USE OF SOFTWARE IN COLLEGE MATHEMATICS COURSES: A GLIMPSE OF TWO PROJECT INITIATIVES

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Abstract

More and more faculty are increasingly in favor of introducing mathematical software, in their teaching, to address students' failure in entry-level college courses in mathematics. We discuss the implementation of two programs at Texas A&M International University (TAMIU), where mathematical software has been used as a proposed solution to this problem. In one program, it has been embedded as a component of the College Algebra course, and in another as an integral part of a program that prepares incoming freshman for College Algebra. The purpose of this paper is to elaborate and analyze the experience in undertaking this task. We will highlight the extent of students' success from the use of software.

Preliminaries

Education is considered as one of the most effective interventions to improve social and economical standards of individuals and communities in today's society. This, together with technology, can make a difference in student learning. Considering the diversity of the global marketplace, the high school diploma is, as of now, inadequate to bring reasonable change in living standards for all in terms of good jobs and basic amenities. There have not been many good results in terms of the number of American college graduates who have the necessary skills in mathematics to empower the workforce required to keep the country in the forefront of Science, Technology, Engineering, and Mathematics (STEM) disciplines (Thiel, 2008). This problem must be fixed due to the increasing demand for these courses that serve as a gateway to many disciplines. Failure in these courses detracts students from pursuing science majors.

Research showed that the transformational activities related to algebra conducted in technological environments such as Computer Algebra System (CAS) signaled the importance of the quality of the tasks and the classroom discussions during which the teacher can present the conceptual aspects of the activity diligently (Kieran, 2007). It is widely known that technology makes a difference in college mathematics teaching (Adams, 1997) and that the introduction of software tools and other hybrid structures have resulted in some success (Kinney, 2001).

In the sections that follow, two initiatives implemented at TAMIU to achieve these objectives will be discussed briefly: the Mathematics Enrichment Project (MEP) and the College Algebra Project.

The Mathematics Enrichment Project is a week-long workshop that provides activities for students who plan to take College Algebra. The workshop is offered during the week previous to the beginning of the semester, and only students that are enrolled in College Algebra are admitted to the workshop. Three carefully designed daily instructional sessions are the earmark of these five days workshop. One of them, during the afternoon, is reserved for students to work in ALEKS mathematical software, trying to complete a pie of items related to College Algebra topics.

On the other hand, the College Algebra Project is geared towards student success in College Algebra courses. In this setting, MathZone and ALEKS software were used to assist student to learn and practice the content that was covered in lectures. MathZone was used to provide online homework assignments. Two main features of MathZone are that students can seek online help and practice a question several times before the actual question they need to answer is attempted. On the other hand, ALEKS provided necessary tutorials on prerequisite materials needed by students, as well as it complemented the teaching done in the classroom. If the software detected that a student still needs to work on a particular area, ALEKS will make sure that the student gains knowledge in that area. It will not let a student proceed to other topics otherwise.

Mathematics Enrichment Project (MEP)

With funding secured from the STEM Recruitment, Retention, and Graduation (STEM-RRG) grant (STEM-RRG, 2008), the Mathematics Enrichment Project was implemented on January 2009. During fifty percent of the sessions students worked in ALEKS, while the other fifty percent was delivered in a lecture format. While students worked in ALEKS in groups of two. As current reform efforts in mathematics advocate, when working in groups the engagement of students in meaningful tasks create communities where students can discuss and reflect on their learning, which has greater potential than working alone (Post, 2008).

Over the week period, participants who worked on ALEKS attempted to complete the pie based on seven areas of topics: Real Numbers (RN) 28 items, Exponents and Polynomials (EP) 25 items, Equations and Inequalities (EI) 41 items, Linear and Quadratic Functions (LQ) 36 items, Rational Expressions (RE) 20 items, Radical Expressions (RdE) 23 items, and Geometry (GO) 24 items. The total pie was 193 items. The scores obtained from participation in ALEKS tutorials and assessments on each topic was recorded for Initial Assessment, Learning after initial assessment, a Progress Assessment, and Learning after the progress assessment. The topics chosen for the workshop are found in review chapter of a typical pre-college algebra textbook (Barnett, Ziegler, and Byleen, 2008), and were selected with the understanding that this workshop together with the necessary effort to use ALEKS will motivate students to master the entire course of college algebra when they actually take the course.

Table 1: Rates of learning on the basis of each day activities

Workshop Activity	Difference in Scores for all	Relative Rate (as Percentage)	Deficit in Goal (as Percentage)
Initial Assessment			53.95%

Learning	25.5	27.90% ↑	41.02%
Progress Assessment	2.55	2.59% ↑	39.73%
Learning	15.3	12.61% ↑	31.98%

This learning is twofold from assessment to learning and from learning to assessment as the workshop continues. Even though a progress assessment tests students on recently mastered material, we can not only see that students have mastered what they have just practiced, but also add a few more items to their pie. A sure sign that students are making real progress in their learning as is evident in Table 1.

Table 2: Summary of scores on each topic of the assessment

RN	EP	EI	LQ	RE	RdE	GO	ALL
22.2	12.6	22.7	13.1	4.73	4.91	10.5	90.7
26.0	15.3	26.1	16.3	8.0	10.3	14.3	116
25.9	16.2	27.2	17.0	7.91	9.82	14.7	119
26.7	18.6	29.4	20.2	10.5	11.8	16.8	134

Table 2 provides score obtained as the participants take part in their assigned learning activity. The results of the first learning after the initial assessment and the progress assessment are very similar as was expected. There is no learning during a progress assessment. The goal of a progress assessment is not to do learning, but to measure how much has been learned as students continue the workshop activities. The table shows that learning is happening, and that what is being learned is being retained.

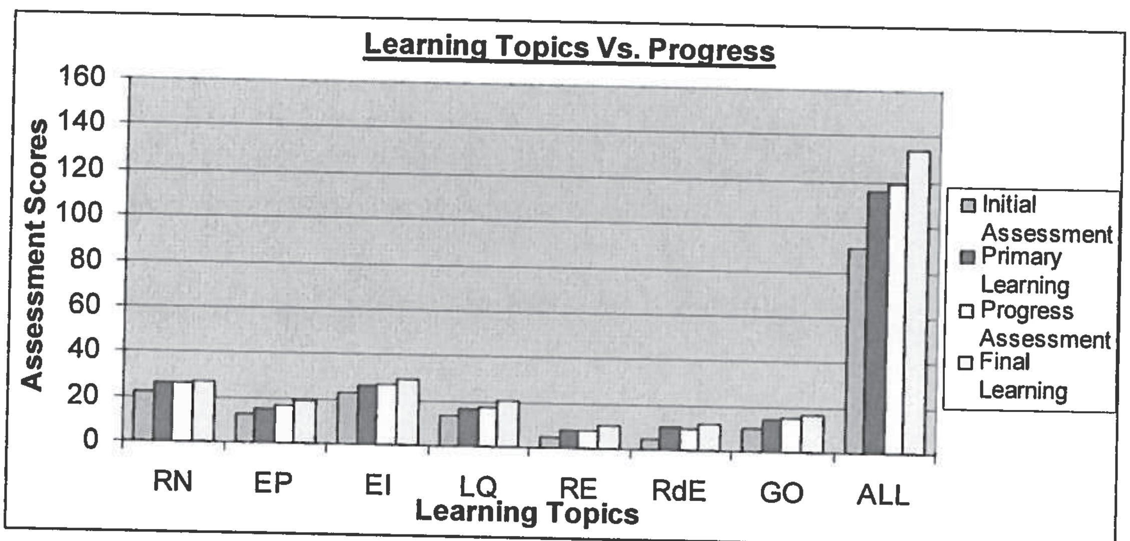

Figure 1: Progression of each learning topic over the sessions

Figure 1 shows that after the initial assessment, learning mode in ALEKS made an increase in the knowledge base of the participants. This is confirmed by the higher scores in the subsequent assessment. This process will continue throughout the learning processes. In some instances, the progress assessment can bring the participants' scores down a bit during this period of activity.

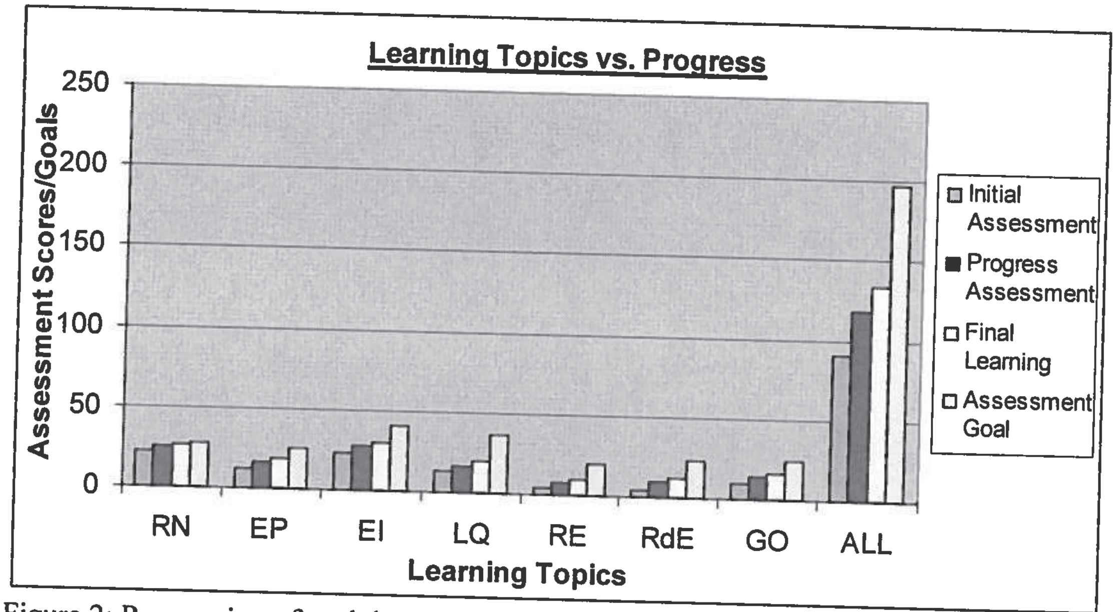

Figure 2: Progression of each learning topic toward the topic goals

The change in each item of the pie in relation to the set goal appears in Figure 2. While students clearly mastered the Real Numbers topic, they failed to master other topics like Rational or Radical Equations. When students started working in ALEKS they naturally started working in items that they were most familiar with, and once they had finished working on those topics they would move towards items that they were less familiar with. For example, in the Rational Equations or Radical Equations topic students took some time to get started into it, although it was clear that they needed help in those topics. Those topics were covered during lecture on the third and fourth day, coinciding with the time that students started to work in it, and in the next two days they advanced from 10% to 50% in both topics. Another important remark about the progress that students made during this time relates to the resources that they had. While a student can advance in the pie from any computer connected to the Internet, the resources of tutors and faculty provided by the workshop also made a significant difference in their progress. In many instances, a concept that would have taken a student a significant amount of time to master was quickly explained by a tutor or faculty, and this allowed the student to advance quickly. What this all amounts to, is that the right tools and support can make a difference in the learning of a motivated student, and the progress shown in Figure 2 is a clear indication of that principle.

Most students got their progress assessment two days after their initial assessment, the rest of the time was spent in learning mode. Progress assessment is a great indicator of learning, and it can only be compared to the previous aggregate learning. Results show that students not only learned what they had been practicing, but also gained a bit (a real sign that they had learned!). The slow increase is due to the fact that adding an item to the pie takes time. Normally, a student is presented with a problem, and if the student does not know how to solve the problem, the student has to read a page to learn how to solve that problem, then practice it another problem, and if solved correctly, practice it at least two more times. This is time consuming as adding such items to the pie is a slow process.

Table 3 lists comments received from participants for an open-ended question in the feedback form at the end of the workshop to suggest that the introduction of this software brought a new excitement among the participants in learning mathematics.

Table 3: Participant comments for: Please comment‡ on ALEKS in helping you grasp mathematical concepts

1. *Although there are some language barriers, it is very clear, strongly recommended!*
2. *It was useful. I recommend it for learning/sharpening skills.*
3. *It explained material very well.*
4. *It helped with the explanation it gave about the math topics.*
5. *ALEKS explains problems when student does not comprehend.*
6. *ALEKS is a helpful program to fully understand mathematical concepts.*
7. *It helped me learn different ways to solve problems.*
8. *ALEKS was very helpful at explaining new math concepts.*
9. *ALEKS was a great help. It helped me out by explaining things I didn't know. It was fun!*
10. *Very helpful. Explained very understand.*
11. *It helps improve my practice on many items.*
12. *ALEKS is incredible software and it really explained everything it added to what the professors taught.*
13. *It was great exercise.*
14. *It is actually useful.*
15. *The explanations were concise and helpful.*
16. *I learned more with ALEKS that with my high school teachers.*
17. *It is a great program. I will use it in the future.*
18. *It was excellent.*
19. *Best math program. Provided great examples and explanations.*
20. *ALEKS is an amazing instructional program with great explanations.*
21. *ALEKS helps the basic overall understanding of mathematics without a teacher.*
22. *Very useful to understand class.*
23. *It was helpful in thoroughly explaining how to do the problems when I don't understand them.*

‡ Some spelling and grammatical errors were corrected for inclusion in Table 3

College Algebra Project

This past fall, all College Algebra sections followed a common syllabus. Software applications were embedded into coursework delivery and assessments. Funding for this component of the project comes from a Title V grant received from the United States Department of Education (Title-V, 2007). The semester grade of students was based 45% on student's work on two software products (ALEKS & MathZone). One provided tutorials and assessments while the other was used for weekly homework assignments for students. Figure 3 describes the items used for calculation of student grades for these two components of the course based on potential points to be earned by students.

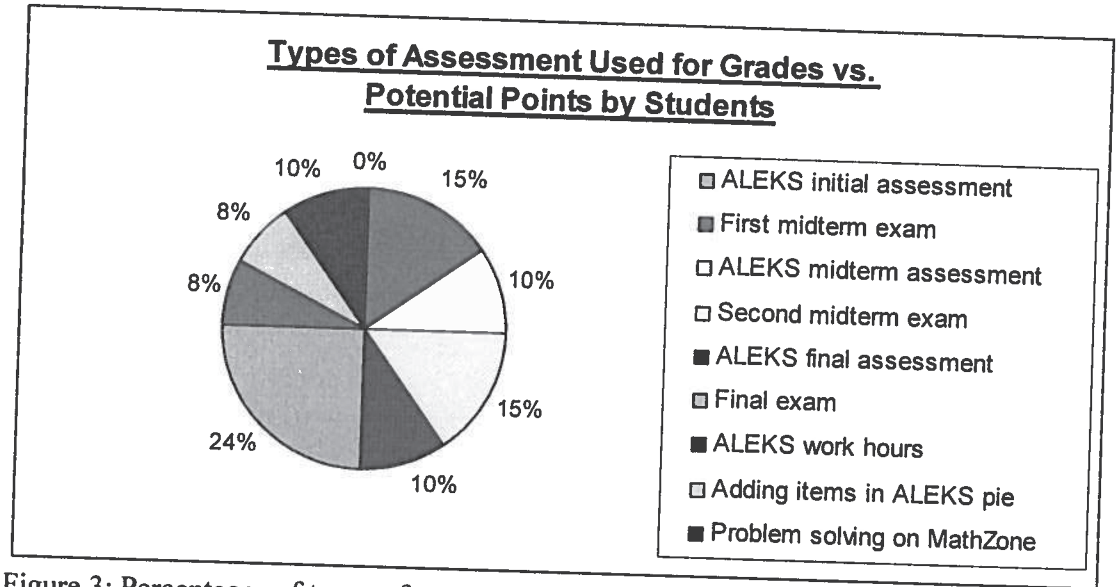

Figure 3: Percentages of types of assessment contributed to student grades

The primary focus on the use of these two software applications is to improve student performance in the courses and consequently, to improve the retention rates and strong showing on their grades.

Figure 4 depicts average ALEKS hours and other scores received in the initial assessment, midterm assessment, and final assessment by those who completed the course throughout all sections.

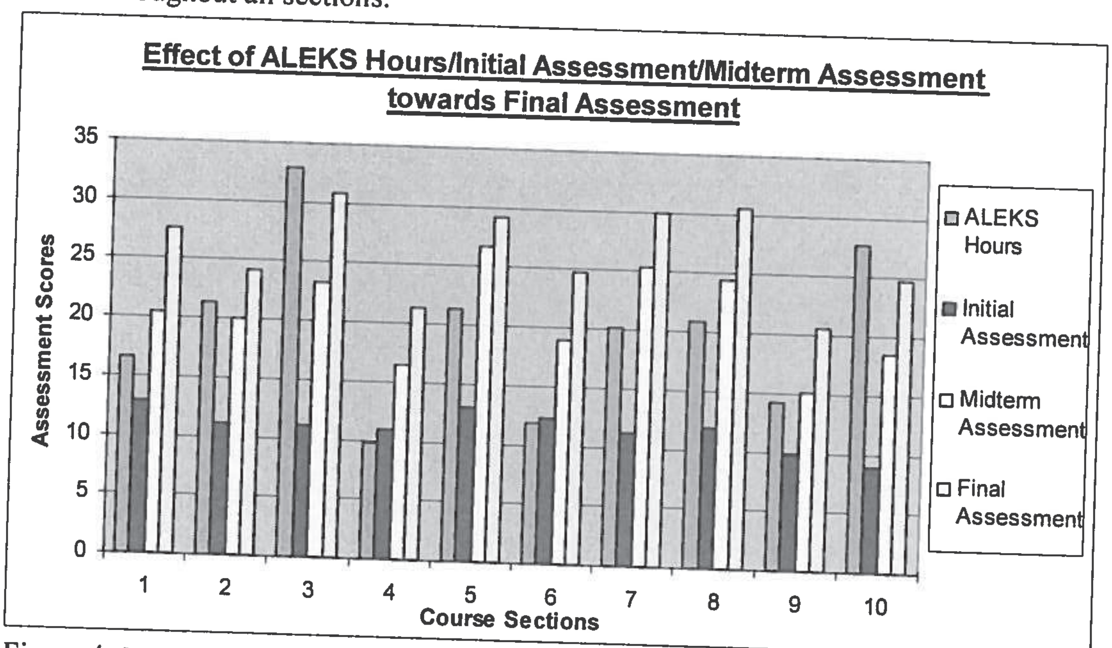

Figure 4: Impact of ALEKS hours on assessment scores in students that completed the course

Figure 5 is drawn including those who did not complete the final ALEKS assessment. It can be seen from Figures 4 & 5 that those who completed the final ALEKS assessment received higher initial assessment scores compared to all the students together in majority of sections.

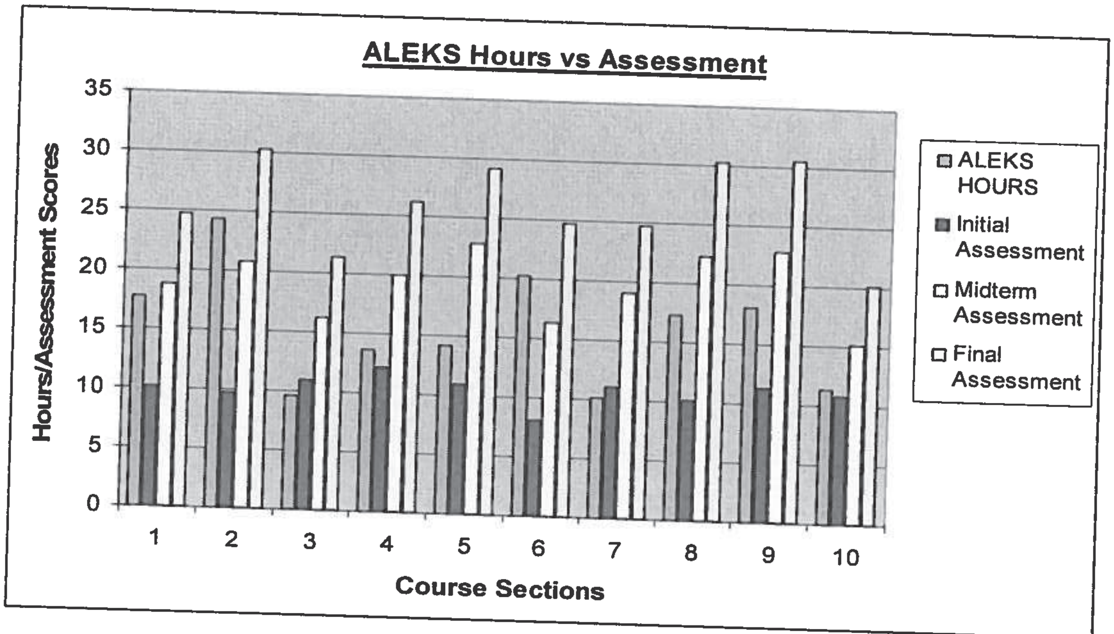

Figure 5: Impact of ALEKS hours on assessment scores for all students

All ALEKS assessments covered material typically found in a college algebra course in accordance with the common course syllabus. It is assumed that the students will be able to learn these materials at the completion of the coursework.

Figure 5 is a multiple bar graph for all the students constructed using averages for ALEKS hours, initial assessment scores, midterm assessment scores, and final assessment scores in all 10 sections. It shows that at the end of all assessments and ALEKS hours students were able to make substantial progress towards completing the topics in the course. On average, for those who took the final ALEKS assessment completed a total of ALEKS 19.3 hours for all sections throughout the semester. This is equivalent to 1½ SCH of additional learning. The chart shows that students did not take much time, nor that they advanced enough in their pie. As students worked in ALEKS, we can see how their pies increase, but in this case they did not spend much time in their pie. This was mostly because there was no planned correlation between lecture time and ALEKS time. While a student could be working in lecture in systems of linear equations, the same student might be working in polynomial equations in ALEKS, and this mismatch made many students give up on ALEKS, and work in homework (which was directly correlated to class) and just concentrate on activities that were directly related to lecture. On the other hand, it was also possible that a student could not work on a topic already covered in class, since they had not satisfied the prerequisite to work on it in ALEKS, and this increased the dislike of many students towards ALEKS.

Conclusions

With regard to the MEP project, a final determination on the success of this intervention is yet to be made at the conclusion of the Spring 2009 semester. Another possible area for future research might be to study the effects of technology on the students who could not be successful in the courses following this intervention. Some of the topics considered are not totally independent in terms of the subject areas considered in MEP. The analysis assumes a minimum influence among each other subject topics. As for College Algebra project, it is continued in the spring semester with major modifications in the way ALEKS is being used. The results will be compared with that of this paper to determine whether there is any deviation in the findings. However, more long-term studies are needed before any meaningful conclusion is made with regard to software use in college mathematics courses.

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ALEKS: https://www.aleks.com

MathZone: https://www.mhhe.com/math/mathzone/