



## **Engineering Boot Camp: A Broadly Based Online Summer Bridge Program for Engineering Freshmen**

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## **Abstract**

This paper describes an evidence-based practice implemented by the College of Engineering at the University of North Carolina Charlotte with objectives to increase retention and success of first year engineering students. Freshmen accepted into the engineering program typically were very successful in high school, leading many to falsely believe that the same habits that led to high school success will lead to college success. Combined with the new campus environment, the lack of study skills and unrealistic expectations may result in more instability than most have experienced in their young lives. Students who do not swiftly recognize their deficiencies and adapt to more effective habits and tools may perform poorly in their classes, leading to low first semester GPAs. This in turn may cause them to question their career choice and doubt their ability to successfully complete the engineering program. Such negative self-belief could result in a low retention rate for the College of Engineering. To help address these problems, the on-line Boot Camp program is designed to help students improve perseverance, math readiness, and spatial visualization. It also helps them adjust to campus life, set realistic academic expectations, choose or confirm their choice of major, introduce them to academic and administrative resources, and provide opportunities to interact with upper class students and other freshmen prior to their arrival on campus in August.

Few students will need to address all areas, but most students have needs in two or more areas. The program is designed to be inexpensive to administer and require low maintenance while accommodating about 500 students each summer. Students enroll in the program during summer orientation and are urged to complete it on a voluntary basis before the fall semester begins. Results from the first two years of the program look promising.

## **Introduction**

Summer bridge programs have been implemented at numerous universities to help incoming freshmen prepare for the new challenges that lie ahead of them at college [1] [2] [3] [4]. Most existing programs are on-campus, small-scale programs that focus on one or two areas of student preparation, such as mathematics or science. An on-campus summer bridge program for the entire College of Engineering freshman class would be cost prohibitive. Instead, in an effort to increase the retention and success rate of its engineering students, the University of North Carolina at Charlotte (UNC Charlotte) Lee College of Engineering implemented an online summer bridge program for all incoming freshmen. This work explores the program and discusses its early results.

## Identifying the Problem

Engineers are the problem solvers of the future. The President's Council of Advisors on Science and Technology released a report in 2012 citing the need for STEM graduates, in particular engineering graduates to help the nation strengthen its workforce and innovate solutions to problems in many sectors of the economy [5].

At a state level, the leaders of the University of North Carolina (UNC) system have set a goal of raising the education level of the citizens of the state. "By 2018, [UNC System] will help North Carolina increase the percentage of state residents with a bachelor's degree or higher from 26% to 32%." [6]. At UNC Charlotte, the College of Engineering is striving to meet this goal by offering degree programs in seven disciplines of engineering: Civil, Computer, Electrical, Mechanical, and Systems Engineering; Engineering Technology; and Construction Management. The College of Engineering conferred 468 BS degrees in engineering in the 2014-2015 academic year.

To graduate more engineers, the options are to recruit more students or to retain a higher portion of those already recruited through graduation. Currently, the college is working to increase the graduation rate by both recruiting more transfer students and improving retention of new freshmen. Less than half of the new freshmen who start in the Lee College of Engineering graduate with a degree from the college six years later. Historically, about two-thirds of new freshmen are retained in the college one year later and about 80% are retained at the University. There are a significant number of students who remain in the engineering program, but are struggling with doubts about their ability to successfully complete the program and are at risk of leaving the program before graduation.

A wide variety of college readiness gaps cause students to struggle. The typical UNC Charlotte new engineering freshman is a high-performing high school student who is particularly successful in their high school math and science classes, with a respectable average MSAT score of 612. Their natural talent in these subject areas means they typically did not have to exert themselves in high school beyond short study bursts before exams. Even high-achieving high school students, with a resume of honors and AP courses, rarely are intellectually challenged enough to acquire the study, time-management, and note-taking skills needed for university level work [7]. As a result, when faced with college level coursework - in addition to the less structured college learning environment and the change in living situation - many first year students find themselves overwhelmed and facing academic failure for the first time without all the necessary tools to succeed. Without significant adjustment on their part, their approach to the rigorous academic work often results in poor academic performance in the first year.

An additional hurdle faced by new freshmen at UNC Charlotte is that approximately 43% are first generation college students [8]. This leads to varying expectations about their first year of college and families often do not know how to best support their young student. In addition, a large percentage of the students admitted to the College of Engineering state they chose their major without researching what the career and academic path actually involve, compounding the unrealistic expectations of the entering freshman. Finally many well-qualified students

find the transition from high school to engineering student overwhelming, and ultimately leave the college or university due to poor performance. Despite numerous studies conducted by the college, it is not easy to predict which freshmen will experience poor performance and which will adjust and perform well. Providing new freshmen with information about what the engineering profession is and what engineering academic life will be like may help them develop realistic expectations and fully commit themselves to the educational pursuit.

Student success is not accurately predicted by the SAT score or high school GPA alone [9]. An intangible element, grit, described by Angela Duckworth as the “perseverance and passion for long-term goals,” is needed for success [10]. In their study of different student groups, Ms. Duckworth and her peers observed the ability to pursue long-term goals with perseverance and passion is attributed to belief in one’s capabilities. This perseverance is as important as intelligence in leading to ultimate success.

### **Examples of Bridge Programs**

The problem faced by freshmen at UNC Charlotte is not unique. Other universities have used summer bridge programs to help navigate the journey between high school and college with varying success. Some programs target underrepresented minority populations and first generation students. For example, Virginia Commonwealth’s Summer Transition Program (STP) focuses on raising mathematics levels of minority freshmen in its engineering program. The STP - a four week residential program - had success in improving academic preparation in participants. While the focus was mathematics preparation, the residential nature of the program also allowed the participants to engage with the campus environment, develop or strengthen study skills, and form realistic expectations of the upcoming school year [1]. This and similar programs were evaluated and a few common threads were found. [1][2][3][4]

- Small-scale on-campus programs typically have a positive impact on the small number of students that participate.
- Math preparation and study skills improvement help the students beyond their math courses by developing reasonable college expectations.
- On campus summer bridge programs are expensive to administer.

### **UNC Charlotte’s Engineering Boot Camp**

As established earlier, the UNC System has set its sights on increasing graduation rates. Higher graduation rates are not possible without higher retention of freshmen. A few residential summer bridge programs already exist at UNC Charlotte, including the Math Crash Course and the University Transition Opportunity Program that targets underrepresented minority and first generation students. Both programs are relatively small in scale, highly resource intensive, and are not exclusive to engineering students.

Because it is difficult to predict which students will have difficulty adjusting to the college environment and academic expectations, the Engineering Boot Camp (EBC) is offered to the entire population of enrolled new freshmen. A residential program for approximately 500 incoming freshmen engineering students each summer was not feasible because of its cost and

lack of human and other resources. However, an online program that addresses a variety of the readiness gaps was considered a manageable, affordable option. The program, offered through Moodle, the course management system used by UNC Charlotte, also provides an opportunity for students to familiarize themselves with the software prior to the start of the semester.

After careful consideration, the following areas were identified as most useful for improving retention and success in engineering freshmen:

- Cultivating perseverance
- Math readiness
- Spatial visualization
- Adjusting to campus life
- Setting realistic academic expectations
- Choosing a career in engineering
- Academic and administrative resources
- Interaction with leaders and fellow engineering freshmen

During summer orientation, students are guided through self-enrollment into the Boot Camp site on Moodle and given instructions to return to the site using their personal computer to complete the program. Students may complete the EBC before the beginning of the fall semester at their own pace. With the exception of *Math Readiness* which refers the students to ALEKS<sup>®</sup>, these goals are accomplished through a series of Moodle modules at no cost to the student. Students read articles, watch presentations and videos, take quizzes, participate in forum discussions, and research web links. Program completion is urged, but not required. Other than an increased level of awareness and preparedness, no incentive is offered. In summer 2015, 435 EBC registered participants were divided into five Moodle sections to keep the sections from becoming too large and unwieldy.

Many of the modules have self-grading quizzes that restate the top 3-5 take away ideas. The Moodle gradebook provides a low maintenance method of measuring student progress through the program. Content and goals for the modules are briefly discussed below.

*Cultivating Perseverance.* Based heavily of the work of Angela Duckworth's Grit Scale students are asked to rate a series of statements such as "*I have difficulty maintaining my focus on a project that takes more than a few months to complete*" according to how similar the statement is relative to how they see themselves [11]. The students are directed to view a TedTalk by Angela Duckworth about Grit and the importance of perseverance in achieving success [12]. This module about perseverance is aimed at helping students see the relationship between their daily choices and the ability to reach their long term goals.

*Math Readiness.* Math readiness is administered via McGraw-Hill's ALEKS<sup>®</sup> online math programs. The purpose of this module is two-fold: refresh basic math skills and enable students to move up one math level to ensure they start at the appropriate math course for their curriculum. Students are directed to choose one of three ALEKS<sup>®</sup> options: *Math Refresher* (for all students who are entering at the appropriate math level), *Move Up to Calculus* (for engineering majors), and *Move up to Pre-Calculus* (for engineering technology and

construction management majors). This is the only portion of the EBC that requires a fee, which is paid directly to McGraw-Hill.

*Spatial Visualization.* According to Sorby [13] and Veurink [14], students with greater spatial awareness are more confident in their engineering studies and better prepared for higher level math and science courses. The EBC provides a series of exercises to practice spatial visualization skills and explain its relevance [15].

*Adjusting to Campus Life.* In this section a variety of slide shows, presentations, and videos detail basic areas of the university environment many students will be adjusting to. These include campus housing features, rules and what to expect, student health center features and access, wellness center access, student recreational services, school spirit and traditions, veteran services, disability services, financial responsibility and common pitfalls. The presentations are short and to the point.

*Setting Realistic Academic Expectations.* This section provides an introduction to the academic side of campus in the form of slideshows, presentations, and videos prepared primarily by upper class engineering students. “What to Expect...” modules on chemistry, calculus and Introduction to Engineering courses include tips for success, information about reading a syllabus, class size, study tips, and where to find tutoring. This section also highlights study habits, advising services, and how to use them and library resources. The focus is on the student taking control of their resources and making informed decisions.

*Choosing a Career in Engineering.* Mainly through videos and links to quality engineering education sites, students are encouraged to explore the disciplines of engineering, the path to professional licensure, and academic curricula. Sites that profile “a day in the life of an engineer” are particularly useful in helping students develop realistic career expectations.

*Academic and Administrative Resources.* Understanding the safety net that exists at UNC Charlotte can help address some of the anxiety felt by freshmen preparing to attend a large urban research university. This module provides students with information about what to do or who to see for a variety of issues, including the University Center for Academic Excellence, Counseling Center, Dean of Students, and academic advisors.

*Interaction with Leaders and Fellow Engineering Freshmen.* The forum is used to reach out to new engineering freshmen. Upper class engineering students host the forum and suggest students read a current news article or watch a video and encourage discussion about the engineering implications or simply marvel at the engineering accomplishments. The student hosts also suggest news articles that pose ethical challenges and video games that challenge the student’s ability to visualize in 3D, such as Smart Kit’s *Interlocked* game [16]. The *Interlocked* game serves as one of many crossover points, where the tools serves two purposes within the EBC: to practice 3D Visualization and as an interaction focus in the forum. The goal of this topic area is to help the students develop a sense of community and make learning part of the conversation before arriving for classes in the fall.

Due to its low maintenance design, administration of the EBC program is inexpensive. The program was administered in 2015 for just under \$8,000, approximately \$18.50 per participant.

The program was funded through an internal grant from UNC Charlotte's Division of Academic Affairs. A majority of the funds were used for student workers who helped design and update the content, guided students through EBC registration during orientation, monitored student progress, and hosted the forums. A small portion of the funding was used to purchase marketing materials for the program. The fee for ALEKS® was paid by the student directly to McGraw-Hill.

## Results

The Math program will be removed from the EBC starting in 2016 and offered as a separate Moodle option. For this reason, the participation and impact of the Math program is not discussed here but will be disseminated at a future time

As shown in Table 1, in summer 2014, 384 students enrolled in the EBC and 23% completed at least two-thirds of the basic (non-math) content. These students ended the fall semester with an average GPA of 3.06, while those completing less content had an average GPA of 2.75. One year retention within the College of Engineering for students who completed at least two thirds of the Boot Camp program was 7.7% percentage points higher than for students who completed less than one third of the program (73.3% vs. 65.6%).

Table 1. Summer 2014 Boot Camp Participation

<b># of Quizzes Completed</b>	<b># of Students</b>	<b>% of Students</b>	<b>Average Freshman Cumulative GPA</b>	<b>1 Year Retention in College</b>
0-6	256	58.9%	2.75	65.6%
7-13	27	6.2%	2.77	55.6%
14-19	101	23.2%	3.06	73.3%

In summer 2015, 435 students enrolled in the EBC. As shown in Table 2, approximately 37% of the students completed at least two-thirds of the basic (non-math) content. Students who completed at least two thirds of the EBC content appeared to benefit with an average fall semester GPA of 2.95. In contrast, students who completed less than two thirds of the EBC modules had an average GPA of 2.62.

Table 2. Summer 2015 Boot Camp Participation

<b># of Quizzes Completed</b>	<b># of Students</b>	<b>% of Students</b>	<b>Average Fall 2015 Semester GPA</b>
0-6	261	60.0%	2.62
7-13	14	3.2%	2.49
14-18	160	36.8%	2.95

EBC participation is unlikely to be the sole reason for the higher GPA and one-year retention. One confounding factor is that of self-selection; the students who were proactive in completing the EBC were also likely to be more industrious and conscientious regarding their coursework.

### **Future Direction**

Students' lack of proficiency in basic mathematics, algebra, and geometry skills caused the College of Engineering to remove the ALEKS® *Math Refresher* option from the EBC to create a stand-alone program, the Engineering Pre-Requisite Program. All freshman engineering majors must complete the program before enrolling in the Introduction to Engineering course, which is a required course taken in the first semester. Students have until mid-summer to complete the Engineering Pre-Requisite Program. The goal of this change is to help students refresh math skills, develop proficiency, and prepare them for success in basic engineering mathematics used in the Introduction to Engineering course. The Engineering Pre-Requisite is also expected to help improve performance in Calculus I.

Another change will be how the EBC is delivered to the students. UNC Charlotte is changing course management systems from Moodle to Canvas, effective fall 2017. For 2016, the program will remain in Moodle, with plans to use Canvas for 2017. The migration from Moodle to Canvas is expected to be relatively easy based on pilot studies.

In order to maintain its usefulness, the EBC is modified and updated annually to reflect changes in the campus and university policies. The Forum interaction portion of the Boot Camp has room for growth. For example, student workers are developing a menu of topics and questions that can be used as prompts. These improvements, combined with better timed communications with the participants, should help increase student interaction and community building. Finally, sending timely e-postcards to remind students to complete the EBC should help improve the program completion rate.

Academic Affairs has funded the program again in 2016. Other colleges at UNC Charlotte are considering adapting the idea to enhance their summer orientation program. Continued support and interest by the UNC Charlotte community will ensure continuation of this innovative preparatory program.

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