Pedagogical Research
2026, 11(2), em0261
e-ISSN: 2468-4929
https://www.pedagogicalresearch.com

MODESTUM

Research Article

OPEN ACCESS

Transforming math education: Empowering learners to set their own pace in personalized learning environments

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Citation: Sivalingam, S., Herath, D., & Yukna, J. (2026). Transforming math education: Empowering learners to set their own pace in personalized learning environments. *Pedagogical Research, 11*(2), em0261. https://doi.org/10.29333/pr/18187

ARTICLE INFO

Received: 14 Jul 2025

Accepted: 12 Sep 2025

ABSTRACT

Mathematics is a fundamental pillar for developing problem-solving abilities, fostering logical reasoning, and honing critical thinking skills, all of which are essential for achieving academic success in college and flourishing in personal and professional endeavours. However, the percentage of students dropping out of Science, Technology, Engineering, and Mathematics (STEM) disciplines after unsuccessful completion of a mathematics course has received much attention in recent decades. While grades of 'B or C or D' are common in mathematics, students tend to drop out of STEM-related disciplines after earning a C as a final grade. To boost retention and to encourage students to pursue a path in STEM disciplines, this paper introduces a new model in learning mathematics: (1) learning at your own pace with an individualized learning path and (2) combining two consecutive mathematics courses in the same classroom, where students have the flexibility to enroll in one course and do the other based on their progress. Although this model was built for mathematics courses, the changes could be implemented in any discipline with sequential courses. The study is not about an emporium model.

Keywords: STEM discipline, new model, mathematics learning, self-paced learning, constructivist

INTRODUCTION

Given the fundamental role of mathematics in twenty-first-century economies, it is a matter of social justice and equity that all young people be able to access mathematics education. Ernest (2005) mentioned that mathematics contains many of humankind's most potent, exciting, and profound ideas.

Ernest (2015) stated that the standard aims of school mathematics are intended to develop the following three categories:

(1) Functional numeric,

(2) Practical and work-related knowledge and skills,

(3) Advanced specialist knowledge of mathematics.

These categories are necessary and valuable for the learner, predominantly for employment, functioning in society, further studying, sustaining mathematics, and mathematical interests. However, students entering college-level mathematics courses, particularly STEM discipline students, are not always prepared for rigorous college-level mathematics.

The curriculum in STEM disciplines almost always requires students to complete a minimum number of mathematics courses. Successfully completing these courses is crucial to progress through STEM disciplines and for STEM retention. Students are often placed in mathematics courses based on their mathematics courses from high school, which can lead to underprepared students having difficulty in completing the college-level mathematics courses successfully. The purpose of this study is to create a model where students can learn mathematics at their own pace using a customized learning path, build new knowledge on top of the prior mathematical background, and have the freedom to move between consecutive mathematics courses within the semester. The model includes adaptive, active, and differentiated learning to accommodate students enrolled in these courses.

The researchers implemented a self-paced and differentiated learning model to help students move from College Algebra to College Algebra and Trigonometry or vice versa within a semester. Students get credit for the completed course. The implementation was done in the spring of 2022 as one course section named "Math 117 - 125." In this paper, the researchers discuss the nature of the model and its implementation. In the future, the researchers intend to compare and analyze the data of this new model to traditionally taught mathematics courses.

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LITERATURE REVIEW

STEM Retention

McCormick and Lucas (2011) noted in their report, “Exploring Mathematics College Readiness in the United States,” that a surprisingly large number of students who graduated from high school were unprepared for post-secondary education. Students’ under-preparedness in mathematics was one of the major factors contributing to the dropout of STEM-related disciplines. Ernest (2015) argued that there is a misalignment of expectations of students regarding secondary education and higher education. The authors further noted that college readiness in mathematics is a significant factor in job opportunities and career choices.

Lack of mathematics skills and proper mathematical background results in poor numerical manipulation, which can lead to low confidence and failure (Sithole et al., 2017). Mathematics is required in almost all STEM-related degrees and as a tool to understand the laws and other concepts in STEM disciplines. Students often find the STEM path difficult due to the lack of a solid mathematics background and tend to switch to other disciplines.

Nehm (2014) predicted that by 2025, the U.S. would be short of two million STEM workers (Source: U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System). In 2020, the overall 6-year graduation rate for the first time, full-time undergraduate students who began seeking a bachelor’s degree at 4-year degree-granting institutions in fall 2014 was 64%. The 6-year graduation rate was 63% at public institutions, 68% at private non-profit institutions, and 29% at private for-profit institutions. Postsecondary institutions conferred about two million bachelor’s degrees in 2019-20. More than half (58%) were concentrated in six fields of study. Business is the most prevalent field of study. Engineering, biological, biomedical sciences, and psychology were at 6% each. Between the years 2009-2010 and 2019-2020, the total number of bachelor’s degrees produced increased by 24%. Within this group business degree comprised 8%. The report highlights that the United States lacks an adequate number of workers to keep up with the growing demand in STEM-related jobs (National Center for Education Statistics, Integrated Postsecondary Education Data System).

Mathematics and STEM Retention

Of the many students who enrolled in a STEM degree end up switching to other majors are those who perform poorly relative to their peers in STEM major and /or drop out of college before completing the academic degrees (Sithole et al., 2017). Geary (2013) noted that students’ challenges in learning mathematics can be due to associating symbols with the physical quantities and a lack of mathematical logical reasoning. Understanding the barriers for students dropping out of STEM fields is necessary for increasing engagement and retention of STEM undergraduate students.

Lack of STEM self-efficacy and sense of belonging has been identified as a contributing factor of reluctance to pursue STEM-related degrees. The authors defined STEM self-efficacy as belief that a student can succeed in STEM classes. Sense of belonging refers to belonging to a community; either within a mathematics course or any other STEM-related course, where students work collectively instead of individual learning. Comley et al. (2015) argued that student cognition and motivation, as well as institutional policies, determine student course grades and retention in STEM related majors. The authors also included that self-efficacy, continued interest in learning more about the subject, and focus on classes and studying remain the main components in STEM-related student retention.

Learning Methods

Implementing diverse pedagogical strategies and learning methods is essential to effectively support STEM learners. As highlighted in the White House report by the President’s Council of Advisors on Science and Technology (2012), developing the mindset of a STEM professional involves not only acquiring knowledge but also cultivating habits of mind, skills, and disciplinary identity-elements that cannot be effectively fostered through a single mode of instruction. Chamberlin and Powers (2010) emphasized the importance of mathematics instructors adapting to the varied needs of their students, who come from different backgrounds and possess distinct learning preferences. Mukhanov et al. (2019) further supported this by asserting that individualized learning allows all students to engage with the same content, but at levels tailored to their unique experiences and capabilities.

Similarly, DeVore et al. (2017) advocated for the integration of electronic tools that facilitate self-paced, adaptive learning, enabling students to progress based on their individual mathematical backgrounds while receiving varying levels of scaffolding as needed. As Tesene (2018) observed, today’s increasingly diverse student populations bring a wider spectrum of aptitudes and skill levels into college classrooms, further underscoring the need for flexible and inclusive teaching practices. Gupta et al. (2024) emphasized that a fundamental goal of the educational system should be to cultivate independent learners who are inquisitive, critical, creative, and capable of directing their own learning. According to Merkez, such learners thrive in physical and social environments that are intentionally designed to support autonomy and engagement. With the rapid advancement and widespread availability of technology over the past two decades, students now have unprecedented access to educational resources beyond the traditional classroom setting. However, several factors can still impede the development of self-directed learning, including lack of motivation, fear of the subject matter, and insufficient foundational knowledge.

To address these challenges, Gupta et al. (2024) highlighted the benefits of integrating adaptive learning technologies. These tools not only support personalized learning experiences but also save valuable instructional time by automating feedback and tracking individual progress. Adaptive platforms allow instructors to differentiate instruction effectively, tailoring content and support to meet the unique needs and skill levels of each student. One of the notable advantages of adaptive learning is the immediacy of feedback and access to targeted resources, which significantly shortens the delay between student performance and corrective guidance.

However, the successful implementation of adaptive courseware requires thoughtful planning and faculty preparation. As Sivalingam (2021) noted, instructors must receive adequate training to maximize the effectiveness of these technologies and to ensure that the integration supports, rather than replaces, meaningful instruction. When used intentionally, adaptive learning environments can enhance student agency, bridge knowledge gaps, and foster the confidence needed for independent learning.

In this study, researchers integrated adaptive courseware powered by artificial intelligence (AI) alongside active learning strategies to enhance student learning outcomes. Adaptive learning technologies utilize AI models that dynamically adjust the difficulty and pacing of content in real time, tailoring instruction to each student's individual progress and mathematical skill level. This personalized approach helps accelerate learning by meeting students where they are and providing scaffolding as needed.

Complementing this, active learning was employed to foster deeper student engagement. Active learning is defined as a process in which students participate in meaningful activities that prompt them to reflect on and apply what they are learning. It encourages students to assess their understanding continuously through problem-solving, critical thinking, and collaboration. Van Hout-Wolters et al. (2000) emphasized that active learning promotes self-regulated learning by giving students the responsibility to make decisions about their learning processes. They argued that active learning is particularly beneficial for students across the performance spectrum, providing necessary support for those struggling while offering enrichment for more advanced learners. Furthermore, active learning benefits instructors by increasing opportunities for interactive, hands-on engagement in the classroom.

This research also adopts a student-centered teaching approach, shifting the focus away from traditional lecture-based instruction to one where students take ownership of their learning. In this model, learners actively construct knowledge through both independent study and peer collaboration, while instructors act as facilitators or coaches. Faculty guide students in developing essential skills such as inquiry, analysis, and persistence, ultimately fostering a more inclusive and responsive educational environment.

THEORETICAL FRAMEWORK

This study was modelled using constructivism learning theory, particularly learning environments and pedagogical goals cited by Bada (2015) in their article. Constructivism theory is based on the idea that learners build their knowledge from existing foundations. It emphasizes the active role that learners use to build their own understanding. In the constructivism framework, the instructor should act as a facilitator and help students to become active participants in their learning. Bada (2015) noted that the central idea of constructivism is that learners build new knowledge upon the foundation of previous knowledge, which sharply contrasts with the traditional method of learning that promotes receiving, not constructing. In addition, the researchers mentioned that learning should be active and not passive.

The three main types of constructivism are C*ognitive, Social, and Radical.* Of the three types, *Cognitive and Social* constructivism align most closely with this study. In *Cognitive* constructivism, knowledge is constructed through mental processes, and the learner is an active problem-solver. In *Social* constructivism, knowledge is created through interactions, collaboration with peers, and the learner is an active participant in constructing the knowledge. Social constructivism was a part of this study as the researchers offered a positive environment where students worked in groups depending on their background and discussed applications, general questions, or even helped each other.

The two key components of constructivism are:

(1) Learners come to the classroom construct with prior knowledge, and that prior knowledge influences what new or modified language they will construct,

(2) Learning is active and not passive. Learners are expected to actively engage during the process to avoid inconsistency or misunderstanding in the new learning experiences (Phillips, 1995).

As cited by Bada (2015), the researchers considered the following pedagogical goals.

(1) To provide experience with the knowledge construction process (students determine how they will learn),

(2) To provide experience in and appreciation for multiple perspectives (evaluation of alternative solutions),

(3) To embed learning in realistic contexts (authentic tasks),

(4) To encourage ownership and a voice in the learning process (student centered learning),

(5) To embed learning in social experience (collaboration),

(6) To encourage the use of multiple modes of representation (video, audio text, etc.),

(7) To encourage awareness of the knowledge construction process (reflection, metacognition).

While creating the new model, the researcher had the understanding that students came to their classroom with various backgrounds and do not have similar or equal knowledge. For this reason, the researchers promoted the idea of including differentiated learning with flexibility. Constructivism theory fits the purpose of building new knowledge from whatever knowledge students have already. In addition, the constructivist framework focuses on clarifying any misunderstandings the students have made in gaining knowledge. The researchers' intention to create a student-centered model where the student is an active learner was based on the cognitive constructivist theory.

METHODS

Introduction

Beach et al. (2012) studied the requirements of the learning styles of STEM education. The authors suggested that shifting the model of basic courses from an instruction-based or teacher-centred approach to a learning or student-centred model could help address high attrition rates and promote best teaching practices at all levels within the STEM disciplines. In their review, the authors noted the possibility of successfully employing student-centred models based on the substantial quantity of research done on learning and instructional strategies.

The National Research Council (Singer et al., 2012) summarized key research findings on the conceptual understandings of students who are in undergraduate STEM programs. Their report noted that, in general, students had difficulty understanding the concepts and interactions not directly related to their learning. Their research found that in all disciplines, students do not have an accurate grasp of fundamental concepts. Most of the STEM classes are taught in the traditional method. Although it is effective for some subset of students, it is not optimal for all the students in the classroom. As per their report, the authors suggested that the instructors should use a variety of strategies to make the lectures interactive and effective in obtaining the learning objectives.

Some strategies summarized in the report were:

- Engaging students in the classroom with activities that would help in learning the concepts and provide dynamic feedback,
- Collaborative work in the classroom or outside of the classroom,
- Including methods for conceptual understanding, critical thinking, problem solving and metacognition,
- Using technology that is most effective in teaching and learning ,
- Shifting from information delivery and sharing to self-paced learning and practice in class.

With these ideas, the researchers created a model, named “Math at Your Own Pace". The intention is to provide students with a customized learning path, empowering them with active learning, recognizing at-risk students and providing help, and assessing factors affecting course completion. Along with the self-paced learning, the idea of two consecutive courses being taught in the same classroom as crossover courses was introduced. At the end of the semester, students get credit for one of the two courses based on their progress. This study took place in a medium-sized Midwestern university and was implemented in spring 2022. The model used in this study was chosen to help students learn mathematics in a supportive setting instead of the traditional class setting. The courses were co-taught by the researchers, who are faculty members in the department of mathematics.

Proposed Method

Observations from the past showed that students were placed in introductory mathematics courses based on their high school completion of mathematics courses. With the traditional teaching methods, unprepared students were not able to follow the rigorous course material. We came up with the idea of implementing a model that provides flexibility in learning mathematics. Historically, students register for either Math 117 or Math 125. The prerequisite requirement for these two courses is the completion of Intermediate Algebra (Math 116) with a ‘C’ as the final grade. The 117,125 courses are required for, but not limited to, STEM students. Math 125 covers the same algebraic topics as Math 117 but also includes trigonometry.

The researchers of this study observed that the students earning Cs, Ds, or Fs as grades in Math 125 would have performed better in the slower-paced Math 117. On the other hand, many students who easily passed Math 117 could have benefited from the challenge of Math 125 and could have earned credit for it. Since pre-requisite course completion did not seem to be effective in placing the students in Math 117 or Math 125, the researchers proposed the new model to address this issue. For Math 117 and Math 125, the researchers created a flexible special experience where students in the same class section earn credit for either Math 117 or Math 125, depending on their mastery of the learning outcomes. While every student is in the same room, each student pursues a unique, personalized path to their success. Their learning path is customized using adaptive, active learning, and differentiated learning pedagogies. Weekly lesson plans were developed in detail for the two tracks ahead of the semester. The tracks were posted in the syllabus, Canvas, (the Learning Management System), and ALEKS, an adaptive courseware.

Students who register in this new model choose a path at the beginning of the semester and follow their track to complete the weekly topics. Students cover the material at a pace to either complete Math 117 or Math 125 within the semester. Students are encouraged to complete the weekly topics of their chosen track on time. Faculty were flexible in providing support for those who could not maintain the set pace. Course credit was determined by students’ progress and their final grades at the end of the semester. Students have the option and flexibility to move up to Math 125 or down to Math 117, depending on their progress and faculty approval. In addition, students can decide to get credit for Math 117, even if they have completed Math 125 and have a C or D as their final grade. This was done by comparing the final grades and completion of content in both courses. The model provides an opportunity to get a higher grade in Math 117 and take Math 125 in the following semester.

Class structure

Based on the research conducted by Singer et al. (2012), students’ learning, retention of what they learned, and attitudes about learning science can be enhanced through different learning technologies. However, learning technologies alone do not achieve desired outcomes, but rather how the technology is used. In this new course model, the researchers used ALEKS, an adaptive courseware, to measure and set the mastery level for each module. ALEKS is an AI-based learning and assessment system that quickly and accurately determines each student's knowledge of a subject and helps them to work on the topics they are ready to learn.

The researchers' classroom included the Teaching Acceptance Model (Tam, 2000), which includes the following basic characteristics of constructivist learning environments.

(1) Knowledge is shared between teachers and students,

(2) Teachers and students will share authority,

(3) Teacher's role should be of a facilitator or guide,

(4) Learning groups should consist of small numbers of heterogeneous students.

Students were placed in learning pods i.e. in groups in the classroom based on weekly ALEKS assessment and reports. Students are placed in different pods each week based on their progress. Each learning pod is designed to address a specific topic (learning outcome) at a particular mastery level. Students in a pod mostly worked on similar topics and were encouraged to discuss topic-related questions, and projects. Lectures were limited to 45 minutes per week, and the rest of the time was used to answer students' question. Faculty moved around among the different groups and worked with students during class time. This reduced the burden of having to focus on different knowledge levels within the entirety of the class.

Faculty-student interactions can significantly influence students' persistence in STEM fields (Watkins & Mazur, 2013). The authors noted that the student-faculty interactions both in and outside of the classroom effectively contribute to retaining students in STEM disciplines. As per their research, interactions during office hours or any setting outside of the classroom can have a positive effect and encourage students' continued commitment to STEM. This model included several other factors that contributed to student success in these courses. Sivalingam (2021) recommended that providing timely feedback would help students to understand their mistakes and rectify them in a timely manner. Providing support outside of the classroom is also essential in student learning (Sivalingam, 2021). Since the class was co-taught by the researchers, the researchers had a combined 12 hours of office hours per week. The researchers decided to keep unique office hours to provide greater access for students. The University provides math tutoring through its Student Success Center, and students are informed of the service.

Figure 1 shows how students worked at their own pace to complete the topics for later weeks of the semester. The topic completion shown in **Figure 1** was recorded during week 5 of the spring 2022 semester. The graph shows the differentiated progress of three students in Math 117 - College Algebra.

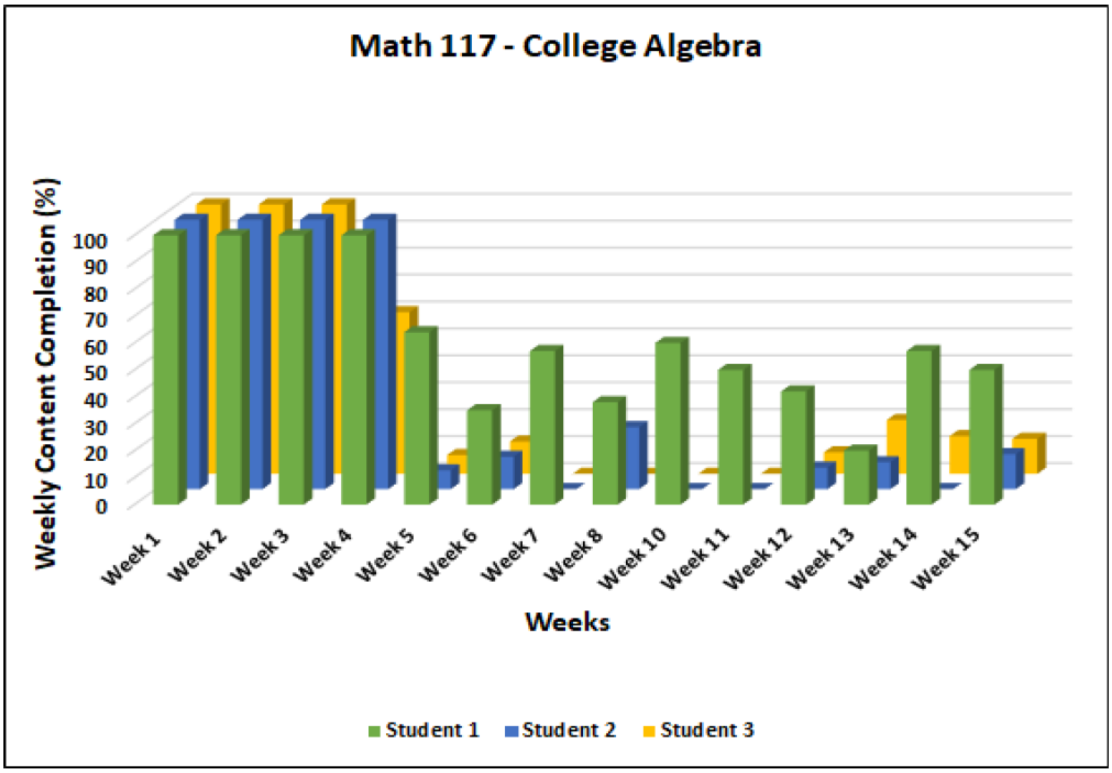

Figure 1. Math 117 - Week 5 progress of a sample of students (Source: ALEKS Student Reports from MATH 117 SP 2022)

Figure 2 shows how students in Math 125 - College Algebra and Trigonometry, worked at their pace to complete the topics for later weeks of the semester. The topic completion shown in **Figure 2** was recorded from ALEKS during week 5 of the spring 2022 semester. The graph shows the differentiated progress of three students in Math 125 - College Algebra and Trigonometry.

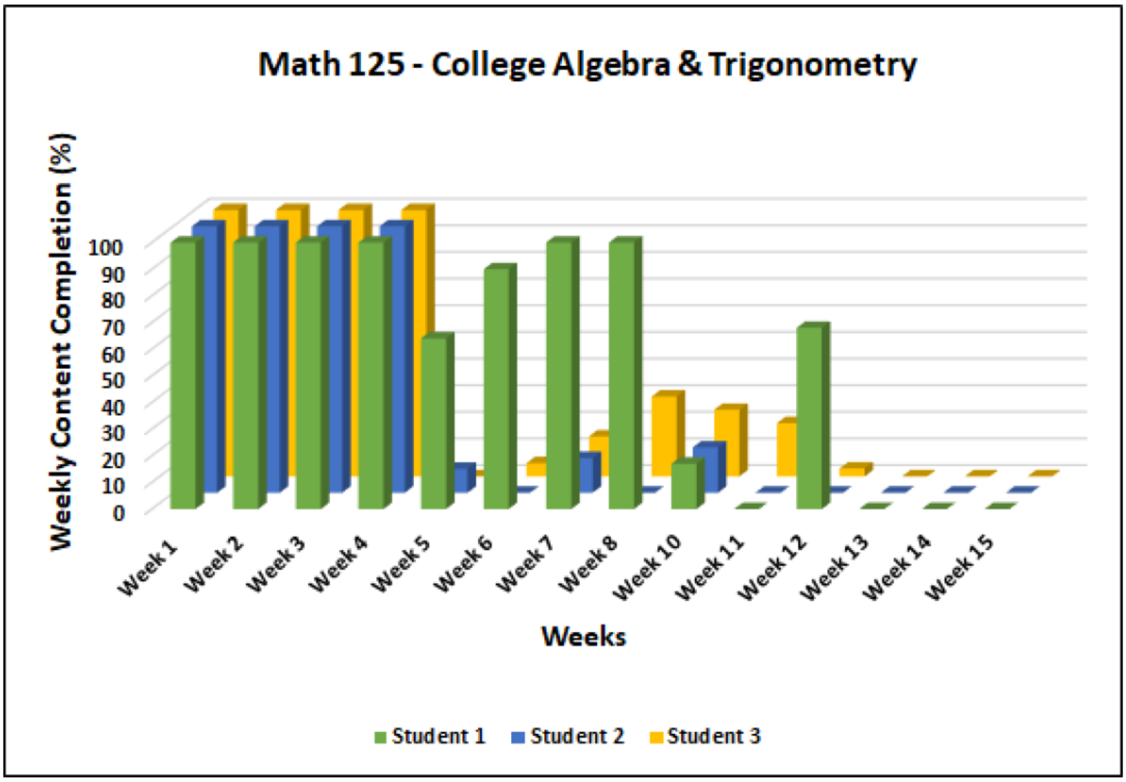

Figure 2. Math 125 - Week 5 progress of a sample of students (Source: ALEKS Student Reports from MATH 125 SP 2022)

Differentiated learning

Anderson (1999) asserted that although the taxonomic level of an objective depends on prior learning by the students, the practical idea of it is difficult to apply. Anderson noted that students enter a course from diverse backgrounds and with various levels of prerequisite knowledge. Additionally, in a class populated by students with diverse learning foundations, it might be appropriate to use different cognitive processes for different sets of students to achieve the same objectives.

The new model has the flexibility to accommodate students with different mathematics backgrounds and focuses on differentiated learning throughout the semester. After the preliminary assessment through an initial knowledge check in ALEKS, students are provided with a customized path depending on assessment results. The customized path fosters a differentiated learning environment in this model, which is not feasible in a traditional setting. As the students mastered a topic, they were moved to learn the next topic in their learning modules. Faculty acted as facilitators rather than as authorities on the subject. The model is intended to encourage students to own the learning with minimal lecture and individual help on topics.

Students were not able to proceed to the next module without completing the previous topic that was in the customized learning path. Hence, the assumption that a particular topic is too easy or difficult for all the students is eliminated in this model. Students practiced numerous problems in a topic that ALEKS created algorithmically to attain mastery. While mastery is being measured using ALEKS, additional learning interventions were implemented through the feedback provided by ALEKS, and the faculty.

Active learning

Active learning is one of the requirements for the new model. Hence, the outcomes of each module were connected to simple diagnostic projects. These projects are based on the revised Bloom's taxonomy model, where students use both the knowledge and cognitive dimensions. Projects were created based on remembering definitions, terms, and formulas where students should be able to understand and apply mathematical concepts. Application and synthesis projects challenged students to identify the problem, recall concepts, interpret the problem, choose an appropriate method, and solve.

Singer et al. (2012) mentioned that group work has been associated with different outcomes, which include critical thinking, higher level reasoning, students' understanding of their group members' perspectives, understanding of attitudes and achievements of their fellow students, instructors, and understanding the subject matter. Depending on their mastery of a particular topic, students worked on projects that focused on the lower end of Bloom's taxonomy (understand) or work on real-world projects that connect multiple concepts together at the higher end of bloom's taxonomy (apply, analyze, or create).

Kortz et al. (2008) noted that even when taught by the same instructor during a semester, on average, students who learned through lectures scored lower on tests than the student who participated in interactive sessions. Through in-class projects, students were able to apply subject knowledge, critical thinking skills, and decision-making skills to understand real-world applications. The researchers did regular class observations during the spring 2022 semester in the Math 117-125 pilot course. Observations include helping students with questions, observing group work, projects, and classroom discussions.

Data Collection and Discussion

Data collection

The final grades of the students enrolled in the Math 117-125 model, "Math at Your Own Pace," were the data used in this study. Students were informed by their advisors about the model before joining the course. Students had the option to enroll in this model or in a traditional model. The enrolled number of students for the pilot course was capped at 20, with 10 students in each track. On the first day of the semester, the model and learning methods were explained to the students, and questions were answered during the first few weeks. Apart from this, the model was explained in the course syllabus, which was on Canvas. Anonymous surveys (See **Appendix**) were created in Qualtrics by the researchers during the first, 4th, 8th, and 15th weeks to understand students' perspectives of the model.

In Fall 2022, the researchers filed an IRB application to analyze the data collected in this course to determine if the model provided any answer to the question, "Does self-paced and differentiated learning help students complete Math 117 and progress to Math 125 in a single semester?" Math 117-125 pilot course students' final grade data is used in this research and was collected from the university's academic records division. Informal, anonymous surveys were used to understand the students' perspectives and for any dynamic changes during the semester.

RESULTS

Students enrolled in this course could finish College Algebra (Math 117) or College Algebra and Trigonometry (Math 125) after choosing a path at the start of the semester. In the spring 2022 pilot course, ten students were enrolled in each section of Math 117, and Math 125, respectively. Students worked at their own pace through the semester, and three students completed the course content for Math 117 and moved to Math 125. Of the three students, one of the students clearly indicated their intention on moving to Math 125 by week 6 and followed through it. The other two students completed Math 117 in 11 and week 12 and completed the trigonometry topics during the rest of the semester. **Figure 3** shows the changes during the semester.

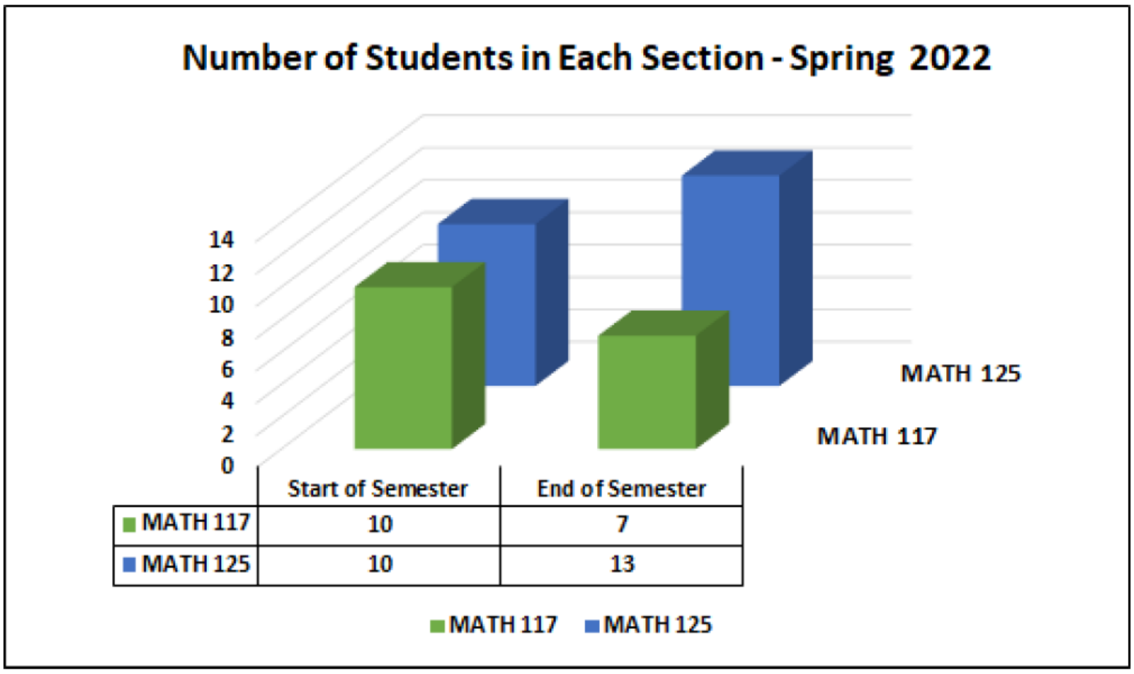

Figure 3. Math 117 and Math 125: Number of students in each track (Source: ALEKS Student Reports from Math 117 and Math 125 SP 2022)

The faculty conducted anonymous surveys during the semester's first, fourth, eighth, and fifteenth weeks. Each survey contained five questions about the model to understand the students' perspectives and make appropriate changes or further explanations. In each survey, the researchers added students' ease of following the model/track as one of the questions. **Figure 4** shows that at the beginning of the semester, 60% of the students were able to follow the model/track. However, none of the students answered no to the question in week 1, but noted that sometimes they have understood, and one student said not applicable (N/A). Statistics showed that the results were consistently positive until the researchers reached week 15, where the percentage of students saying "NO" to this question went to 13% from zero. Further discussion in the class revealed that the students who moved from Math 117 to Math 125 had some confusion during their transition.

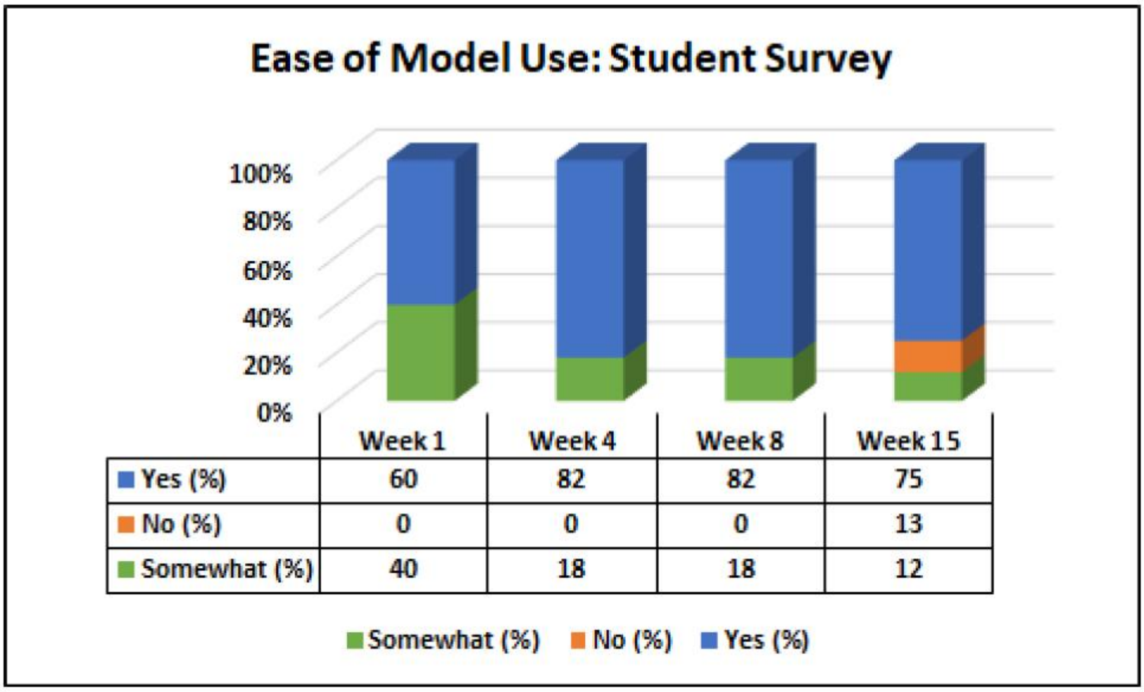

Figure 4. Ease of following the model/ track (Source: Survey results from students in Math 117 and Math 125 SP 202)

Figure 5 shows the survey response related to the students' ease of Canvas and ALEKS navigation, "Is the course on Canvas, ALEKS easy to navigate?" The researchers assumed that the students might not have worked on Hence, they included the question in week 1 and week 4 to understand students' experiences and establish a baseline ability to navigate Canvas and ALEKS. During week 4, 9% of the students responded with "NO" to the question, and 18% responded that navigating Canvas and ALEKS was somewhat confusing. The answers were helpful to illuminate issues early enough that it did not become a recurring issue for students.

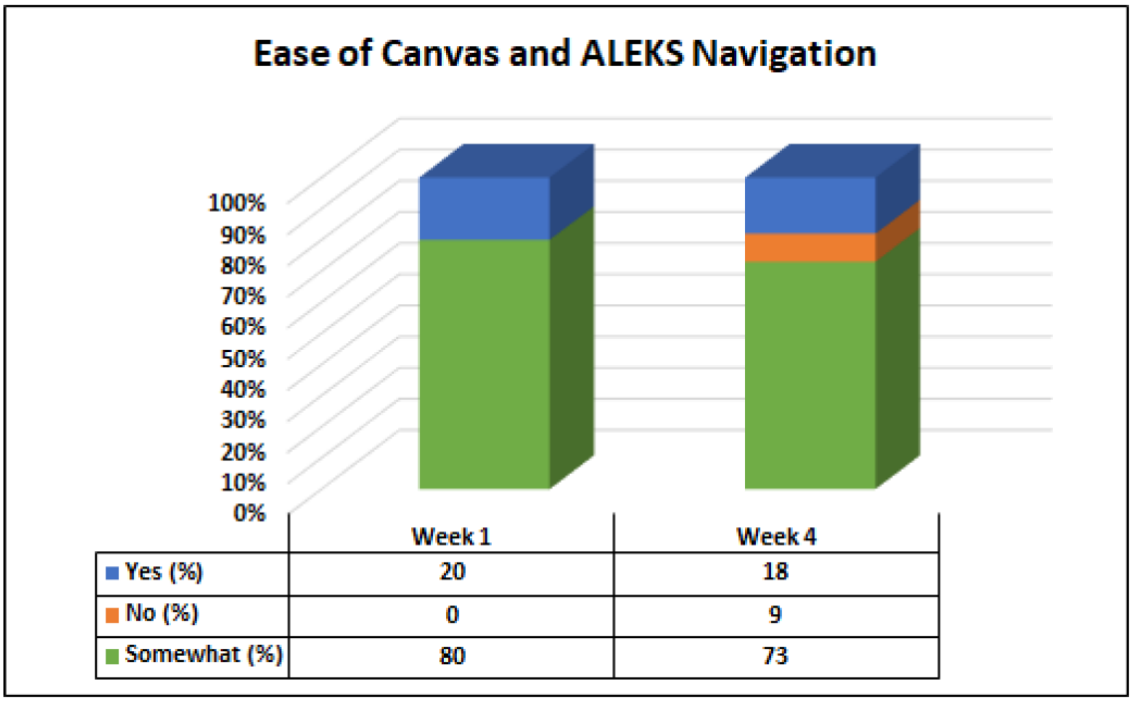

Figure 5. Ease of Canvas/ ALEKS navigation (Source: ALEKS Student Reports from Math 117 and Math 125 SP 2022)

The researchers monitored students' progress through ALEKS reports every week. Additionally, the researchers wanted the students to reflect on their own progress and encourage them to stay on track. Therefore, a question, "Are you progressing on your track?" was included in the surveys to prompt student reflection. **Figure 6** shows the responses from students about their progress by week 8 and week 15. The data showed that by week 15, 12% of the students responded that they were behind/getting back on track.

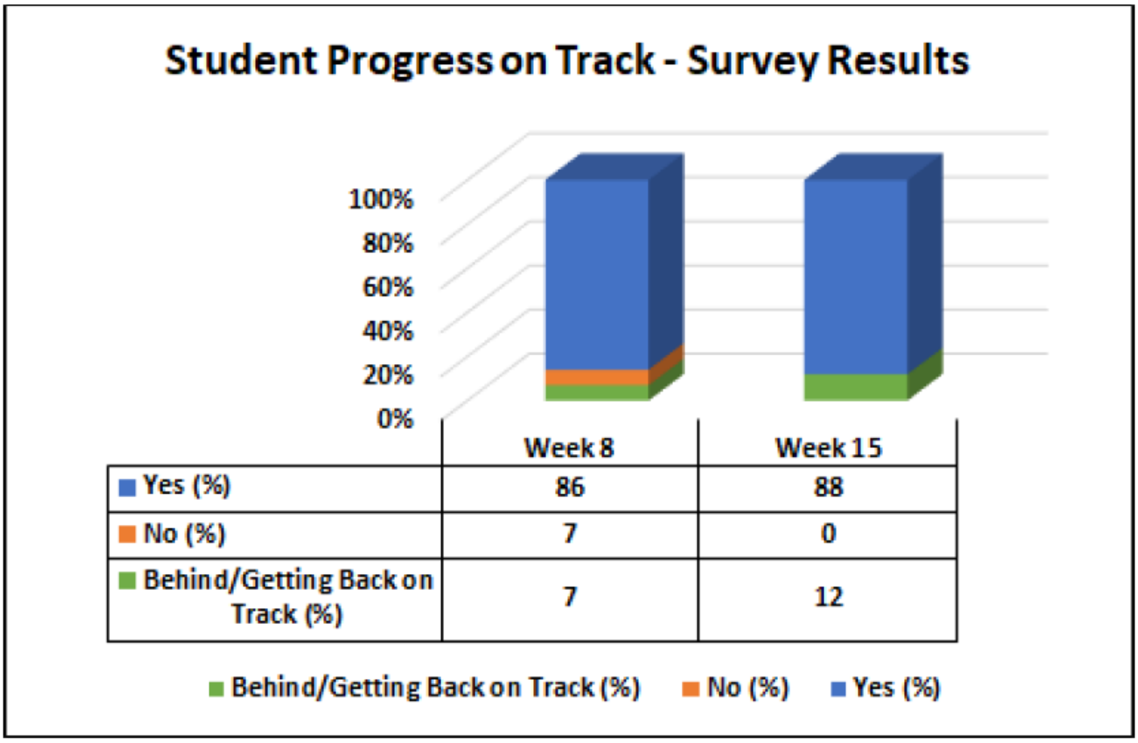

Figure 6. Student self-assess their progress while staying on their individualized track (Source: ALEKS Student Reports from Math 117 and Math 125 SP 2022)

DISCUSSIONS

Lytle et al. (2021) noted that STEM-related graduates are in growing demand in the United States and throughout the world. The authors noted that it is essential to understand how to engage and retain students in STEM disciplines. The model explained in this study is a new course structure to improve the success and completion rate of students in Math 117 or Math 125 with the flexibility of completing either of the courses.

The study is unique in that, rather than a lower or a failing grade in a higher course students had the opportunity to get a better grade in a lower-level course. Since the prerequisite for College Algebra (Math 117), and College Algebra and Trigonometry (Math 125) are the same, there are students enrolled in both courses. However, some students may not be able to handle the fast-paced Math 125 after being in the class for a couple of weeks. At this point, the options are to drop out with an economic loss or continue but receive a lower grade or fail at the end of the semester.

The researchers' initial implementation of the model was beneficial for the students who took the classes. One of the benefits was that students who were initially enrolled in Math 117 where able to complete Math 125 within the same semester. Initially, there were 10 in Math 117 and 10 in Math 125. However, three students from Math 117 moved to Math 125, completed the course requirement, and passed the course. This is 30% of the total number of students enrolled in Math 117. Student responses to course surveys attest to the efficacy of the model. For example, one student reported that:

> I wanted to advance quickly in my math skills, but I also wanted to have the option of a security blanket in case I didn't do as well as I'd hoped.

In a traditional class setting, this would not have been possible. Additionally, students who were behind in completing the weekly tasks had the flexibility to complete them and progress. To that point, one of the failing students decided to pull through after eight weeks in a 16-week course and completed the course. The student was failing Math 117 until week 8, even though the instructors repeatedly let the student know that help is available in learning the topics. After eight weeks, the student approached and informed the faculty of their intention to complete Math 117. The instructors created a lesson plan for the student, which the student followed through and ultimately passed the course.

CONCLUSION & FUTURE RESEARCH

With traditional classroom settings and lectures, students become passive listeners and do not have a voice in course management. As constructivist theory points out, the traditional way of teaching is teacher-centric and focuses on completing the syllabus rather than focusing on the learner and the learning process. With Math 117 and Math 125 being a part of the STEM curriculum and foundational to other disciplines, a new student-centered model with the flexibility to learn the material is necessary. Students enrolled in any mathematics courses come with different math backgrounds and knowledge. The new model, “Math at Your Own Pace,” provides an opportunity in learning math at their own pace and with an individualized path.

With ALEKS, an adaptive courseware, instructors created a customized learning path for students at various levels. This new model could be financially beneficial for students if they can move forward and complete a more advanced course. For students who are unable to move forward as fast as their peers, this model is still beneficial to learn in a self-paced mode, earn a better grade in a lower-level course, and make academic progress. This model can be applied to any consecutive mathematics courses or other disciplines.

The Researchers' goal in phase II is to compare the data of this new model to the traditional courses of Math 117 and Math 125 for different semesters. The plan is to explore the impact of self-paced and differentiated instructions on students’ learning and academic progress with the traditional model in college-level mathematics.

Author contributions: SS & DH: data curation, formal analysis, investigation, methodology, resources, software implementation; **SS, DH, & JY:** validation, visualization, writing – original draft, writing - review & editing; **JY:** conceptualization, supervision. All authors agreed with the results and conclusions.

Acknowledgement: The authors would like to extend their heart gratitude to the College of Arts and Sciences interim dean, Dr. Jason Telford, and Dr. Vaughn Anderson, Associate Professor of English, for their valuable time in reviewing and providing suggestions.

Funding: No funding source is reported for this study.

Ethical statement: The authors stated that approval was obtained from the Institutional Review Board (IRB) of the University of Maryville to use the data described in this model. The study was conducted in accordance with IRB protocol number 22-73. Written informed consents were obtained from the participants.

AI statement: The authors stated that You.com was used to correct two paragraphs.

Declaration of interest: The authors report that there are no competing interests to declare.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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APPENDIX

Survey Questions that help us understand the model

1. How are you finding the course so far?
2. Are you progressing on your track?
3. Can you tell us a plus and a wish for this course?
4. Is the model/track requirements clear to you?
5. Is the course on Canvas, ALEKS easy to navigate?