Is Active Learning with Technology Changing Minority Students' Attitudes Towards Mathematics?

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Abstract: In this paper we present results on the effects of active learning and technology on student class participation, satisfaction and learning. We used ScaleUP and EMPORIUM active learning models in our redesigned pre-calculus and calculus courses. These models have been modified for minority students to increase their interaction with faculty and students, and improve their engagement and performance. There is a strong pedagogical belief that the more time students spend on solving mathematical problems, the more proficient they become. We discuss our successes and challenges, document student attitudes toward active learning using technology, and propose some recommendations moving forward.

Introduction

In the last decade, many significant research developments have taken place in the way mathematics is taught in general education mathematics courses. These developments appear in areas of broad interest and relevance to students in many disciplines [1]. Engaging students in active learning and technology increases the excitement of non-traditional and minority students. Research has shown that minority students tend to perform better in active learning environment rather than using traditional lecture structures. [2], [3], [4], [5]. With growing interest from government and businesses in hiring professionals in these fields, the need to train minority students with strong mathematical and analytical skills to be competitive in today's global economy has increased. North Carolina A&T State University has a STEM focus and has been ranked by US News & World Report as the No. 2 public historically black college or university in the nation. Therefore, NC A&T serves as an excellent location to conduct this research.

Bonwell defines active learning in the following way:

(1) Students are involved in more than listening
(2) Less emphasis is placed on transmitting information and more on developing students' skills
(3) Students are involved in higher-order thinking (analysis, synthesis, evaluation)
(4) Students are engaged in activities (e.g. reading, discussing, writing)
(5) Greater emphasis is placed on students' exploration of their own attitudes and values

Chickering and Gamson [7] stated that it is good practice to measure the time students spent on task. The average US college student spends less than one hour studying for each one hour spent in class which is far below their peers in other developed countries such as the UK [8]. The failure rates among underserved students in gatekeeper courses such as pre-calculus and calculus are alarming. For those who complete the course, some fail to master the core concepts and knowledge needed for follow-up courses.

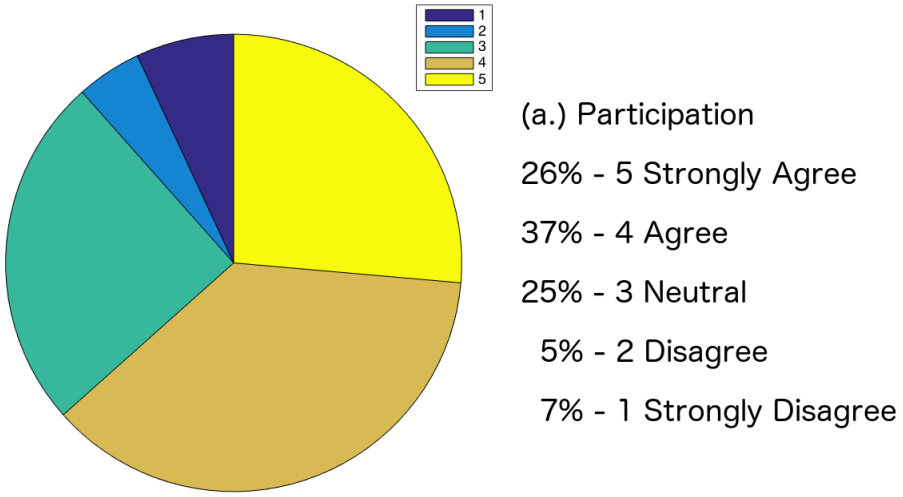

Figure 1: Summary results of survey questions regarding participation using the Likert scale.

In general, an estimated 60 percent of students in public institutions fail to complete their degrees, of which half leave during their freshman year [9]. Clearly, making significant improvement in gatekeeper courses can have major impact on student success and retention.

Methodology

The two redesigned courses considered in this paper are general education mathematics courses: pre-calculus and calculus, both targeted at students in Technology, Business, Agriculture and the Health Sciences. The classes in question are composed of traditional and non-traditional (adult/online) students. The overwhelmingly majority are from protected minority groups. For the majority of our students, the high expectation of them to do more reading on their own may be not be ideal. Thus, the students need more reinforcement and motivation that can be achieved through more active in-class lectures and just-in-time remediation. This is reinforced through the use of technology with more hands-on practice work in three ways: in-class discussion of exercises, use of the workbook, and online homework assignments.

Based on the specific needs of our student population, the pre-calculus (annual enrollment of over 400) and the calculus for business and technology (annual enrollment of over 800) have been redesigned by implementing the use of additional technology as teaching tools and active learning techniques. The main goal of this redesign is to improve student success, retention, and attitudes towards learning.

The redesign model for the pre-calculus is the modified EMPORIUM model. Whereas the regular Emporium model eliminates all lectures, we have adopted two hours of traditional lectures and two hours of active learning where students have personal assistance while they practice with interactive software - MyLabsPlus at the Mathematics Department Learning Resource Center. This center is equipped with computers and media tools for teaching. The interactive section includes tutorials, practice exercises from a workbook created for the course [10] and published by Pearson Publishing, homework, and quizzes. Graduate Teaching Assistants (GTAs) and tutors help students during the interactive section of the class.

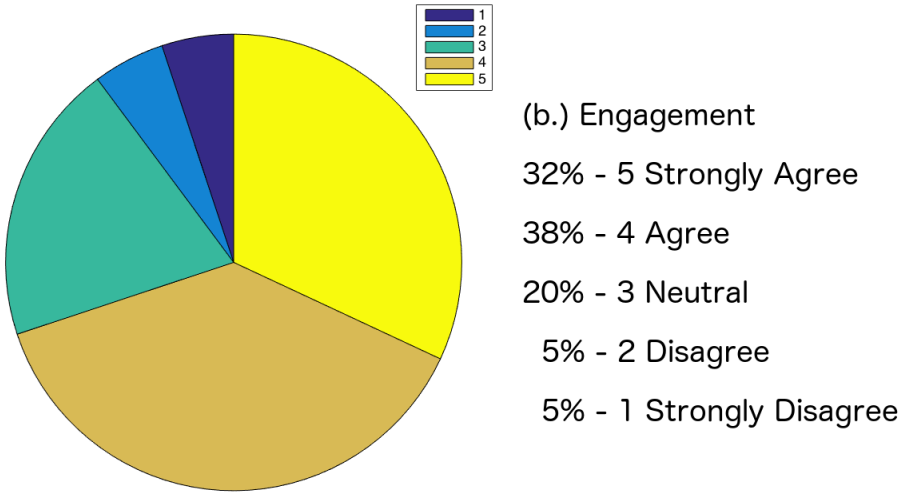

Figure 2: Summary results of survey questions regarding engagement using the Likert scale.

The redesign of the Calculus for Business and Technology course follows the Student-Centered Active Learning Environment with the Upside-down Pedagogies model, which was developed by North Carolina State University. Our mathematics department has adopted the SCALE-UP [11] model for our Calculus 1 course. The main distinction between SCALE-UP and traditional active learning ideas is the use of the active learning classroom, in which the classroom environment itself is altered to facilitate active learning [12]. The redesigned course has an equivalent three hours of lectures and an hour of roundtable active learning with interaction among students, GTAs and instructors. A workbook has been created for this course [13] and published by Pearson Publishing. In addition, there are worksheets used during the interactive sessions. The questions on the worksheets are designed to reinforce students' understanding of the lecturer materials.

Improving student attitudes towards mathematics

The main goal of this paper is to analyze the effect that using active learning and technology has on changing minority student attitudes towards mathematics. We believe that improving student engagement and improving student attitudes towards learning in class are crucial in addressing and closing the achievement gap of minority students.

Specifically, we try to determine the effect active learning and technology (ACLT) in the class have on

(a) **Participation** – whether ACLT increased student participation in the learning experience, increased contribution and participation in the class, improved communication/interactivity, promoted discussion with the instructor and other students, made collaboration with classmates easier
(b) **Engagement** – whether ACLT increased student willingness to put forth effort to complete the activities, increased interest and curiosity about the course subject

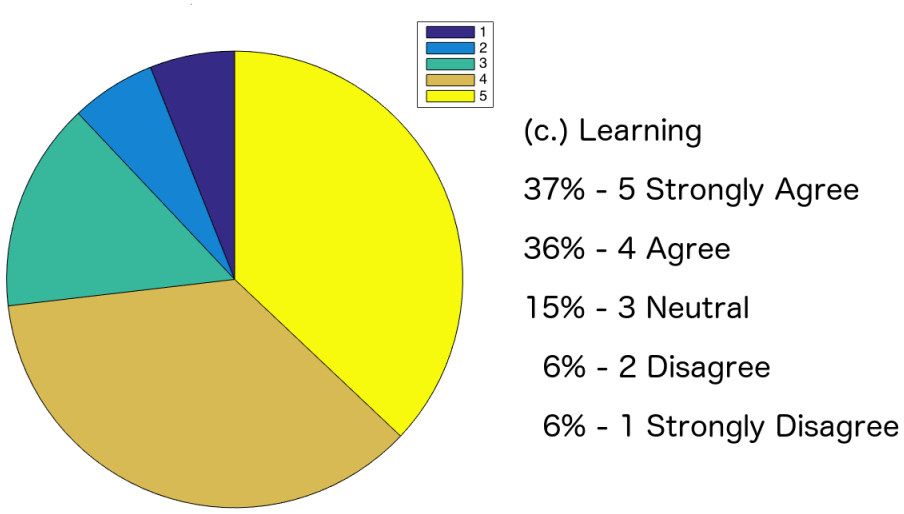

Figure 3: Summary results of survey questions regarding learning using the Likert scale.

(c) **Learning and Performance** – whether ACLT was beneficial to student learning, deepened learning and understanding of the course topics and concepts, helped student performance on exams and on assignments

(d) **Satisfaction** – whether ACLT was more successful in facilitating multiple types of learning activities, was more relevant than a lecture format, offered greater flexibility and time efficiency in studying. Whether it was fun, led to interactions that were exciting, provided a comfortable learning environment, and enhanced the in-class learning experience.

Surveys can be one of the most efficient ways to obtain the above data. They provide a scalable and relatively efficient approach for studying student responses to classroom instruction, motivation related to learning and self-reflection. To obtain the results, we utilized the University of Wisconsin-Milwaukee "Active Learning Classroom Student Survey," [14] and divided the questions into the four categories. A link to the survey is given in the references section of this article.

Survey Results

Survey results are summarized as follows as well as in Figures 1-4.

(a) Participation. The overall mean of all questions on participation is 3.72 on a 5 point Likert scale. The statement "enabled me to communicate effectively with my classmates" received the highest score on the survey of 4.07, The lowest was "made me want to attend/contribute in class" at 3.56.

(b) Engagement. The overall mean on all survey questions on engagement was 3.86. The statement "increased my willingness to put forth effort to complete the activities" received the highest score of 4.37, while the lowest was "promoted connection with the instructor through discussion" at 3.37.

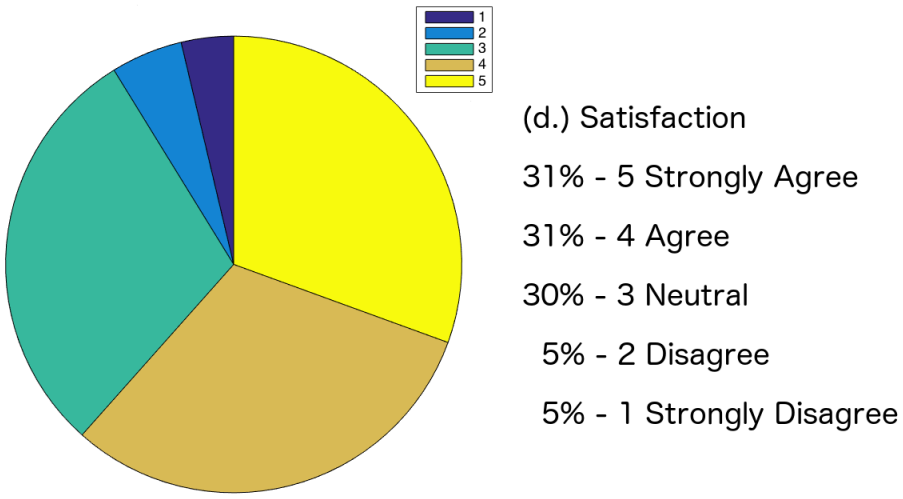

Figure 4: Summary results of survey questions regarding satisfaction using the Likert scale.

(c) Learning. The overall mean for all survey questions on learning was 3.92. The statement, "was beneficial to my learning" received the highest score of 4.19, while the lowest was "helped me to do better on exams" at 3.70

(d) Satisfaction. The overall mean for all survey questions on satisfaction was 3.69. The statement "made it easier to collaborate with other students" received the highest score of 4.15, while the lowest was "it was fun" at 3.19.

Conclusion

Our results show that introducing active learning and technology has been very successful in gateway math courses and that it changed students attitude towards mathematics. Students strongly agreed that the new course design was beneficial for their learning. They, also strongly agree that the active learning course structure facilitates interaction and discussion with fellow students. The most important results that came from the survey are that students strongly agree that they became more engaged in the course and that they state their willingness to put forth effort to complete the activities.

The results in the survey on some questions that scored lower are not surprising. Students still do not find the math class fun and are not so happy to attend. Students are unrealistic regarding grade expectations. On the survey, 50% of the students indicated that they think they will make an A in the class. Therefore, it is not surprising that the question on "helped me to do better on exams" scored a lower survey rating – they always expected to do very well. This survey shows that instructors should continue to encourage communication and promote connections with students through discussion.

Results presented here on improving student attitudes towards mathematics are part of a bigger study currently underway by the authors focusing on the impact of active learning and technology on retention, learning, and the successful degree completion of minority students.

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