagement allows the professor more time to devote towards more beneficial activities to enhance the educational process. In McGraw Hill's case studies (2017) they find that prepared students have higher levels of engagement in activities such as attendance and course retention. Johnson et al. (2009) found that metacognitive activity was correlated with student satisfaction, including that they felt they were a part of the class and belonged. Hopland and Nyhus (2016) concluded that student satisfaction with their learning environment, namely their teacher, motivates them and stimulates effort. As students feel like they are a part of the class and belong, they should perceive a higher level of engagement on their part. Furthermore, as Johnson et al. (2009) found a positive correlation between student engagement and metacognitive skills, it could also be posited that lower performing students do not possess the requisite skills needed to feel engaged in classroom activities relative to higher performing students. Therefore, the use of an OALT should provide more

perceived benefits to the lower performing students relative to the higher performing students. This leads to our next testable hypotheses:

(2) Do students feel more engaged in classroom activities due to usage of an OALT?

H3: Students will perceive that an OALT helps them feel more engaged.

H4: Lower performing students will perceive that an OALT helps them be more engaged relative to higher performing students.

As educators, the ultimate objective of different techniques and supplements is to enhance student learning and performance. That is one of the purported benefits of OALTs such as LearnSmart® (McGraw Hill, 2015). One of the interesting aspects of the relationship relates to the association with the roles that preparation and engagement have with performance. As already discussed, students with higher metacognitive skills are more prepared relative to the students with lower metacognitive skills. These higher metacognitive skill students also had higher exam performance compared to their lower metacognitive skill peers (Ravenscroft et al. 2012). Therefore, it is reasonable to expect a direct relationship between perceived preparation and perceived performance.

One factor that other studies did not consider with performance is the level of student engagement. LearnSmart® advertises that more prepared students will be more engaged in classroom activities. This increased engagement is an important step in the education process, making it vital to ongoing success in the course. Students who are more engaged in the classroom are better able to be active learners. The increased engagement creates higher levels of attention and interest that allow them to absorb and retain in-class information more effectively than those students with lower levels of engagement. The in-class environment is an important part of the learning process and students who become more engaged are likely to see improved performance.

Many studies have found that higher metacognitive skills are positively related to knowledge retention and student performance (Ravenscroft et al. 2012, Dull and Scheifer 2009). To help explain this relationship, Ravenscroft et al. (2012) develops the notion of fixed and growth mindsets, stating the former is outcome focused while the latter is process focused. Fixed mindsets "usually have a more helpless orientation which leads to lower achievement and they tend to see abilities as fixed and to believe that effort, attention, and time on task will not increase their skill". Whereas growth mindsets "do not interpret poor performance as a sign that they lack the ability, but rather as a signal that they must apply different study approaches. For students with a growth mindset, failure becomes a challenge to search for a more effective way to learn and prepare for a test of one's skill and knowledge". In general, we expect that the use of an OALT will have a positive impact on both actual and perceived student performance. If one reasonably assumes higher performing students have both high metacognitive skills and a growth mindset, their benefit from an OALT may be less than other students with a growth mindset, but lesser developed metacognitive skills. In contrast, students with a fixed mindset might not benefit significantly from an OALT regardless of their metacognitive abilities.

To understand the relationship between preparation, engagement, and performance, we developed a mediation analysis (Hayes, 2013). A mediation analysis is a statistical analysis designed to help answer the question of how some causal agent "X" transmits its effects on "Y." A mediating variable ("M") intervenes the relationship between X and Y such that there is an indirect effect. Said differently, X influences M, which in turn influences Y.

While we expect the OALT to result in higher levels of preparation (X) and ultimately performance (Y), we hypothesize student engagement (M) mediates the relationship. Because the OALT provides immediate feedback to the student regarding areas of strength and weakness, the student is able to seek out additional information in the classroom to expand the depth of knowledge in areas of strength and improve knowledge in areas of weakness. This creates an important additional touchpoint in the learning process because an instructor facilitates the in-class learning. Given the prepared student is aware of both strength and problem areas, he/she can seek further depth of

understanding as well as additional guidance and clarity from the instructor whereas the "unskilled and unaware" are still stuck at the surface level.

As we model the relationship, it is paramount in understanding whether classroom engagement is a mediating variable between preparation and performance, or whether engagement is another outcome activity like classroom performance. We can therefore depict the relationship as shown in Figure 1. In summary, we examine whether preparation has a direct relationship with performance, or whether engagement has a mediating effect on the relationship between preparation and performance. This leads to our final three hypotheses:

(3) Do students retain more knowledge due to usage of an OALT?

H5: Students will have higher perceived and actual performance with an OALT.

H6: Lower performing students will have more benefits from the use of an OALT with their perceived and actual performance relative to higher performing students.

H7: The relationship between students' perceived preparation and students' perceived performance is mediated by student engagement.

Methodology

Students in two different, senior-level courses at a regional mid-western university were the subject of this study. One course was in accounting, while the other was in finance, and both were upper division, required courses for the respective majors. As such, students have self-selected into a major that suits their interests and career goals. However, these courses may not necessarily fit with the specialization they may wish to pursue. Both courses had in-class exams as the predominant method of grade determination and both courses used LearnSmart® assignments as a required, graded supplement to in-class instruction. Because the courses were offered at the exact same time, there were no students who participated in both classes during this term. In addition, all students had prior experience using on-line homework systems.

Paper surveys were completed during class time at the end of the 5th, 10th, and 15th (last) week of classes. The surveys were distributed and collected by another instructor, and students were informed that the survey responses would not be part of grade determination, nor would they be viewed by their instructor until after final grades were submitted. In-class exams were given and graded within a week of administering the first two surveys, while the third survey was given during the final class period, just prior to administration of a cumulative final exam.

Identical surveys were given to the students present for each survey administration. If students were absent from class on that day, they did not have any responses for that survey. The response rate for the three surveys was 87%. In addition, responses of students dropping the course after one or two surveys are included in the results. There were two students who took the first survey and subsequently dropped the course.

Each survey included 13 questions using a 5-point Likert scale ranging from 1 – Strongly Disagree to 5 – Strongly Agree. In addition, students were also asked two open-ended questions about what the greatest benefit and greatest disadvantage was associated with LearnSmart®/SmartBook®. Each student was also asked to provide demographic characteristics, including his/her name, age, composite ACT score, and the student's cumulative GPA prior to taking the course.

As we seek to understand the benefit of an OALT on the learning process, we address our three primary research questions. First, we examine how an OALT affects students' preparation prior to a topic being covered in class. Next, we look at the learning process and how an OALT might benefit students while they are actively engaged in the learning process. Finally, we study the results of the learning process, as supported by an OALT.

Anecdotal evidence from the open-ended responses suggested that students with higher pre-course GPAs did not find LearnSmart® and its activities to be a good use of their time. Prior experience also suggests that students who did not have a strong track record of classroom performance (C students) tend to be ineffective in their preparation and also put insufficient effort toward improving their preparation methods. Because these students have taken a number of major courses by this time, and due to their continued lower performance, perhaps these students have developed a Fixed mindset towards classroom preparation. Therefore, while these students could potentially benefit the most through an OALT, the lack of resiliency from their Fixed mindset could be limiting its value to those students. By using a model estimation feature in SPSS, as shown in Figure 2, we have shown the scatterplot of responses of students from the first survey as to whether they felt LearnSmart® helped them better prepare for class. As evidenced by the SPSS results, the GPA variable does not exhibit a linear relationship with the students' responses as to their perceived level of preparedness. Both our stronger and weaker students tended to dislike LearnSmart®, perhaps for different reasons. To account for this relationship, when testing our hypotheses, we categorized the cumulative GPA results into 3 categories: A students are those with GPA's of 3.5 and up, B students are those with GPA's of 2.5 – 3.49, and C students have GPA's less than 2.5. Since students with GPA's less than 2.5 are more at risk, we also believe this categorization will be more useful in utilizing the results of our study.

This categorization of students can also be supported from a metacognition perspective. As discussed earlier, metacognition consists of two components: knowledge of cognition and regulation of cognition (Bruning et al. 1995). An OALT can provide supporting techniques to help a student overcome his/her deficiencies by changing the types and way information is presented to the unique individual. If a student has lower metacognition, it could be due to a combination of either low knowledge of cognition and/or low regulation of cognition. It could be expected that an OALT could help to overcome deficiencies due to low knowledge of cognition by introducing and presenting new strategies of how to study and prepare. However, if the deficiency is due to low regulation of cognition, or a Fixed mindset (Ravenscroft et al., 2012), there could be issues that an OALT cannot help to overcome. Some of the factors considered with regulation of cognition are: (a) I ask myself …, (b) I ask others …, (c) I stop and re-read…., and (d) I stop and go over…. Many of these are dependent on the efforts of the student and his/her willingness to expend the additional efforts to be successful, which an OALT cannot demand the student to exert. If the cause for lower metacognition is based on these factors for regulation of metacognition, it could be expected that an OALT would not be beneficial for that student as he/she will simply not put forth the necessary effort to be successful. Similarly, a Fixed-mindset student sees no hope in expending the effort to leverage an OALT, their choice to not expend effort will all but guarantee low performance.

Results

1) Are students more prepared for class due to usage of an OALT?

Perhaps the most direct way to answer this question objectively is with a series of in-class quizzes designed to explore exposure versus mastery. We use the OALT in hopes that our students enter the classroom better prepared to actively engage in the learning process. To be clear, we do not expect that they have mastered the content, but that they are familiar with the material, better equipped to participate, ask questions and absorb new information. We use student perception of preparation, an indirect measure, in this study. Using a 5-point Likert scale, we asked our students to agree/disagree with the statement:

- LearnSmart®/SmartBook® helps me prepare better for and get more out of class.

We examine the first hypothesis, that LearnSmart® helps students feel more prepared for class, by utilizing the responses taken from student surveys conducted three times during the semester. As seen in Table 1, student respondents slightly agreed, on average, that LearnSmart® did help them feel more prepared for class. However, there are two interesting observations from these responses. The first observation is that the perception of LearnSmart® helping to prepare declined over the semester. The second observation is that the A students consistently felt that LearnSmart® was less helpful than the other groups. In addition, the lower performing

students, the C students, also had a lower perception as to LearnSmart's® helpfulness. Figure 1 illustrates this finding graphically. With a full semester's use to inform them, our best students clearly felt that LearnSmart® was not as beneficial in making them more prepared for class. To further evaluate this, we perform a one-way ANOVA and find that there are differences in means among the three groups in the Week 5 and Week 15 responses at the $p<.05$ level.

We also asked the students two other questions that could impact their perceptions of whether LearnSmart® helped them feel more prepared for class. One question was whether LearnSmart® questions served as a useful guide to SmartBook® (Useful), and the other was if the student liked using LearnSmart® relative to other class resources (Liked). There were differences of means among the different GPA categories that were significant at the $p<.10$ level for Week 5 and Week 10 for both surveys (results not shown), but there were no differences for Week 15 for either question. To evaluate whether these factors influenced the students' perceptions of preparedness, we ran regression model (1):

$$(1)\quad Preparedness = \alpha + \beta_1 HiGPA + \beta_2 LoGPA + \beta_3 Useful + \beta_4 Liked + \varepsilon$$

As can be seen in Table 2, even after controlling for whether they liked LearnSmart® and whether they felt LearnSmart® questions were a useful guide, the A students' perceptions of whether LearnSmart® helped them be better prepared were significantly lower than the B students in 2 of the 3 surveys, most significantly so in the final survey. There were two other findings that were also meaningful. Students who felt LearnSmart® served as a useful guide did tend to feel that it helped them prepare better (significant in 2 of the 3 surveys); and students who liked LearnSmart® more than other resources also tended to perceive that it helped them prepare better (significant in 1 of the 3 surveys).

2) Are students more engaged in classroom activities due to usage of an OALT?

New instructors quickly learn that no two classes are the same. Each class seems to develop its own "personality." Nonetheless, instructors learn that a classroom with broad involvement and engagement is both more enjoyable for the instructor and more productive for the students. Prior studies of classroom involvement or engagement tended to focus on passive activities, such as attendance and retention (McGraw Hill, 2017). Pang (2010) suggests that the more successful students, the ones who successfully engage in metacognitive strategies, are the ones who are actively involved in their learning environment. Therefore, we evaluate student engagement by considering factors that are specific to a student's level of involvement and interest in the classroom material and activities. We use four survey questions to gather our students' impression of LearnSmart®/SmartBook®'s impact on their engagement in classroom activities throughout the semester. The questions, using the same 5-point Likert scale, are provided below. The first two questions are reverse scaled.

- LearnSmart®/SmartBook® decreases my attentiveness in class.
- LearnSmart®/SmartBook® decreases my willingness to ask questions in class.
- LearnSmart®/SmartBook® increases my involvement in class discussions.
- LearnSmart®/SmartBook® increased my interest in topics in this class.

Through these four questions, our students self-assess their level of involvement and engagement in our courses. We start by asking if LearnSmart® affects students' attentiveness in class. On average, as depicted in Table 3, our students disagreed that it decreased their attentiveness. One-way ANOVA tests show that while there was a significant difference in the means at the $p<.05$ level in the first two surveys, the difference eroded by the final administration.

If students are prepared and engaged, it follows that they are more likely to be willing to ask questions in class. Table 4 provides evidence that our students largely agreed that LearnSmart® helped provide the confidence to ask questions during class. While there was a difference in the means, significant at the $p<.10$ level during week 5, there seemed to be broad agreement among the students throughout the rest of the term.

If students are attentive and asking questions, it should also be expected for them to be more involved in classroom activities. Table 5 suggests that our A and B students do not believe it impacts their involvement, but throughout the term our C students become more involved in classroom discussions. The difference in the means is insignificant until week 15, when it becomes significant at the $p<0.10$ level.

The fourth attribute of engagement that we examined was the students' interest in the topics of the class. Table 6 shows that our A students are neutral to slightly negative by the end of the term in their view that LearnSmart® helps enhance their interest in topics in the current class. B and C students, on the other hand, tend to be slightly positive regarding the question, with C students increasing their opinion throughout the course that LearnSmart® increases their interest. In week 15, we find a difference in the means significant at the $p<0.05$ level.

As discussed earlier, the degree to which students like SmartBook® (Liked) and find it useful (Useful) could impact their level of engagement in the course. We further examine the degree to which students who self-report that they are better prepared (Prepared) also report higher level of involvement or engagement. This is included because students who feel more prepared for class should also be more likely to be engaged in classroom activities. To evaluate whether these factors influenced the students' perceptions of engagement, we ran regression model (2):

$$(2)\quad Engagement = \alpha + \beta_1 HiGPA + \beta_2 LoGPA + \beta_3 Useful + \beta_4 Liked + \beta_5 Prepared + \varepsilon$$

We evaluate the model for all four of our engagement questions. For the first question, LearnSmart® decreases my attentiveness in class, the results are shown in Table 7. Surprisingly, there were no significant results except for Prepared, which was significant in the week 10 survey. Because attentiveness was designed as a negatively scaled response (decreases attentiveness), a negative coefficient on Prepared is consistent with the expected relationship.

Our findings for the second question, LearnSmart® decreases my willingness to ask questions in class, are similar. The explanatory results of the model (R-Square) are very low. The only significant result parallels that from the prior regression. The regression results are shown in Table 8.

The results for the third engagement question, increases my willingness to ask questions in class, are provided in Table 9. While there is no difference between the A and B students, the C students do feel it increases their involvement at a level that is statistically significant in 2 of the 3 surveys, and increasingly so throughout the term. The Useful and Prepared variables also consistently showed a positive relationship with the students' willingness to ask questions in class, but these were only statistically significant in 1 of the 3 surveys.

The results of our final engagement question, increased my interest in topics in this class, follows in Table 10. The most interesting findings associated with this measurement of engagement were that *Prepared* was significant for all 3 surveys. In other words, students who felt that LearnSmart® helped them prepare better for class found an increase in their interest in the topics covered in the course. As faculty members, we always want our students to be interested in the topics covered in our courses, so this was an extremely desirable engagement benefit. Across all four characteristics of engagement, the one variable that consistently had a strong relationship with a student's perception of engagement was the student's perception of being prepared. This finding helps to reinforce an important relationship that if a course resource helps students feel more prepared, that should lead to a greater level of student engagement in course activities.

3) Do students retain more knowledge due to usage of an OALT?

The first two questions in this study address a means to an end. Cumulative knowledge and learning retention are what we and our students ultimately seek. In answering this question, we use both subjective, indirect measures and objective, direct measures. The following questions provide students' perception of the OALT's success in enhancing their metacognitive skills and, ultimately, their knowledge acquisition. These tests seek to explore if the students believed the tool was useful in learning retention.

- LearnSmart®/SmartBook® helps me retain information better.
- LearnSmart®'s Recharge feature helps me retain information better.

In evaluating hypothesis 3, we examine the students' perceptions as to whether LearnSmart® and the LearnSmart® Recharge feature helps them retain information better. In table 11, the mean scores show that there is considerable variation among the three groups, with the A students feeling it does not help, while the B students slightly agree that it helps, and the C students' responses falling between the other groups. ANOVA tests indicate that the differences are significant in week 5 (p =0.02), week 10 (p = 0.06), and week 15 (p = 0.09).

As to whether Recharge helps with information retention (Table 12), ANOVA tests indicate that there were no significant differences in mean values across the groups. The Recharge feature was optional in our courses. An analysis of a question asking the students if they used it consistently resulted in an average "neither agree/disagree" response. A review of the open-ended responses suggests that only a limited number of students exerted a meaningful effort toward utilizing the Recharge feature.

Similar to prior tests, it is expected that students who felt LearnSmart® was a useful guide (Useful) and who liked using LearnSmart® (Liked) would be more likely to feel that LearnSmart® helps them to retain information better. We further examine the degree to which students who self-report that they are better prepared (Prepared) also report a higher level of information retention. This is included because students who feel more prepared for class should also be more likely to feel as if they learned more. To examine that relationship, we test the following regression formula:

$$(3)\quad Retention = \alpha + \beta_1 HiGPA + \beta_2 LoGPA + \beta_3 Useful + \beta_4 Liked + \beta_5 Prepared + \varepsilon$$

In examining students' perceptions of performance, if LearnSmart® helped them retain information better, results from all three surveys were similar. Students that felt LearnSmart® helped them feel more prepared were much more likely to feel that LearnSmart® helped them retain information better. None of the other variables had a significant relationship with students' perception of performance. Our findings suggest that Preparation has a direct relation on perceived performance. However, the previous hypothesis showed that Preparation had a strong association with perceived student Engagement. So the next thing to consider is whether Preparation has a direct association with perceived Performance, or whether Engagement has a mediating effect on Performance.

In order to test whether student engagement mediated the relationship between student preparation and student performance (Hypothesis 7), a regression analysis was used. A discriminant validity test using the Average Interscale Correlation (AVISC) was performed and the results of .715, .666, and 740, demonstrated that student preparation, student engagement, and student performance were separate constructs, respectively. A principal components and reliability analyses were performed to ensure the variables loaded properly. The correlations for the student preparation, student engagement, and student performance constructs were all statistically significant at the $p < .01$ level and the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sampling adequacy resulted in factor scores of .727, .715, and .769, respectively. A rotated component matrix had low scores of .881, .908, and .678 for student preparation, student engagement, and student performance respectively. The Chronbach Alpha scores for student preparation, student engagement, and student performance were .880, .927, and .843, respectively.

Results indicated that student preparation was significantly correlated with student engagement (b = .442, SE = .108, and $p < .01$). In addition, the results indicated that student preparation was significantly correlated with student performance (b = .834, SE = .089, and $p < .01$). The results did not support a full or partial mediation however, as the relationship between student engagement and student performance was not significant (b = .107, SE = .1318, and $p > .10$). Approximately 85% of the variance in performance was accounted for by the predictors ($R^2 = .848$). The indirect effect was tested using a bootstrap estimation approach with 5,000 samples (Hayes, 2013). The results indicated that the indirect coefficient was not significant (b = .047, SE = .059, CI = -.053, .176).

One possible reason for the lack of mediation is that the preparation variable was so strongly related to the performance measure, that the engagement variable could not have a mediating influence. Because the question asked about being more prepared for class, we cannot tell if the students interpreted preparation as being more prepared to participate in classroom activities or more prepared to take the exams. If the students primarily viewed that question as prepared for exams, then the influence of the engagement variable would be limited on the relationship between preparation and performance.

When evaluating whether students felt the Recharge feature helped them retain information better, it is important to not only include the Useful and Liked responses, but also whether students consistently used the Recharge feature (Consistent). That relationship is expressed in the following regression formula:

$$(4)\quad Retention = \alpha + \beta_1 HiGPA + \beta_2 LoGPA + \beta_3 Useful + \beta_4 Liked + \beta_5 Consistent + \varepsilon$$

In testing the Recharge feature, the regression results are shown in Table 14. Findings indicate no differences among the three categories of students in any of the three survey periods; all differences were insignificant. Throughout the semester, the magnitude and statistical significance of the relationship between how much our students liked LearnSmart® and how much they felt it helped them retain knowledge increased. The most interesting finding is only in the final survey did students who agreed with consistently using the Recharge feature also agree the Recharge feature helped them retain information better. Perhaps an appreciation for the Recharge feature was gained through prolonged exposure. Alternatively, since the Recharge feature was optional, students may have experimented with it on an ad hoc basis throughout the course. By the end of the course, those that used it more consistently may have discovered its value.

Does LearnSmart® Improve Course Performance?

More directly and objectively, we also measure learning retention through student exam scores. One of our courses contained 4 noncumulative exams and a cumulative final exam. The second course included 3 noncumulative exams and a cumulative final exam. Because it also includes quiz scores, homework and projects, we do not include course total in our measure of learning retention.

In this section we evaluate the relationship between our students' performance on exams, their prior academic performance, and their perception of LearnSmart®'s contribution to their learning. As in our prior tests, we segment our students into A, B, and C students. We further control for academic ability by including their overall ACT score (ACT). Finally, we compare students' responses to "LearnSmart®/SmartBook® helps me retain information better" (Retain) and "LearnSmart®'s Recharge feature helps me retain information better" (Recharge) on each survey with their performance on an exam administered just prior to a survey. The week 15 survey is compared to a cumulative final exam administered in both courses. This relationship is formalized in model (5).

$$(5)\quad Performance = \alpha + \beta_1 HiGPA + \beta_2 LoGPA + \beta_3 ACT + \beta_4 Retain + \beta_5 Recharge + \varepsilon$$

Significant results from this test, as shown in Table 15, are limited largely to the first survey administration and to our A students. It is not particularly surprising that our A students tend to consistently and significantly score higher on our exams than other students. However, our control for academic ability, ACT score, is not significant in any regression. Curiously, students that felt LearnSmart® helped them retain information better experienced increased exam performance, but only for the first exam. In contrast, and also for the first exam, those that found value in the Recharge feature, actually performed more poorly. The disconnect between perceived performance, "retain information better," and the actual results could be the result of calibration error documented in Ravenscroft et al. (2012). While we would hope that the magnitude of the error would be reduced by the use of an OALT, there is evidence that students still were not able to accurately predict their true performance.

Conclusion and Suggestions for Further Research

As higher education works to improve the effectiveness and efficiency of student learning, it is important for faculty to understand how different technologies and strategies impact individual students. As students prepare for a dynamic work environment, it is important for faculty to not only help their students acquire valuable technical skills, but also to develop and acquire metacognitive skills that will help prepare them for the challenges they will face during their careers. One important tool that has recently become available to faculty members is an online adaptive learning technology (OALT), which attempts to improve metacognition, through more effective study habits, and to improve academic performance. While this research does not directly study metacognition, we do evaluate the impacts that an OALT on students' perceptions of preparation, engagement, and performance.

This study contributes to the literature in three ways. The first important finding is that the perceived benefits of an OALT do not have a linear relationship with a student's prior academic performance. While prior metacognition studies have found that higher performing students possess higher metacognitive skills, it could be expected that an OALT should provide the most benefit to lower metacognitive skill students (lower performers) and the least benefit to higher metacognitive skill students (higher performers). While our results did show that the higher performing students (A students) did experience lower perceived benefits, we also found that the lower performing students (C students) also experienced lower perceived benefits. This lower perceived performance could have been attributed to those student's unwillingness to put in the required effort, perhaps due to a Fixed mindset (Ravenscroft et al. 2012) or poor regulation of cognition. A second contribution of our study is the finding that if students felt the OALT increased their preparation, the students felt more engaged in classroom activities, including their level of interest in the course topics. As faculty members, it is so important to find tools and techniques that help with student engagement and interest. Our results suggest that the key to this is discovering tools and techniques that focus on making the student feel prepared. The third important finding of this study is the examination of the relationship between preparation and performance, and the potential mediating effect engagement has on that relationship. While our results did not conclusively find there was a mediating relationship, we are hopeful this will encourage future studies to examine the relationships among these three variables in student learning. One item that could use further analysis is the aspects of preparation, whether preparation could be viewed as having a classroom preparation dimension (being prepared to do deeper learning in the classroom environment) and an examination preparation dimension (being prepared to demonstrate the knowledge and skills you have acquired). Perhaps classroom preparation enhances engagement, which in turn strengthens examination preparation and ultimately improves results.

There have been numerous studies examining metacognitive skills in business and accounting education. While this study does not directly test metacognitive skills, LearnSmart® does include reports that provide feedback to the faculty and students about metacognitive performance. It may be interesting to know if an OALT such as LearnSmart® does help students improve their metacognitive skills (learning how to learn). Another important finding that deserves further exploration is the different perceptions of students who are at different levels of performance. While C students could clearly benefit from improved study habits, faculty members need to find ways to make them want to utilize the resources that could help them be more successful. If A students already possess strong study skills, what value can an OALT such as LearnSmart® provide for these students? One other factor that our study was not able to address was the role an OALT plays at an earlier stage of academic preparation. The students in our study were primarily seniors who have taken multiple courses in their respective majors and have developed skills and mindsets over the prior years of courses in that major topic. Perhaps lower performing students that do not have such an extensive history in a topic are more likely to benefit and adapt from the use of an OALT. All of these should further help faculty better understand the benefits they could expect from the use of an OALT while trying to improve their classroom experience.

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Appendix A: Survey Instrument

Name _____
Bear # _____
Age _____
ACT score _____ (approximate if you don't recall exact composite score)

Years attending our University _____

Started college our University _____
Transferred from other 4-year university YES / NO
Transferred from a community college YES / NO

1. I am very interested in the content of this class.

1…	……..2	……..3	…..……..	….4	…….5
strongly disagree	slightly disagree	neither agree/disagree	slightly agree	strongly agree	

2. I am only taking this class because it is a requirement for my major.

1…	……..2	……..3	…..……..	….4	…….5
strongly disagree	slightly disagree	neither agree/disagree	slightly agree	strongly agree	

3. I have consistently used the Learnsmart/smartbook Recharge feature.

1…	……..2	……..3	…..……..	….4	…….5
strongly disagree	slightly disagree	neither agree/disagree	slightly agree	strongly agree	

4. The learnsmart questions served as a useful guide to smartbook.

1…	……..2	……..3	…..……..	….4	…….5
strongly disagree	slightly disagree	neither agree/disagree	slightly agree	strongly agree	

5. I liked using Learnsmart/smartbook relative to other class resources.

1…	……..2	……..3	…..……..	….4	…….5
strongly disagree	slightly disagree	neither agree/disagree	slightly agree	strongly agree	

6. Whether I selected "Unsure," "I know it," "Think so," or "No idea," I always used smartbook to "Read about this" before I submitted my answer.

1…	……..2	……..3	…..……..	….4	…….5
strongly disagree	slightly disagree	neither agree/disagree	slightly agree	strongly agree	

disagree

Please consider the following questions relative to a traditional class with no on-line homework system/e-book:

7. Learnsmart/smartbook helps me prepare better for and get more out of class.

1…	……..2	……..3	…..……..	….4	…….5
strongly disagree	slightly disagree	neither agree/disagree	slightly agree	strongly agree	

8. Learnsmart/smartbook helps me retain information better.

1…	……..2	……..3	…..……..	….4	…….5
strongly disagree	slightly disagree	neither agree/disagree	slightly agree	strongly agree	

9. Learnsmart/smartbook decreases my attentiveness in class.

1… ……..2……..3…..……..….4…….5
strongly slightly neither slightly strongly
disagree disagree agree/disagree agree agree

10. Learnsmart's Recharge feature helps me retain information better.

1… ……..2……..3…..……..….4…….5
strongly slightly neither slightly strongly
disagree disagree agree/disagree agree agree

11. Learnsmart/smartbook decreases my willingness to ask questions in class.

1… ……..2……..3…..……..….4…….5
strongly slightly neither slightly strongly
disagree disagree agree/disagree agree agree

12. Learnsmart/smartbook increases my involvement in class discussions.

1… ……..2……..3…..……..….4…….5
strongly slightly neither slightly strongly
disagree disagree agree/disagree agree agree

13. Learnsmart/smartbook increased my interest in topics in this class.

1… ……..2……..3…..……..….4…….5
strongly slightly neither slightly strongly
disagree disagree agree/disagree agree agree

14. Please use the following questions to provide any other feedback you feel is relevant to the use of learnsmart/smartbook relative to other online homework resources or traditional courses without online resources.

i. The greatest benefit(s) of learnsmart/smartbook is:

ii. The greatest disadvantage(s) of learnsmart/smartbook is:

Figure 1: Engagement as a Mediating Variable

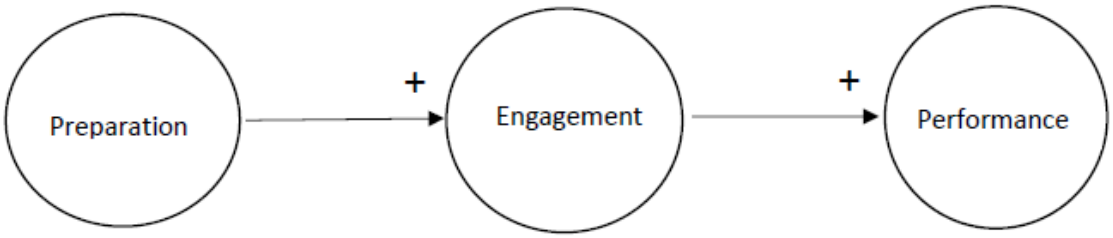

Figure 2: SPSS Model Estimation

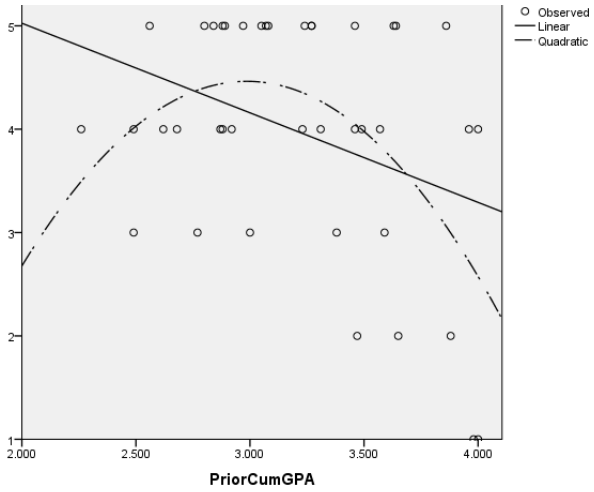

Table 1: LearnSmart®/SmartBook® helps me <u>prepare better</u> for and get more out of class.

	A students	B Students	C students	Overall
Week 5	3.27 (11)	4.31 (26)	3.67 (3)	3.98 (40)
Week 10	3.40 (10)	4.08 (25)	3.67 (3)	3.87 (38)
Week 15	2.70 (10)	4.18 (22)	3.50 (4)	3.69 (36)

Figure 3: LearnSmart®/SmartBook® helps me prepare better for and get more out of class.

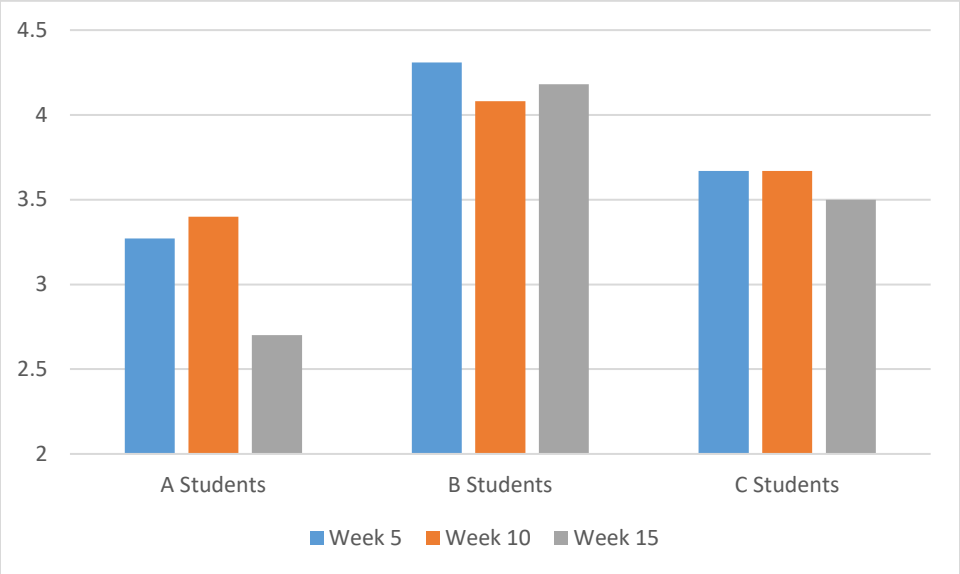

Table 2: Regression Results, Model (1)

	R-Square	B1 (p value)	B2 (p value)	B3 (p value)	B4 (p value)
Week 5	0.577	-0.63 (0.04)	0.36 (0.49)	0.59 (0.00)	0.20 (0.21)
Week 10	0.354	-0.10 (0.81)	-0.62 (0.32)	0.50 (0.03)	0.18 (0.32)
Week 15	0.743	-0.90 (0.00)	0.00 (.98)	0.18 (0.24)	0.62 (0.00)

Table 3: LearnSmart®/SmartBook® decreases my attentiveness in class.

	A students	B Students	C students	Overall
Week 5	2.18 (11)	1.58 (26)	3.00 (3)	1.85 (40)
Week 10	2.20 (10)	1.44 (25)	2.00 (3)	1.68 (38)
Week 15	2.10 (10)	1.55 (22)	1.50 (4)	1.69 (36)

Table 4: LearnSmart®/SmartBook® decreases my willingness to ask questions in class.

	A students	B Students	C students	Overall
Week 5	1.64 (11)	1.77 (26)	3.00 (3)	1.83 (40)
Week 10	2.20 (10)	1.68 (25)	1.67 (3)	1.82 (38)
Week 15	1.70 (10)	1.77 (22)	1.75 (4)	1.75 (36)

Table 5: LearnSmart®/SmartBook® increases my involvement in class discussions.

	A students	B Students	C students	Overall
Week 5	3.18 (11)	3.38 (26)	3.67 (3)	3.35 (40)
Week 10	3.00 (10)	2.92 (25)	4.00 (3)	3.03 (38)
Week 15	2.80 (10)	3.14 (22)	4.25 (4)	3.17 (36)

Table 6: LearnSmart®/SmartBook® increased my interest in topics in this class.

	A students	B Students	C students	Overall
Week 5	3.00 (11)	3.69 (26)	3.67 (3)	3.50 (40)
Week 10	3.10 (10)	3.48 (25)	3.33 (3)	3.37 (38)
Week 15	2.80 (10)	3.73 (22)	4.00 (4)	3.50 (36)

Table 7: Regression Results, Model (2): LearnSmart®/SmartBook® decreases my attentiveness in class.

	R-Square	B1 (p value)	B2 (p value)	B3 (p value)	B4 (p value)	B5 (p value)
Week 5	0.314	0.26 (0.49)	0.85 (0.18)	-0.26 (0.30)	-0.17 (0.40)	-0.06 (0.78)
Week 10	0.302	0.41 (0.18)	0.41 (0.41)	0.11 (0.57)	-0.14 (0.33)	-0.3 (0.03)
Week 15	0.286	0.46 (0.19)	-0.23 (0.60)	-0.21 (0.21)	-0.22 (0.26)	0.15 (0.42)

Table 8: Regression Results, Model (2): LearnSmart®/SmartBook® decreases my willingness to ask questions in class.

	R-Square	B1 (p value)	B2 (p value)	B3 (p value)	B4 (p value)	B5 (p value)
Week 5	0.245	-0.26 (0.77)	0.70 (0.24)	-0.35 (0.13)	-0.07 (0.69)	0.11 (0.55)
Week 10	0.288	0.29 (0.34)	-0.25 (0.61)	0.06 (0.73)	0.03 (0.83)	-0.39 (0.01)
Week 15	0.092	-0.11 (0.77)	-0.20 (0.67)	-0.08 (0.63)	-0.21 (0.31)	0.14 (0.48)

Table 9: Regression Results, Model (2): LearnSmart®/SmartBook® increases my involvement in class discussions.

	R-Square	B1 (p value)	B2 (p value)	B3 (p value)	B4 (p value)	B5 (p value)
Week 5	0.248	0.07 (0.82)	0.71 (0.19)	0.20 (0.36)	0.19 (0.25)	0.06 (0.71)
Week 10	0.387	0.57 (0.11)	0.97 (0.09)	0.43 (0.04)	0.08 (0.63)	0.14 (0.36)
Week 15	0.373	0.32 (0.42)	1.19 (0.02)	0.17 (0.38)	-0.31 (0.15)	0.51 (0.02)

Table 10: Regression Results, Model (2): LearnSmart®/SmartBook® increased my interest in topics in this class.

	R-Square	B1 (p value)	B2 (p value)	B3 (p value)	B4 (p value)	B5 (p value)
Week 5	0.436	-0.22 (0.48)	0.46 (0.38)	0.17 (0.41)	-0.03 (0.84)	0.43 (0.01)
Week 10	0.292	-0.02 (0.96)	-0.07 (0.89)	0.20 (0.30)	0.004 (0.98)	0.29 (0.05)
Week 15	0.518	-0.20 (0.19)	0.50 (0.25)	0.23 (0.16)	-0.15 (0.42)	0.44 (0.03)

Table 11: LearnSmart®/SmartBook® helps me retain information better.

	A students	B Students	C students	Overall
Week 5	3.18 (11)	4.15 (26)	3.33 (3)	3.83 (40)
Week 10	2.90 (10)	3.92 (25)	3.67 (3)	3.63 (38)
Week 15	2.70 (10)	3.86 (22)	3.50 (4)	3.50 (36)

Figure 4: LearnSmart®/SmartBook® helps me retain information better.

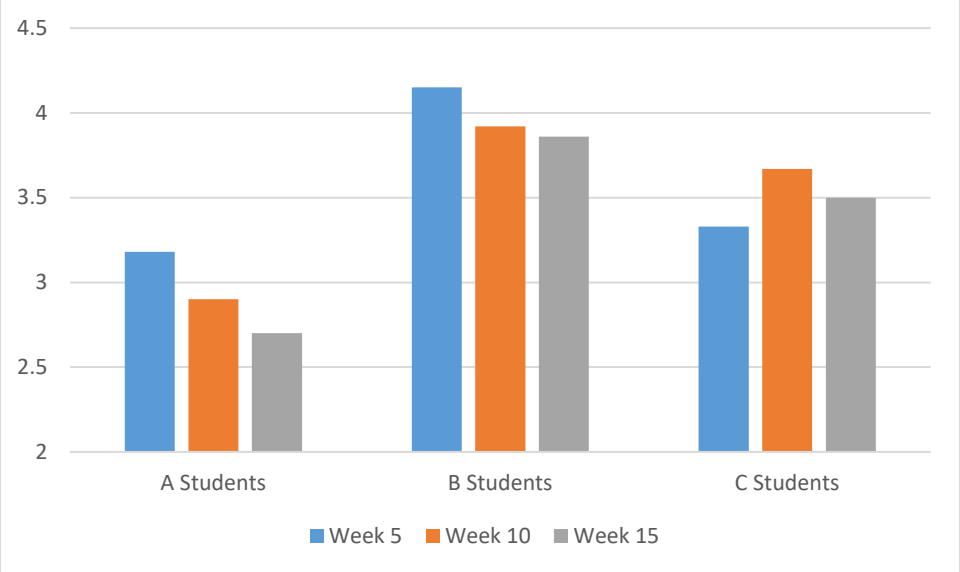

Table 12: LearnSmart®'s Recharge feature helps me retain information better.

	A students	B Students	C students	Overall
Week 5	3.09 (11)	3.31 (26)	3.00 (3)	3.23 (40)
Week 10	3.20 (10)	3.68 (25)	4.00 (3)	3.58 (38)
Week 15	2.50 (10)	3.23 (22)	3.50 (4)	3.06 (36)

Table 13: Regression Results, Model (3): LearnSmart®/SmartBook® helps me retain information better.

	R-Square	B1 (p value)	B2 (p value)	B3 (p value)	B4 (p value)	B5 (p value)
Week 5	0.796	-0.23 (0.24)	-0.29 (0.37)	0.07 (0.59)	-0.06 (0.59)	0.73 (0.00)
Week 10	0.783	-0.35 (0.14)	-0.04 (0.91)	0.15 (0.27)	0.07 (0.52)	0.71 (0.00)
Week 15	0.785	0.04 (0.91)	0.15 (0.70)	0.19 (0.20)	0.01 (0.93)	0.76 (0.00)

Table 14: Regression Results, Model (4): LearnSmart®'s Recharge feature helps me retain information better.

	R-Square	B1 (p value)	B2 (p value)	B3 (p value)	B4 (p value)	B5 (p value)
Week 5	0.376	0.09 (0.74)	0.36 (0.47)	0.13 (0.18)	0.28 (0.11)	0.24 (0.12)
Week 10	0.478	-0.27 (0.32)	0.32 (0.44)	0.25 (0.01)	0.39 (0.02)	-0.10 (0.44)
Week 15	0.661	-0.20 (0.50)	0.50 (0.23)	0.36 (0.00)	0.15 (0.36)	0.34 (0.02)

Table 15: Regression Results, Model (5): Exam Performance.

	R-Square	B1 (p value)	B2 (p value)	B3 (p value)	B4 (p value)	B5 (p value)
Week 5	0.495	13.08 (0.00)	-4.71 (0.29)	-0.28 (0.53)	3.51 (0.04)	-4.61 (0.005)
Week 10	0.390	6.82 (0.095)	-4.96 (0.30)	-0.27 (0.59)	-1.71 (0.28)	-2.13 (0.31)
Week 15	0.334	10.29 (0.06)	-9.832 (0.10)	0.085 (0.91)	1.20 (0.61)	-1.98 (0.46)