

Reinforcing Math Placement through a Summer Bridge Program: Work in Progress

Dr. Elizabeth A. Powell, Tennessee Technological University

Dr. Beth Powell has a doctorate in Rhetoric and Composition from the University of Louisville. Her research is in engineering communication, and she works as the Assistant Director for the College of Engineering Student Success Center at Tennessee Tech Un

Dr. Kumar Yelamarthi, Tennessee Technological University

Kumar Yelamarthi received his Ph.D. and M.S degree from Wright State University in 2008 and 2004, and B.E. from University of Madras, India in 2000. He is currently the Associate Dean and Professor in the College of Engineering at Tennessee Tech University. In the past, he served as the Director for School of Engineering and Technology, and Professor of Electrical & Computer Engineering and at Central Michigan University (CMU). He served as the chair for Electrical Engineering and Computer Engineering programs, and Assistant to the Dean of College of Science and Engineering at CMU. His research interest is in the areas of Internet of Things, wireless sensor networks, edge computing, embedded systems, and engineering education. He has published over 160 articles and delivered over 100 talks in these areas. He has successfully raised several externally funded grants of over \$1.5 Million from organizations such as NSF, NASA, and the industry.

Throughout his career, Yelamarthi has launched multiple engineering programs, including undergraduate programs and 2+2 programs with international universities, as well as CMU's graduate program in engineering. He has served as a chair, technical program committee chair, treasurer for several international conferences, and as a reviewer and panelist for numerous externally funded proposals. He served as editor for journal special issues, currently serves as the topic editor for Sensors, on the editorial board for Internet of Things journal, and International Journal of Forensic Software Engineering,. He has served as the Chair of IEEE Northeast Michigan Section, and vice-chair for ASEE North Central Section.

He is a senior member of IEEE, founding advisor for the IEEE Student Chapter at CMU, an elected member of Tau Beta Pi engineering honor society, Omicron Delta Kappa national leadership honor society, and a senior member of IETI.

Reinforcing Math Placement through a Summer Bridge Program: Work in Progress

Beth Powell; Kumar Yelamarthi

Tennessee Tech University/Tennessee Tech University

Abstract

While all courses engineering students pursue in college are based on mathematics and science, at Tennessee Tech University, nearly 50% of engineering students are under-prepared for calculus and must enroll in pre-calculus. Starting with pre-calculus leads to higher attrition rates or longer time-to-graduation rates. To address this issue, Tennessee Tech University has piloted a Reinforce Advanced Math Placement (RAMP) program in summer 2022 for 83 first-time freshman students in engineering, engineering technology, and computer science majors. Students participated in a one-week residential program to prepare for math and engineering courses and to get a jump-start on college life. At the end of the week, they took a math placement test, with 66% of students scoring into a higher math class. This paper presents a detailed description of the program implementation, results, and conclusions about the program.

Keywords

Retention, Bridge Program, Mathematics

Introduction and Background

Retention and persistence are major concerns for engineering education, and it is well-documented that preparation in math is a key predictor of success for engineering students [1; 2]. Students are aware that, while good math skills can be an essential component of their engineering education, lack of preparation in math can be a barrier [3]. At Tennessee Tech University, the expectation is that a student will begin their studies prepared to take Calculus I in their first semester. However, nearly 50% of students enroll in pre-calculus. This is due to a lack of math preparedness in high school or low ACT scores. This lack of preparedness and having to start at pre-calculus often adds time to students' graduation, and also leads to higher attrition in the first year.

To address these issues, Tennessee Tech University has developed and piloted a Reinforce Advanced Math Placement (RAMP) program in summer 2022 for 83 first-time freshman students in engineering, engineering technology, and computer science majors. This evidence-based intervention is based on research that shows that bridge programs have been widely used by engineering schools, colleges, and departments to address similar issues, with well-documented success [4, 5, 6]. Success ranges based on program goals, such as increased retention [7], predictions of lower time-to-graduation rates [8], improved math skills or readiness [9], and general college readiness [5].

Based on the unique needs at Tennessee Tech University, the RAMP program was developed with several goals. The highest priority was advancing math knowledge; it was important as well

to increase students' self-efficacy in math, as studies have shown that when students' self-efficacy increases, their performance increases [10]. Moreover, the program was developed to provide incoming freshmen with a way to engage, to get involved, and to gain a sense of belonging, as evidence suggests a strong correlation between these factors and college student success [see, for example, 11], and that leveraging a framework consistent with key concepts (e.g., knowledge acquisition, intervention, sense of belonging, and disciplinary identity) helps students connect their content knowledge to professional outcomes and enhances motivation and confidence that supports sustained persistence [12, 13]. The CoE at Tennessee Tech University has a minimum GPA and Math ACT requirement for admission; in addition to nearly 50% of incoming freshmen entering a pre-calculus or pre-algebra math course, 20% of incoming students also fail to meet the required ACT scores for admission to the College of Engineering. These students are placed in the College of Interdisciplinary Studies as pre-engineering students; unfortunately, many of those students fail to transfer into the CoE at all. Thus, it was important that RAMP both assisted those who were admitted to the College, by providing math reinforcement, and that it fostered a sense of belongingness, to improve transfer and retention rates for students who are considered pre-engineering.

Description of the Program

Program Participants

The target population for this program included incoming first-time freshmen engineering, pre-engineering, engineering technology, and computer science majors at Tennessee Tech University that were placed at or below Calculus I. A total of 83 students participated in RAMP.

Program Staff

The program enlisted a staff of three math department faculty, one math department graduate assistant, and seven peer mentors. These peer mentors were sophomore, junior, and senior engineering majors at Tennessee Tech University. The program also enlisted the support of the University's Testing Learning Center as well as the freshmen advisement staff.

Activities

Activities included math instruction, social and team-building activities, and college preparedness activities. Appendix A shows an overview of the schedule. Following are descriptions of the various activities.

Math Instruction: Eighteen hours of math instruction was offered to RAMP participants, within the following categories: College Algebra, Trigonometry, and Calculus. RAMP participants were placed into these sections based on their ACT math score placement.

Table 1: RAMP Participants' math placement based on ACT scores:

Math section	Number of participants in section
Calculus	10 (12%)
Algebra	45 (54%)
Trigonometry	28 (34%)
Total	83

Following are descriptions of the math sections:

- Algebra: Exponents and Radicals; LCM (using it to add fractions); Special Products; GCF (using it to factor expressions); Inequalities and Absolute Value; Graphs; Logarithms.
- Trigonometry: Circular functions and radian measure, graphs of the trigonometric functions, trigonometric identities and equations, the inverse trigonometric functions, polar coordinates. Applications involving triangles, vectors in the plane, and complex numbers.
- Calculus: Limits, continuity, derivatives and integrals of functions of one variable with applications.

Students participated in 18 hours of math sessions throughout Monday through Thursday, and on Friday, they were encouraged to schedule an appointment with the Testing Learning Center on campus to take the Accuplacer. A description of the Accuplacer can be found below.

Social, Team-Building, and Student Success Activities: In addition to attending math sessions, the students interacted with peer mentors, who planned daily activities to help the students become acclimated to campus and to bond with one another. Activities occurred in the afternoon, after the math sessions, though the peer mentors were available throughout the day. The activities included an ice breaker “bingo” game on the first night, a scavenger hunt, volleyball games, visits to the campus gym, and a board-game night. The Director of the CoE Student Success Center was invited to speak to the students about resources available to them on campus, and on the last day, the RAMP team held an award ceremony, where students were given enamel pins to celebrate their completion of the program.

Accuplacer Test and Advisement: After successfully completing the four-day math bridge program, participants were, as stated above, encouraged to take the Accuplacer to see if they could be placed in a higher-level math course. The students whose math placement changed were then encouraged to meet with the freshmen advisement staff who assisted them in updating their course schedules. The Accuplacer is a standardized test that evaluates students’ skills; it is available for evaluating various content, including math skills. At Tennessee Tech, the test can be used to determine course placement.

Assessment and Feedback

Working with the Center for Innovation in Teaching and Learning, the RAMP staff, including math faculty members, developed surveys that students would take each day as an “exit ticket” after their math instruction. Questions included the following:

- What concept did you explore today that you had forgotten (or gotten rusty on) from your past math classes?
- Were there any unclear concepts from today?
- If you answered yes for the previous questions, please state which concepts were unclear.
- What actions can/did the instructors take to help you be successful?

The daily exit tickets were used in the capacity of formative assessment for the instructors to continuously meet the needs of the students throughout the bridge.

In addition to formative assessment, the goals to improve math scores and reinforce math skills and knowledge were evaluated through the Accuplacer scores. Of the 83 students who participated in the RAMP program, 75 (90%) took the Accuplacer. Out of those students who took the Accuplacer, 49 (65%) placed into a higher math course. The placement was based solely on the scores from the Accuplacer.

Discussion and Conclusions

The RAMP program was developed to address an issue many engineering schools contend with: engineering programs are designed with the expectation that students take Calculus I and Calculus II in their freshman year. Unfortunately, at Tennessee Tech University, historical trends show that about 50% of the incoming first-time freshman students are placed in College Algebra or Pre-Calculus. Additionally, about 50% of the students placed in Calculus I do not pass the course. This leads to an adversarial effect of lower first-year retention in the program at 63% and a longer time to graduation. The RAMP staff's preliminary findings suggest that nearly 2/3 of participants have moved into a higher math class, thus shaving off a semester, or even two semesters they might previously have needed to spend at the university, as the math classes serve as pre-requisites for engineering coursework. In this regards, the program was successful.

Analysis of other metrics set for the program, including mid-term and long-term goals of retention and persistence, will continue to be evaluated, to determine how well the program addresses the following issue: of the 2020 incoming freshmen at Tennessee Tech University, only 63% remained in the College of Engineering, while 9% moved to a different college and 29% left the university within the first year. Typical reasons cited for leaving the university include lack of awareness of academic support resources, sense of belonging, the uncertainty of best practices to succeed in college, etc. This one-week residential RAMP program was created to fill this void by engaging in extensive team-building activities, exposure to academic resources on campus, networking activities with college peer mentors to learn best practices, and overall obtaining a jump-start on college. The ideas was to instill a sense of belonging among students, aid in improving the first-to second-year retention, and increase the number of graduating students in engineering disciplines overall. More analyses are being conducted to determine if this aspect of the program was successful.

Beth Powell

Dr. Beth Powell has a doctorate in Rhetoric and Composition from the University of Louisville. Her research is in engineering communication, and she works as the Assistant Director for the College of Engineering Student Success Center at Tennessee Tech University.

Kumar Yelamarthi

Kumar Yelamarthi received his Ph.D. and M.S degree from Wright State University in 2008 and 2004, and B.E. from University of Madras, India in 2000. He is currently the Associate Dean and Professor in the College of Engineering at Tennessee Tech University. His research interest is in the areas of Internet of Things, wireless sensor networks, edge computing, embedded systems, and engineering education. He has published over 175 articles and delivered over 100 talks in these areas. He has successfully raised several externally funded grants of over \$1.5 Million from organizations such as NSF, NASA, and the industry.

References

- [1] W. Tyson, R. Lee, K. M. Borman, M. A. & Hanson, “Science, technology, engineering, and mathematics (STEM) pathways: High school science and math coursework and postsecondary degree attainment,” *Journal of Education for Students Placed at Risk*, vol. 12, no. 3, pp. 243-270, 2007.
- [2] E. Bowen, J. Prior, S. Lloyd, S. Thomas, & L. Newman-Ford, “Engineering more engineers—bridging the mathematics and careers advice gap,” *Engineering Education*, vol. 2, no.1, pp. 23-32, 2007.
- [3] P. Winkelman, “Perceptions of mathematics in engineering,” *European Journal of Engineering Education*, vol. 34, no. 4, pp. 305-316, 2009.
- [4] V. A. Bradford, T. Rahhal, & H. Salim, “Work in Progress: Engineering Success Bridge Program: Creating Sense of Belonging through Campus and Industry Supported Summer Bridge Program,” *Paper presented at 2020 First-Year Engineering Experience*, East Lansing, Michigan. <https://peer.asee.org/35789>, July 2020.
- [5] A. Galbraith, L. B. Massey, H. A. Schluterman, & B. Crisel, B. “Preparing Engineering Students for the Fall Semester through a Summer Math Bridge Program,” *Paper presented at 2021 First-Year Engineering Experience, Virtual*. <https://peer.asee.org/38400>, August 2021.
- [6] C. Caldwell & R. Hughes, “An Engineering Summer Bridge Program Utilizing a Safe Space to Increase Math Efficacy,” *Paper presented at 2021 First-Year Engineering Experience, Virtual*. <https://strategy.asee.org/38368>, August 2021.
- [7] O. Brown, R. A. Hensel, L. M. Morris, & J. Dygert, “An Integrated Supplemental Program to Enhance the First-year Engineering Experience,” *Paper presented at 2018 ASEE Annual Conference & Exposition*, Salt Lake City, Utah. 10.18260/1-2—29792, June 2018.
- [8] L. Cancado, J. Reisel, & C. Walker, “Impacts of a Summer Bridge Program in Engineering on Student Retention and Graduation,” *Journal of STEM Education*, vol. 19, no. 2, Laboratory for Innovative Technology in Engineering Education (LITEE), 2018.
- [9] N. Islam & Y. Zhou, “Improving Engineering Students’ College Math Readiness by MSEIP Summer Bridge Program,” *Proceedings of the ASME 2018 International Mechanical Engineering Congress and Exposition. Volume 5: Engineering Education*. Pittsburgh, Pennsylvania, USA. November 9–15, 2018. V005T07A026. ASME. <https://doi.org/10.1115/IMECE2018-88685>
- [10] S. Parsons, T. Croft, & M. Harrison, “Does students’ confidence in their ability in mathematics matter?” *Teaching Mathematics and its Applications*, vol. 28 no. 2, pp. 53-68, 2009.
- [11] V. Tinto, “From theory to action: Exploring the institutional conditions for student retention,” in *Higher Education: Handbook of Theory and Research*, vol. 25, J. Smart, Ed. Dordrecht: Springer, 2010.
- [12] S. O. Fakayode, J. J. Davis, L. Yu, P. A. Meikle, R. Darbeau, & G. Hale, “Transforming STEM Departments for Inclusion: Creative Innovation, Challenges, Adaptation, and Sustainability at the University of Arkansas-Fort Smith,” *Broadening Participation in STEM (Diversity in Higher Education, Vol. 22)*, Emerald Publishing Limited, Bingley, pp. 73-10, 2019.
- [13] L. L. Winfield, L. B. Hibbard, K. M. Jackson, & S. S. Johnson, “Cultivating Agency through

the Chemistry and Biochemistry Curriculum at Spelman College,” *Diversity in Higher Education*, 2019.

Appendix A: RAMP Program schedule

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Orientation with icebreakers and dinner	8:00 Breakfast	8:00 Breakfast	8:00 Breakfast	8:00 Breakfast	Accuplacer testing
	9:00 Check-in	9:00 Check-in	9:00 Check-in	9:00 Check-in	
	9:30-12:00 Math Instruction	9:30-12:00 Math Instruction	9:30-12:00 Math Instruction	9:30-12:00 Math Instruction	
	12:00 Lunch	12:00 Lunch	12:00 Lunch	12:00 Lunch	
	1:30-3:30 Math Instruction	1:30-3:30 Math Instruction	1:30-3:30 Math Instruction	1:30-3:30 Math Instruction	
	3:30 Break	3:30 Break	3:30 Break	3:30 Break	
	4:00-4:30 Accuplacer Registration	4:00-5:00 Activities with RAMP mentors	4:00-5:00 Student Success Resources Presentation	4:00-5:00 Awards Ceremony	
	Evening activities with RAMP mentors (optional)	Evening activities with RAMP mentors (optional)	Evening activities with RAMP mentors (optional)	Evening activities with RAMP mentors (optional)	

Advisement took place the next week for students whose math placement changed.