

## Teaching Engineering in the General Education Curriculum

### **Dr. Kevin Skenes, The Citadel**

Kevin Skenes is an assistant professor at The Citadel. His research interests include non-destructive evaluation, photoelasticity, manufacturing processes, and engineering education.

### **Dr. Robert J. Rabb P.E., The Citadel**

Robert Rabb is a professor and the Mechanical Engineering Program Director at The Citadel. He previously taught mechanical engineering at the United States Military Academy at West Point. He received his B.S. in Mechanical Engineering from the United States Military Academy and his M.S.E. and PhD in Mechanical Engineering from the University of Texas at Austin. His research and teaching interests are in mechatronics, regenerative power, and multidisciplinary engineering.

### **Dr. Nathan John Washuta P.E., The Citadel**

Dr. Nathan Washuta is an Assistant Professor in the Department of Mechanical Engineering at The Citadel in Charleston, SC. He received both his B.S. and Ph.D. in Mechanical Engineering from The University of Maryland – College Park. His primary research interests include Hydrodynamics, Turbulence, and Experimental Methods.

### **Dr. James Righter, The Citadel**

James Righter is an Assistant Professor of Mechanical Engineering in the School of Engineering (SOE) at The Citadel. He earned his BS in Mechanical Engineering at the U.S. Naval Academy, his MS in Military Studies from the Marine Corps University Command and Staff College, and his PhD in Mechanical Engineering from Clemson University. His research interests include design methods, engineering leadership, collaborative design, and engineering education.

## **Full Paper: Teaching Engineering in the General Education Curriculum**

Many engineering students are excited and motivated when they begin as freshman students, but many change majors or leave early in the first year, having limited exposure to engineering and an abundance to general education requirements. The Citadel had a very historic and outdated general education curriculum, with many courses in the Humanities, and some in basic science and math. After years of limited or no progress in students' critical thinking over four years, the school revised its general education and opted for a strand model. One of the first courses freshmen now experience is a Freshman Seminar and linked composition course. Known as a high impact practice, the Freshman Seminar has been credibly shown to improve student retention and enhance student learning. The academic Freshman Seminar now serves as the common starting point for all entering freshman. It is one of three classes that require the students to produce work that will be graded on six General Education outcomes. The overall theme of the seminar, as well as the topics of the individual seminar sections, are determined by the faculty. Based on the freshman population, there are typically 14-28 different seminar topics and 18-23 sections with approximately 20 students per section. Because of the broad nature of the General Education outcomes, each seminar section varies in its particular topic, spanning many different disciplines. The School of Engineering at The Citadel used the curriculum update as an opportunity to engage both engineering and non-engineering students with engineering topics in the freshman seminars. The new plan calls for each section of the Freshman Seminar to be matched with a three-credit-hour composition course. The composition class is an essential complement to the academic seminar. The instructor of the composition class and the instructor of the seminar develop together their reading lists and assignments. This is the first of several opportunities for interdisciplinary collaboration afforded faculty in the new GenEd plan. The freshman seminar exposes students to engineering beyond a calculated solution, allowing them to think through early decisions and consequences. For engineering students, this initiative helped them see additional pathways in engineering and their larger role. Students worked individually and in teams, and understand the types of knowledge and abilities essential to succeed. The objectives of this paper are to explain some of the Freshman Seminars that provide students with early exposure to engineering, to assess the results quantitatively and qualitatively through surveys, and to discuss the future direction of the program.

### **Introduction: The New General Education**

In 2014, a survey from the Association of American Colleges and Universities (AACU) highlighted several learning outcomes that employers and college students deemed important [1]. In 2015-2016, a review of the institution's general education outcomes and faculty survey revealed that the general education curriculum needed updating. With the 2019-20 academic year, The Citadel began a new General Education program, replacing the Core Curriculum that had been in effect for more than fifty years. The faculty elected a Strand Model General Education program and revised its general education outcomes to match the AACU learning outcomes. A new strands-model General Education curriculum is now required for all students beginning in the fall of 2019.

The Citadel's new Strands-Model General Education purpose is twofold:

- Promoting our students' intellectual development by affording them course-work in the fundamental academic disciplines of mathematics, natural science, literature, history, and social science; and
- Developing our students' skills and dispositions in six essential areas so that, upon successfully completing the curriculum, graduates ought to be able:
  1. To use quantitative reasoning skills to make calculations, interpret data, communicate results, and evaluate an issue or solve a problem;
  2. To communicate ideas in a logical sequence, demonstrating control of syntax and mechanics and the ability to integrate credible and reliable sources;
  3. To analyze complex issues that have varying positions and assumptions using information from credible sources, and to state positions, create new positions, and acknowledge other positions including implications and consequences;
  4. To demonstrate skill in inquiry and analysis, including using a design process, synthesizing information from relevant sources, drawing conclusions, and recognizing implications and limitations;
  5. To demonstrate insight into their own cultural rules and biases, to have accurate understandings of other cultural world views, and to display attitudes of curiosity, openness, and empathy;
  6. To recognize ethical issues when presented in a complex, multilayered (grey) context, to analyze cross-relationships among the issues, and to evaluate ethical perspectives and concepts, including his or her own.

These six essential learning outcomes and student objectives are a subset from the LEAP Initiative (Liberal Education and America's Promise) on General Education developed by the Association of American Colleges and Universities [2]. The specifics of the entire Strand Model General Education are beyond the scope of this paper. However, all strands begin with a Freshman Seminar and corresponding Freshman Writing course.

### **First-Year Academic Seminar**

Freshman Seminars are a part of the General Education curriculum at a number of schools to include the University of Richmond, Virginia Tech, Stanford, Elon, and many others. They are usually part of a set of courses in the schools' strand or thread of the General Education requirement.

At The Citadel, the Freshman Seminar is a six-credit unit composed of two three-credit classes taken concurrently—FSEM 101 and the thematically-linked writing intensive FSWI 101. Beginning in the fall of 2019, every first-year student enrolled in this six-credit unit. The individual seminars, all of which focus on important questions or problems, introduce students to the demands of academic work. Student assignments in the seminars are tied to the six essential General Education outcomes (quantitative literacy, written communication, critical thinking, inquiry and analysis, intercultural knowledge, and ethical reasoning). Seminar students begin to do *signature work*, “synthesizing, analyzing, and applying cumulative knowledge and skills through problem- or inquiry-based assignments or projects [2].”

Taught by faculty from across the campus, the Freshman Seminar serves as an introduction to academic inquiry. All freshmen declare their major before the fall semester, and many degree plans have little exposure to engineering or STEM beyond basic math and science. Several

engineering faculty piloted freshman seminars in the spring 2019 and taught the seminars under the new general education model in AY 2019-20. The engineering faculty saw the seminars as a way to attract different students to some of the courses as well as engage more engineering freshmen beyond their basic Introduction to Engineering (discipline specific) courses. Engineering faculty paired up with writing instructors from other departments (typically English), who taught the linked writing courses. Two of the freshman seminars and their descriptions are discussed below. Table 1 shows the typical grading requirements and weights for the freshman seminars conducted by engineering faculty.

Table 1: Grading Policy for Freshman Seminars

<b>Expected Performance Criteria</b>	<b>% of Grade</b>
Individual Homework (10 -14 ea)	10 – 20 %
Class Discussion	20 %
Short Reports (2-3 ea)	20 - 45%
Presentation (1-2 ea)	10-20 %
Final Project	15 – 20 %
<b>Total</b>	<b>100.0 %</b>

### Military Technology in Society

*Course Description:* Engineering and the military complex have long held a tight relationship. In fact, the word “engineer” is from Middle English and denotes a designer and constructor of fortifications and weapons. We will consider the specific example of military technology. This seminar will introduce students to factors that affect implementation of new technologies for military applications that have found their way into society. The class will strengthen students’ ability to analyze and communicate different issues and be informed citizens concerning implementing new technologies. Students will understand the iterative nature of engineering, technology, and innovations that lead to paradigm shifts. The course will have in-class demonstrations in the context of civilization's ever-evolving methods of modernizing. Central questions to be discussed in the course are: What are our expectations for new military technologies? What are the impacts of “tools of war” on society? How do unplanned events affect technology and expectations?

### Video Game Culture

*Course Description:* This First-Year Seminar will give students a behind-the-scenes look at the cultural phenomenon of video games. The class will begin by looking at the history of video games from a technical standpoint, and move into a discussion of the increasing role video games have played in culture and politics. From there the course will move into a discussion of creative license and censorship in an artistic medium, and the various ways video games are treated in this manner. This will be followed by a discussion on historical accuracy and the integration of real-life events into a player-controlled story. As part of this historical accuracy section, students will be expected to model fundamental physics to predict how objects behave when acted upon by forces in the real world. The course will then address business models for creating video games and how they differ between AAA-level studios like Electronic Arts or Blizzard and indie developers on a shoestring budget. Finally, students will spend time studying the potential effects of video games on real-life actions, ranging from possible links to violence and addiction to therapeutic treatment and the development of fine motor skills.

Other Freshman Seminars included titles such as: 1) Ethics of Human Experimentation; 2) Restoration of Lost Species and Ecosystems; 3) Media, Propaganda, and Cold Wars; 4) Frankenscience; 5) What is an American?; and 5) Texts and Contexts.

### **Assessment of Course Outcomes**

All freshman seminars had six course outcomes that related back to the general education outcomes, listed previously. Over the four year strand model with multiple courses, there is ample opportunity to develop student skills in these outcomes. However, the freshman seminars provide a baseline assessment of the outcomes after only a semester of instruction. To standardize the assessment process, the institution adopted the Valid Assessment of Learning in Undergraduate Education (VALUE) Rubrics from the AACU [3]. Through workshops, the faculty received training and instruction on the rubrics and were allowed to develop assignments to assess using the rubrics. Some faculty chose to have multiple assignments and others chose to have a larger end of term assignment to assess all six course outcomes.

The engineering faculty who taught the freshman seminar had either been through an ABET review or are currently preparing for one. They understand the process of continuous data collection and course assessment and know that evaluation is crucial for the success of the new program. Chickering and Gamson discuss that time on task and active learning leads to better understanding [4]. Also, early improvement and goal-oriented changes based on data collection will keep the program effective in the long term. Smaller, individual assignments early in the term helped instructors calibrate the students' baseline knowledge. Coupled with class discussions, the instructors had a better idea of what to expect from students on the larger assignments that were used for assessing the course outcomes. Additionally, instructors attended school sponsored workshops to develop their awareness of assessment and help calibrate their expectations.

The course outcomes, derived from the general education outcomes, may seem very different from the more familiar ABET outcomes. However, these skills are necessary for non-engineers and engineers alike. The National Academy of Engineering's, Educating the Engineer of 2020, stated that technical excellence is the essential attribute of educating engineers, but these graduates should also possess team communication, ethical reasoning, societal and global contextual analysis skills as well as understanding work strategies [5].

### **Survey and Findings: Student Perception**

At the end of the term, students completed the standard institution-based course evaluation. The method included student survey data that was collected during the last days of class and focused on measuring students' assessment of their ability to meet the course outcome, using a Likert scale (1 = strongly disagree to 5 = strongly agree). For the three semesters of offerings of these two courses (spring 19 – spring 20), the data from approximately 134 students was included in this study.

The survey is significant because the results are from some of the initial offerings of the courses. The classes are made up of first year students, who never had the opportunity to interact with upperclassmen who had taken the course. The results are high, all above 4 points on a 5 point Likert scale (Table 2). The Table also shows the faculties' graded assessment of the outcome (scaled to a 5 point scale) for comparison. The largest difference was in Quantitative Analysis.

Many students did not include a table or graph in the requirement but simply launched into discussion of data. The instructor and student assessments will rarely be perfect matches, so some margin of difference should be expected. As a new course is developed and offered, the faculty can expect some variation as the course is refined with each offering.

While this method may not be perfect, it analyzes data from the instructor and students separately. This objective assessment of course outcomes with objective data from embedded indicators and student assessment of their accomplishment can produce a better evaluation of the course and areas for course improvement. Over time, historical data can track the effects of changes in a course. A review of each course outcome assessment can lead to a rating of how well the students are achieving the general education outcomes. Some limitations of the survey include: limited comparison to other engineering courses and no data on other freshman seminars.

Table 2: Student Perception of Outcome

Outcome	Student Assessment (Subjective)	Faculty Assessment (Objective)
Written Communication	4.32	4.35
Inquiry and Analysis	4.40	4.23
Critical Thinking	4.24	4.17
Ethical Reasoning	4.38	4.31
Quantitative Analysis	4.52	4.11
Intercultural Knowledge	4.36	4.18

Free text replies reinforced the favorable nature of several hands-on activities and the orientation to the breadth of material. When asked what they liked about the course, typical responses included:

- The instructor's ability to break down technology and allow us to think through what really goes into the process of advanced technologies.
- The material is both interesting and diverse. I really enjoyed every subject that was covered.
- The hands on stuff.
- The constantly, perfectly spaced out homework assignments. We never had too much homework but we never had too little. The homework always allowed me to dive into the course and make it a lot more interesting.

While some aspects of the class were successful, the instructors received some feedback and are considering some revisions to the course. One recurring comment was the amount of writing. Some students already had many writing requirements due to their major. When asked what they like least about this course, some free text responses are listed:

- The amount of paper right in the beginning took us back a bit but was definitely manageable.
- Final project. I do not enjoy sharing a grade and effort with other classmates.
- Overall the class is great, I would suggest different types of homework instead of just papers.

- Have more guest speakers if you can.

The freshman seminars are offered in both the fall and spring semesters. Fall freshman seminar students highly recommended these seminars to their spring freshman counterparts. These engineering-faculty-taught sections were the first two freshman seminar sections to reach capacity when registration opened in the fall for spring registration. Students and instructors alike were in agreement with the seminars. Students found the material interesting and were glad they took these particular seminars, rating them higher than the average for all freshman courses. Similarly, instructors had a broader pool of students from different majors who added to the classroom interaction. Across three semesters of offering these particular freshman seminars, the feedback has been positive and evaluations have remained high.

## Conclusions

In this present study, it is difficult to arrive at conclusions on how these freshman seminars affect engineering students or non-engineering students in the long term. The engineering faculty will continue to monitor all courses, and especially the freshman seminar courses, to ensure they have a positive impact on the decisions and interests of all freshmen. Helping students connect to their profession, whether engineering or not, is critical since many of the discipline specific courses are taught during the last two undergraduate years.

One indirect outcome of the freshman seminars in engineering at The Citadel is the collaboration between faculty members in other departments. The cooperation and creative interaction led to many good ideas and organization of the courses, a must for appealing to students and preparing them for more demanding courses. It is probably not possible to design a class that is perfect for every student, especially the first freshman courses that attract such a wide variety of incoming students. However, through continual assessment, feedback from students and efforts to revise the freshman seminars, the authors believe these seminars can be greatly improved to meet the students' interest, and possibly attract a few more to engineering.

## References

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