Assessing a Summer Engineering Math and Projects Bootcamp to Improve Retention and Graduation Rates in Engineering and Computer Science

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Assessing a Summer Engineering Math and Projects Bootcamp to Improve Retention and Graduation Rates in Engineering and Computer Science

This complete Evidence-Based Practice paper discusses the efforts made to increase four-year and six-year graduation rates of students who declare a major in one of the engineering or computer science programs upon matriculating at California State University, Chico (CSU Chico). The four-year and six-year rates in these programs (~12% and 56%, respectively) are well below the University's average graduation rates; it is critical that they increase to meet CSU Chico's goals for graduation rates of 41% and 74%, respectively. The authors created a three-week summer bootcamp to strengthen student understanding of the fundamentals of mathematics and critical thinking as applied in these disciplines through a series of hands-on projects. Expected project outcomes were 1) an improvement in students' math skills and 2) to enable students to make better informed choices for their major in their first year at CSU Chico.

The bootcamp recruited matriculating students in engineering and computer science from underrepresented minorities and first-generation and low-income populations. The core of the bootcamp curriculum was an intensive math program designed to stimulate deeper understanding of algebra and trigonometry and practical problem-solving skills. The curriculum also included Problem-Based Learning (PBL) modules with projects that applied concepts from computer science and mechanical, mechatronic, computer, and electrical engineering.

The first objective is particularly impactful because of the pre-requisite chains in most of our engineering (ENGR) and computer science (CS) curricula. A one-semester delay in graduation occurs when a student is enrolled in MATH 119 Precalculus rather than MATH 120 Analytic Geometry and Calculus. Further delays occur when the student enrolls, instead, in College Algebra or Trigonometry. Data from Spring 2019 revealed failure rates of 15% for Trigonometry, 24% for Precalculus, and 37% for Analytic Geometry and Calculus. Similar percentages of students withdrew from each course. Clearly, failure to complete math courses is a significant barrier to graduation when ENGR and CS students retake one or more math courses.

Many incoming ENGR and CS students have had limited exposure to these disciplines. Bootcamp participants gained this experience during the PBL projects, addressing the project's second goal. Early positive reinforcement that a student's choice of major was correct should reduce the likelihood that the student will change majors, which can extend the time to graduation.

Results of pre- and post-bootcamp surveys demonstrated improved self-confidence regarding skills important to their majors, particularly in their ability to learn and apply math concepts, as well as an increased sense of belonging in the major. The authors also assessed the ALEKS mathematics learning tool as a means to improve students' math skills. Evaluation of the impact that PBL modules had in helping students recognize the importance and application of mathematics in their chosen fields and the faculty reflections on the bootcamp are still in progress. Data on participants' success in Fall 2019 math courses and retention in their majors will be presented. Open-ended responses in the survey provided formative evaluation of the bootcamp and will be used to improve the curriculum. Finally, steps planned to further support the bootcamp cohort's progress towards graduation will be described.

I. Motivation

This section describes how the bootcamp project is expected to improve student success in relation to the campus graduation goals. The targets of Graduation Initiative 2025 at California State University, Chico (CSU Chico) are a four-year graduation rate of 41% and a six-year graduation rate of 74%, which were established to address the demand for a highly educated workforce in the State of California [1]. To achieve these targets, the University must also eliminate equity gaps in degree completion. The four-year and six-year graduation rates for students who declare one of the engineering (ENGR) and computer science (CS) programs as their intended major upon matriculating at CSU Chico are dramatically below the average graduation rates at the University [2]. For the University to meet the goals of Graduation Initiative 2025, actions must be taken to improve the graduation rates in all of the ENGR and CS programs.

The ENGR and CS degree programs require a series of calculus courses to prepare students for the higher division courses in each major, beginning with calculus in the first semester of the freshman year. It is almost impossible to graduate in four years if an incoming freshman student is not qualified to enroll in calculus for two reasons. First, there is typically one or multiple pre-requisite chains that begin with MATH 120 that can run to the capstone courses in the final year of the program. The second reason is almost no upper division ENGR and CS courses are offered at CSU Chico during the summer semester. A further complication is that most universities across the country offer a very limited set of upper division ENGR and CS courses during the summer and few of these articulate as an equivalent to one of our required ENGR and CS courses. Therefore, it is extremely rare for a student to transfer an upper division engineering or computer science course to CSU Chico. Once a student has enrolled in Precalculus Mathematics (MATH 119), Trigonometry (MATH 118), or Concepts and Structures of Mathematics (MATH 110), the student is almost guaranteed to take at least one, two, or three semesters, respectively, beyond the nominal four years.

Anecdotal evidence indicates that about fifty percent of our incoming freshman do not enroll in MATH 120 Calculus as their first math course, but rather one of the following: MATH 110, MATH 118, or MATH 119. This means that about half of our ENGR and CS freshman are likely to take more than four years to graduate as of the first day that they enter the university. Many of our transfer students who completed courses in a degree program outside of engineering and computer science also begin their academic career at CSU Chico in one of these three mathematics courses. A second observation is that there is a smaller, but noticeable, percentage of our students who are not successful in their initial mathematics courses, a student group that is not typically served by intensive, focused tutoring. As mentioned, the most recently available data shows that 15% of the students failed MATH 118, 24% failed MATH 119, and 37% failed MATH 120 in Spring 2019 with a similar percentages of students who withdraw from each course [2]. Each time a student does not pass one of the core calculus courses or the Precalculus courses, the student's graduation date is pushed back by one semester because of the same two reasons – the pre-requisite chain and the inability to accelerate through the programs later in the program because of the lack of upper division ENGR and CS courses offered during the summer semesters. Hence, many students who take significantly longer than four years to graduate have had to retake at least one required mathematics course; some of these students have retaken each of the series of required mathematics courses [3][4][5]. Thus, student success in these mathematic courses is a major factor in determining time to graduation and failures in these courses are significant contributors to the very low four-year and six-year graduation rates in the ENGR and CS programs.

Data on the average DWF and class average and student outcome assessments in discipline-specific courses indicated that a measurable percentage of students who complete the sequence of calculus courses face challenges in the upper division courses where they are required to apply their mathematical knowledge to solve problems in engineering and computer science [2]. We inferred from this data that many of our students have not grasped the critical thinking skills that allow them to combine their math skills with a knowledge of engineering and computer science concepts to solve complex problems and the design of realistic systems [6]. Faculty had also observed that students in our ENGR and CS programs have shown limited knowledge about the careers and job expectations in the engineering and computer science fields. Thus, a larger than desired fraction of students in upper division ENGR and CS courses struggle to complete their degrees and some lack clear career goals even as they approach graduation.

An Engineering Math and Project bootcamp was designed as one element of the programs' efforts to address this initial barrier to graduation by strengthening freshman students' understanding of the fundamentals of mathematics and critical thinking as applied in engineering and computer science [7][8][9]. Faculty members involved in the design of the bootcamp considered hosting the bootcamp during the summer prior to the students' first semester at the university or during the winter session. The purpose of a summer bootcamp would be to strengthen the math skills of students prior to their first semester at the university. The purpose of a winter bootcamp would be to strengthen the skills of students who had difficulty with their first math at the university. Surveys were conducted of freshman students in Spring 2018 to obtain their input, which was used to select the best time for the bootcamp to help students prepare for calculus. Based on this input, the inaugural offering of the Math and Engineering bootcamp was during Summer 2019.

The expected outcomes from the bootcamp project included:

1) Students would improve their math skills to pass the pre-requisite chain for Calculus (MATH 120) and consequently accelerate completion of the core engineering courses, thereby decreasing time to graduation.
2) Students would make more informed decisions when selecting their major in their first year at CSU Chico, which would reduce the number of students who change majors in sophomore or junior years, potentially decreasing delays in graduation.
3) Students would gain a better appreciation about the need to have a solid mathematical foundation when pursuing an engineering or computer science degree.

II. Project Description

Early intervention to address weaknesses in students' mathematical abilities, enabling students to progress more successfully through the series of required calculus courses, is an essential step to reduce the time to graduation. This has been demonstrated at CSU Chico with the success of the Summer Calculus Bootcamp, which serves students who have declared a major in STEM and face or have faced social, educational, or economic barriers to careers in STEM [10]. We incorporated aspects of highly successful bootcamps that provide students with project-based learning from several fields of engineering and computer science. The goal was to have students recognize the importance of mathematics in their chosen fields, which should self-motivate students to master the subject, while providing hands-on experiences of the applications of mathematics and critical thinking in engineering and computer science. Therefore, the bootcamp with an engineering and computer science focus that creates a solid foundation in E&CS students was crucial.

A) Financial Support

The first bootcamp was mainly supported by the CSU Chico Office of Undergraduate Education. Funds paid for lunch and snack, a completion award that would cover costs of housing, ALEKS software package, project hardware, and stipends for faculty and student mentors. The MESA Office of CSU Chico also sponsored two weeks of the lunch expenses. The second bootcamp will also be supported by CSU Chico Office of Undergraduate Education.

B) Student Population

The target participants for the summer bootcamp was, and will continue to be, incoming freshman and transfer students with a focus on underrepresented students and minorities. Approximately twenty students will benefit from this bootcamp each year, which is about 7% of the first-time freshman in the ENGR and CS programs. The students who participated in the inaugural bootcamp were recruited through contacts made by the CSU, Chico MESA Engineering Program staff. Seventeen students participated in the bootcamp out of whom only one student was female. Retaining female students in engineering has been a challenge for engineering colleges. Flyers were also distributed to local high schools. Announcements about the bootcamp with links to an application form were posted on Computer Science and Engineering Departments' websites. An expanded effort to identify and reach incoming students who may benefit from the bootcamp is planned to coincide with an on-campus event for students who have been admitted for Fall 2020, which will be held in April 2020.

C) Timing of the Bootcamp

As mentioned previously, a survey was conducted of the freshman students during their second semester on campus to determine the best time of the bootcamp; whether the current students preferred a bootcamp during the winter break after they have been at CSU Chico or before they begin their studies at CSU Chico. Most of the students indicated that a Summer Bootcamp is preferred. The faculty decided to hold the bootcamp during the last week of July and the first two weeks of August to minimize conflicts with family vacations (their own as well as the students) and to reduce the potential for ‘brain drain’ between the end of the bootcamp and the beginning of the Fall semester. Because of the timing, students were unable to stay in campus housing during the entire bootcamp. Furthermore, many of the students did not intend to live on campus during the academic year. Thus, most of the students either moved into their academic year apartments early or sublet apartments.

D) Bootcamp Implementation

The three week summer bootcamp was structured as follows:

Morning of Day 1: Orientation and Math Evaluation

Mornings of Subsequent Days: Math Tutorials and Problem Solving

Lunch

Monday-Thursday Afternoons: Project-Based Learning

Friday Mornings: Project Demonstrations and competitions

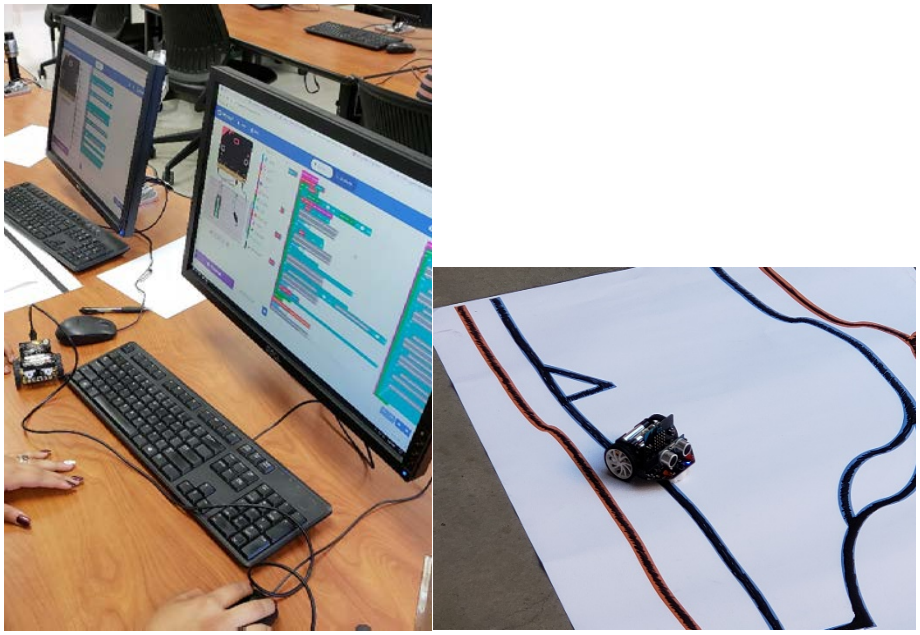
During the morning sessions, students built their math skills through self-guided learning tool called ALEKS [9]. A pre-bootcamp evaluation following an orientation session on the first day of the bootcamp was used to assess the students’ mathematical abilities using a built-in ALEKS tool. The ALEKS software was then automatically customized to a math level that was appropriate for each student’ assessed skills, which range the gamut from algebra to precalculus. A student mentor and a faculty mentor supported students during the subsequent learning process each morning during the three weeks. The students’ progress and their level of activity was monitored through the math tutoring and the ALEKS software and assessed during the mentorship sessions [9]. The question might arise why taking the Precalculus during the summer was not selected over having the math sessions during the bootcamp. Several reasons made us choose the Precalculus sessions that used ALEKS over taking the Pre-Calculus course. These include: 1) The Mathematics and Statistic Department of CSU Chico has not offered Precalculus during the summer sessions in the past. 2) By taking a summer course, the students would have to pay tuition ($1,208 per student). Generally, federal tuition loan programs do not cover summer courses. There is financial aid available to CSU Chico students, but transfer students and incoming freshmen are not eligible as they are not continuing students. 3) If tuition is charged but course enrollment is below a certain threshold, the instructor either needs to take a pay cut or the college would have to allocate funds to pay the difference in salary. 4) Students would have to budget at least an extra week of housing and meals (in addition to the three weeks of the bootcamp) as scheduled summer courses last 4-10 weeks during the summer. 5) There would be more pressure on students to succeed in MATH 119 as they would be taking it for a grade. This may negatively impact their level of participation in the engineering/computer science portion of the bootcamp. This would likely decrease the chance of attaining the goals of the bootcamp related to retention in the engineering/computer science majors.

Lunches were times when there were faculty-student interactions in an informal setting. Some of the lunches were held at local eateries around campus to allow the students to become familiar with the local community. Staff from the MESA Engineering Program also came to many of the lunches, which helped students establish ties with this support program and to ask about other resources in and around campus. Time was also allocated during lunch for students to obtain university IDs, arrange for campus Wi-Fi access, and attend tours of various campus offices and classrooms.

The afternoon sessions of the bootcamp, 3-4 hours in length per day, were designed to introduce students to the relationships and distinction between Mechanical Engineering, Electrical Engineering, Computer Engineering, and Computer Science majors. The activities were chosen to motivate the students to continue their studies through the difficult first year of college, help them realize that many of the ENGR and CS careers rely on the application of math and critical thinking, and show some of the career paths in each discipline. Additionally, faculty and student mentors took students on tours of the engineering labs on campus to familiarize them with the available resources that they could use for their projects and to provide a visual demonstration of the skills that are developed in each of the ENGR disciplines.

During the first week, students were introduced to programming skills using MakeCode with micro:bit microcontrollers on the DF Robot Maqueen robot chassis. MakeCode is a block-based visual programming environment that also transfers programs to the microcontroller via USB. The visual programming environment allows students to concentrate on the operations of decision (if, else, etc.) and loop (do-while, while, for each, etc.) structures and overall algorithm procedures without worrying about precise details required in syntax of textual programming languages.

The students began the first week with an introduction to the different input sensors available on the Maqueen and then explored its operations—moving its wheels, playing musical note frequencies, displaying a message on the LED matrix, and turning lights on and off. Their initial



(a) (b)

Figure 1. (a) Student using Microsoft MakeCode to program micro:bit microcontroller to control the robot chassis, shown in (b).

challenge was to create a routine for their robot to “celebrate” completing a task with movement, display, and sound. The remainder of the week, students worked on increasingly difficult challenges involving programming loops and decisions to command their robots to escape enclosures with a single opening, using sensors to recognize walls and floors. Students tested their algorithms on practice enclosures and compared and contrasted different strategies when assumptions about the problem—including the enclosure size and shape—were gradually withdrawn. Their final challenge was to create a generalized algorithm that would direct their robot to escape three different enclosures of unknown sizes and shapes and to begin their robot’s celebration whenever it had detected it had successfully escaped. Figure 1 shows that students are using Microsoft MakeCode for programming micro:bit microcontroller to control the robot chassis.

During the second week of the bootcamp, students worked on a project in the field of mechanical engineering. The students learned how to use Excel to model a dynamic system, the trebuchet [11] [12]. First, they modeled an elementary projectile path using Excel, including how to use the trapezoidal method of integration to get the coordinates of the parabolic path of the projectile, and how to plot the results. Second, the "see-saw" model of the trebuchet was given to the students and they had to measure the important lengths and masses, plug them into the Excel model to calculate the expected throwing range, test the provided trebuchets, and the efficiency. Students repeated the exercise using a more complete model of the trebuchet and compared the difference in efficiencies. Finally, they tested the trebuchets with a sling, measuring the throwing distances and computing the increased efficiencies. The students discussed why the mathematic models were idealizations of the real system and some of the possible limitations to the models, facilitated by the faculty and student mentors.

During the last week of the bootcamp, students wrote programs for an autonomous vehicle project that incorporated several of the sensors integrated on the micro:bit microcontroller and the robot chassis. These included the optical sensor on the micro:bit microcontroller and the ultrasound and infrared sensors on the Maqueen chassis. Students engaged in activities designed to explain the visible and infrared spectrum and pulse-width modulation (PWM) at the beginning of the week. The students then wrote programs so that the robot would locate a flashlight beam and move towards it, follow the lines printed on poster paper, and navigate through a maze. Tutorials were provided to explain the concepts of a control system and how to program a proportional-integral-derivative (PID) controller for the DC motors of the robots as students began writing the project code. Several applications of optical sensing, PWM, and PID controllers were described during discussions with the students.

On Fridays, student teams demonstrated the projects that they had completed during the week. These were outdoor activities as the campus was closed on Fridays during the summer. A farewell luncheon with all of the faculty and student mentors was held after the final project demonstration on last Friday of the bootcamp. During the luncheon, certificates of completion and awards to the student teams who completed the various projects successfully were distributed.

III. Assessment of Student Success

A longitudinal study has been initiated to determine the relationship between participation in the bootcamps; student success in the sequence of math courses, retention in ENGR and CS programs; the percentages of unsatisfactory (D) or failing (F) final course grades and course withdrawals (W) and class averages in the upper division ENGR and CS courses; the four-year and six-year graduation rates; and student satisfaction with the bootcamps and with their majors upon graduation. The longitudinal study is a work in progress. In this paper, we focus on the short-term impacts of the project. An analysis will also be performed to determine if the bootcamps have had an impact on the equity gap in the graduation rates. Initial outcomes of the bootcamp were assessed in three phases: a formative assessment of the students' attitudes and learning in the bootcamp (Summer 2019), assessment of student learning through ALEKS, and an investigation of students' success at the conclusion of the following semester (Fall 2019).

A. Summer 2019 Bootcamp Formative Assessment

To study the impacts of the bootcamp on students' attitudes about their intended majors and to collect feedback on the bootcamp's format, we collected pre- and post-bootcamp surveys. After gathering the student's name and major, the survey captured their attitude regarding self-efficacy using a Likert-type scale from 1 (strongly disagree) to 5 (strongly agree) on the following items:

- I am confident that I chose the major that best fits my interests and goals
- I expect to graduate with this major
- I know what skills and topics are important to my major
- I feel like I belong within the major
- I am on the right path to succeeding in the major
- I know why math is important to my major
- I can apply math appropriately in my major
- I am confident with Algebra
- I am confident with Geometry
- I am confident with Trigonometry
- I am confident with Precalculus
- I am confident with Calculus
- I enjoy math
- I can apply my math skills to computing and engineering projects

The post-bootcamp survey included these same ratings so we could investigate potential changes in their attitudes. Fourteen (n=14) of the seventeen bootcamp participants (82%) completed both surveys and consented to include their data in our formative assessment. We performed a Wilcoxon-Mann-Whitney test to compare pre- and post-bootcamp ratings to test the hypothesis that the bootcamp would improve students' self-efficacy. Table 1 shows the mean (M) and standard deviation (sd) for each item's rating, as well as the p-value of the hypothesis test.

Overall, the average change in attitude – as represented by Delta – showed mostly small-to-moderate increases in students' ratings of their self-efficacy from before (pre-) to after (post-) the bootcamp. Deltas are greatest for students' confidence with geometry (M = 0.571, sd = 0.938) and trigonometry (M = 0.462, sd = 0.519). The Wilcoxon-Mann-Whitney test found that the change in confidence with geometry approached statistical significance ($p = 0.097$) while the increase in confidence with trigonometry was statistically significant ($p < 0.05$).

Table 1. Summary of Likert-type scale items from pre- and post- bootcamp surveys

Statement	***Pre-Bootcamp (M,sd)***	***Post-Bootcamp (M,sd)***	***Delta (M,sd)***	***Wilcoxon (p)***
I am confident that I chose the major that best fits my interests and goals	4.117, 0.600	4.286, 0.469	0.071, 0.475	0.453
I expect to graduate with this major	4.412, 0.618	4.643, 0.497	0.071, 0.475	0.306
I know what skills and topics are important to my major	3.941, 0.899	4.143, 0.535	0.286, 0.914	0.598
I feel like I belong within the major	4.176, 0.809	4.357, 0.497	0.143, 0.534	0.631
I am on the right path to succeeding in the major	4.412, 0.712	4.357, 0.633	0.000, 1.038	0.741
I know why math is important to my major	4.824, 0.393	4.929, 0.267	0.000, 0.392	0.412
I can apply math appropriately in my major	4.176, 0.809	4.143, 0.864	-0.071, 0.475	0.949
I am confident with Algebra	4.412, 0.618	4.714, 0.469	0.286, 0.611	0.161
I am confident with Geometry	3.941, 0.827	4.429, 0.646	0.571, 0.938	*0.097+*
I am confident with Trigonometry	3.764, 0.752	4.307, 0.480	0.462, 0.519	***0.036****
I am confident with Pre-calculus	3.882, 0.857	4.214, 0.426	0.214, 0.578	0.264
I am confident with Calculus	3.176, 1.286	3.429, 1.016	0.143, 0.770	0.665
I enjoy math	4.471, 0.717	4.571, 0.646	-0.071, 0.475	0.730
I can apply my math skills to computing and engineering projects	4.000, 0.866	4.142, 0.662	0.071, 0.475	0.656

+ indicates $p < 0.10$, * indicates $p < 0.05$. All numbers are rounded to the nearest thousandth. Delta represents Post minus Pre response, calculated for each individual. Participants who responded to an item for Pre or Post (but not both) are included in Pre/Post column they answered, but excluded from Delta for the purpose of hypothesis testing.

However, none of the other deltas were found to be statistically significant. Two of fourteen items had a small negative delta (M = – 0.071 for both) but neither *I can apply math appropriately in my major* ($p = 0.412$) nor *I enjoy math* ($p = 0.730$) deltas were statistically significant. With a small sample (n = 14), we avoid making any strong conclusions from the hypothesis testing. However, we plan to continue to study potential impacts students' self-efficacy in future bootcamps as we gather larger samples. Surveys from larger participant pools will also lead to future studies of the bootcamp's impacts on demographic groups, including females and under-represented ethnic/racial minorities.

The post-bootcamp survey also included questions to help the instructors evaluate and iterate plans for future bootcamps. It incorporated six questions (with the same five-point Likert-type scale) to rate both the morning ALEKS math tutorials and the afternoon engineering projects on how *fun*, *challenging*, and how much they *learned* from either activity. Figure 2 illustrates the mostly-positive responses.

Participants responded with moderate agreement that the math tutorials were *fun* (M = 3.64, sd = 1.08) and *challenging* (M = 3.43, sd = 0.76) and that more strongly agreed that they *learned* from the tutorials (M = 4.50, sd = 0.65). They showed stronger agreement that engineering projects were *fun* (M = 4.43, sd = 0.76) and *challenging* (M = 3.94, sd = 1.00) and *learned* from the projects (M = 4.71, sd = 0.47). It is worth noting that only one participant expressed disagreement with any of the qualities of the engineering projects, responding with a (2) for how *challenging* the projects were.

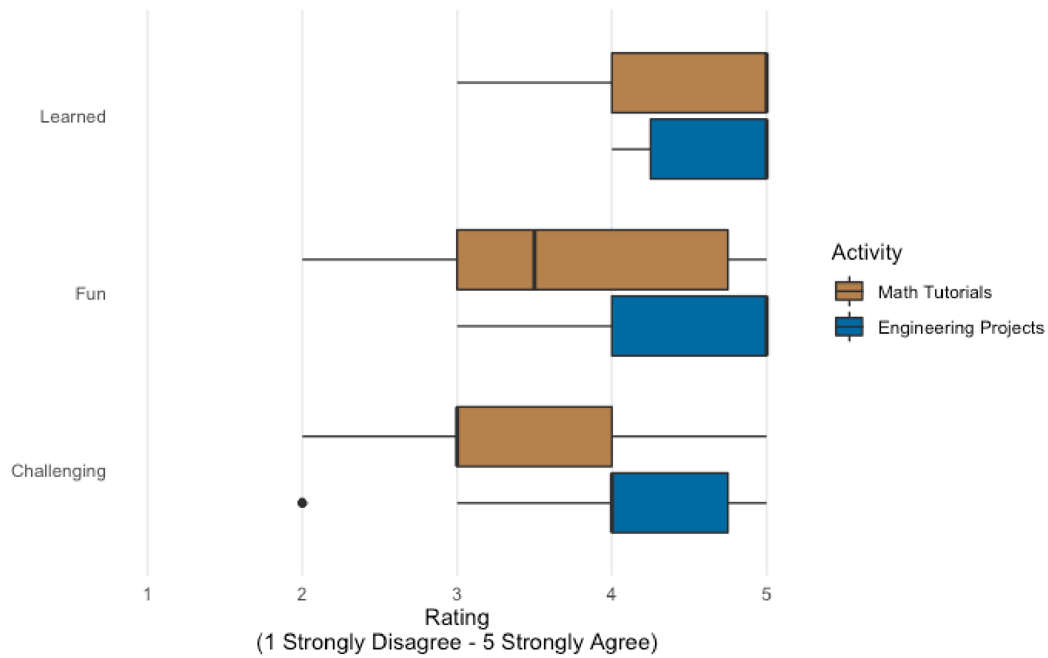


Figure 2. Box-and-whisker plot showing mostly positive ratings for how students learned from the math tutorials and engineering projects as well as how both were fun and challenging.

Finally, students were asked to explain "*What did you like best about the bootcamp?*" and "*How could have the bootcamp been improved?*" as free-form responses. Fourteen participants provided responses to both questions. In response to "*What did you like best about the bootcamp?*" five (36%) students directly mentioned the math tutorial and six (43%) directly mentioned the engineering projects. In reference to their collaboration on engineering projects, one participant stated: "I liked that we had a partner to go with because we had someone with us the whole time during the camp and had friendly competitions." Three participants (21%) expressed an appreciation for the bootcamp's relevancy to their majors (and/or future courses), such as, "Being exposed to some aspects of my major and preparing myself for what is to come."

In response to "*How could have the bootcamp been improved?*" participants expressed some disagreement over whether the bootcamp activities should take either more or less time, with no clear consensus. The most common suggestions for the math tutorials were to (1) provide a clearer indication of individual students' progress and (2) break/distribute the tutorial sessions into smaller parts. Two participants (14%) also suggested that the engineering projects should be more directly related to the math problems and/or integrated together into one final, bigger project.

B. Assessment of student learning through ALEKS

On the first day of the bootcamp math sessions, students took the initial knowledge test of the ALEKS STEM Precalculus course which provided us a measure of students' knowledge levels before the summer course. Table 2 shows the summary of students' grades before and after completing the summer three week math course. The scores have significantly improved for each student as a result of solving several problems, learning the topics that students had not adequately learned in high school or refreshing their memories on the topics that the students had learned in previous earlier. The students that completed the course with a grade of 100% before the end of the three weeks, were directed to an advanced STEM Precalculus course.

Table 2. Summary of students' knowledge assessments before and after the completion of ALEKS STEM Precalculus course

Student Number	***Initial Knowledge Check Mastered (%)***	***Final ALEKS Pre-calculus course Assessment grade (%)***
1	63%	87%
2	38%	83%
3	17%	66%
4	18%	55%
5	26%	70%
6	9%	57%
7	14%	70%
8	42%	93%
9	19%	70%
10	48%	96%
11	61%	100%
12	66%	100%
13	60%	100%
14	66%	100%
15	61%	100%
16	69%	100%

C. Fall 2019 Post-Bootcamp Assessment

An analysis of the students' grades, which was gathered at the end of the Fall 2019 semester has been tabulated in Table 3. Of the 17 bootcamp participants, three were transfer students who had already passed the math courses required for their majors; hence, they did not enroll in a math course in Fall 2019. Their stated purpose for participating in the bootcamp was to become more familiar with their selected majors. Among other participants, one student did not enroll at CSU Chico, and one other student did not enroll in any math classes. One student also withdrew from all the enrolled courses. The reasons why the student withdrew from all courses was not available, but the attendance data collected by the instructors and tutors during the bootcamp shows that these students were not as consistent as other students in participating in the math and project sessions. This data can be used for further mentoring and advising these students. 10 students out of 11 remaining students passed the math course in which they enrolled in the Fall 2019 course (not the same math course for all 11 students) and enrolled in another required math course for Spring 2020. Therefore, 90.9% of the students passed the math courses in which they were enrolled, a substantially higher percentage than the pass rate in these math courses by the average university student.

We continued to support the students during Fall 2019 by providing the ALEKS license codes which could be used until the end of the Fall 2019 semester and could be extended in Spring 2020 upon request. Since most of the freshman students do not take their major lower division courses during the first year, they rarely have classes in the building that Engineering and Computer Science faculty offices are located. Therefore, the interaction of students and their major faculty were minimal. Hence, during the Fall semester, the students were invited to a dinner to connect with faculty, informally talk about their progress and provide feedback. More conversations after the bootcamp and during the Fall semester would be helpful.

Table 3. Summary of students' progress in math courses at the end of Fall 2019 semester

	Number of Students	Percentage of Bootcamp Participants
Participants in Summer 2019 bootcamp	17	
Transfer students who had previously passed required math courses	3	17.6
Did not enroll at CSU Chico	1	5.9
Withdrew from all enrolled courses in Fall 2019	1	5.9
Did not enroll in any math courses	1	5.9
Passed the Fall 2019 math courses	10	58.8
Failed the Fall 2019 math courses	1	5.9
Passed MathLinks Seminar, Intermediate (MATH 116)	1 of 1	5.9
Passed Trigonometry (MATH 118)	2 of 2	11.8
Passed Precalculus (MATH 119)	6 of 7	35.3
Passed Analytic Geometry and Calculus (MATH 120)	1 of 1	5.9

D. Future Work

a. Summer 2020 Bootcamp

We have recruited a Civil Engineering faculty member who is planning a structural engineering project that will be included in the afternoon sessions. This will enable the bootcamp to provide examples from all of the ENGR and CS programs offered at CSU Chico and students who select Civil Engineering as a major will know a faculty member in that department before beginning their freshman year. As the length of the bootcamp has not increased, the time devoted to the Computer Science, Mechanical/Mechatronic Engineering, and Electrical/Electronic/Computer Engineering projects will be reduced. A discussion on how to reduce the schedule of these projects has already been held. Synergies in the existing and proposed projects were identified, which should enable the students to complete four different projects and to see how skills from different disciplines can be applied in design projects.

To better quantify the impact of the bootcamp's morning math sessions, we will ask the students to take the ALEKS Proctored Calculus Readiness Test (CRT) before the bootcamp and at the end of the bootcamp. This will also provide students with hard data on how much effort is required to obtain the knowledge equivalent to a semester-long math course. The latter may help students select a more realistic course load in the following semester and potentially decrease the number of students who withdraw from one or more courses during the Fall 2020 semester.

Funding provided by the Office of Undergraduate Education will enable 20 students to participate in the bootcamp in Summer 2020. Faculty are also working with University Advancement to identify long-term funding for the bootcamps to expand the number of students who can participate in the bootcamps.

b. Assessment

Methods to actively monitor withdrawals from courses and from the institution as students begin the process are under consideration. College advisor staff are also considering potential outreach activities that can be introduced to mitigate reasons for withdrawals that may be linked to unexpectedly heavy academic workloads, failure to integrate into the wider campus community, or other university-related causes.

The longitudal assessment of the bootcamp is a work-in-progress as we continue to monitor students' progress in their math courses, retention in their majors, and the number of years to complete their degrees. We expect a half- to full-semester gain in math abilities following the bootcamps as measured by the software. We expect that this translates to a 1-2 semester decrease in time to graduation for students who participate in the bootcamps compared to incoming ENGR and CS students with similar initial math-readiness scores. Given the small number of participants, the assessment should encompass multiple offerings of the engineering math and projects bootcamp so that statistically-relevant data can be analyzed.

IV. Conclusion

Students reported an increase in their math skills, a stronger sense that they have selected the correct major, and a higher commitment to graduate with the degree after completing the summer engineering math and project bootcamp. Preliminary assessment data indicates that the bootcamp has provided students with a solid foundation in math, which has helped a large percentage of the participants to pass the math courses in the Fall semester after the bootcamp as compared to the general student population in the math courses. Work must be done to determine the reasons why a few of the bootcamp participants either did not begin their academic studies in Fall 2019 or withdrew from all courses after the beginning of the Fall semester. Activities either during the bootcamp or in the Fall semester can then be developed to provide additional support to students who may be likely to do this. Results from the longitudinal study of the project's impact on student success are needed to determine if the initial exposure to ENGR and CS concepts that have helped the students to start their studies with high motivations, the connection with faculty members in ENGR and CS disciplines early in the students' higher education journey coupled with the opportunity to build a community of their peers will increase retention in ENGR and CS majors. These factors are all likely to contribute to increasing the four-year and six-year graduation rates in ENGR and CS. It is anticipated that there is an important side effect of the bootcamp, which is the development of highly motivated students who have improved understanding of the concepts and applications of engineering and computer science who will build the reputations of our programs.

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