

Full Paper: Assessing Achievement of Course Objectives in an Introductory Engineering Design Course

Dr. Jenahvive K. Morgan, Michigan State University

Dr. Jenahvive Morgan is the instructor for EGR 100 - Introduction to Engineering Design and Academic Director of the First-Year Engineering CoRe Experience at Michigan State University. She is also currently the Director of Positions for the ASEE Women in Engineering Division, as well as an ASCE ExCEED Fellow. Dr. Morgan has a PhD and MS in Environmental Engineering from the University of Michigan, and a BS in Chemical Engineering from Michigan State University. Her interests include innovative laboratory experiments for undergraduate instruction, engineering design for first-year students, and encouraging women to study engineering. For the three years prior to teaching at Michigan State University, she taught freshman and sophomore engineering courses at Rowan University. While at Rowan University she was Co-Director of RILED (Rowan Instructional Leadership and Educational Development), the advisor for the student chapter of the Society of Women Engineers (SWE), and given the ASEE Campus Representative Outstanding Achievement Award. Her teaching experience also includes work as a graduate student facilitator and engineering teaching consultant at the University of Michigan.

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Introduction

EGR 100, an Introduction to Engineering Design course, taken by all incoming first-year engineering students, provides an opportunity for multiple core objectives of the engineering program to be addressed. These objectives include a focus on working in teams, solving open-ended problems, understanding the engineering profession, improving communication skills, and understanding the engineering curriculum. These core objectives of EGR 100 were developed to provide students a foundation in the fundamental skills that will assist them in their academic and professional careers.

As part of the course, students work in teams to solve two main design projects over the course of the semester. Each design project involves using their design skills to solve open-ended problems, and then communicate these results in a report. The students work in teams of four to complete these design projects in the lab sections of the course. In the lecture sections, the students learn about the engineering profession and engineering curriculum to prepare them for the challenges that are involved in navigating these future paths.

Students in EGR 100 completed a survey of their experiences in the course at the end of the semester. This data was collected over six semesters and an average of 142 students each semester provided feedback. Five questions were posed to the students to allow the students to reflect on their experiences within the course. The results based on the answers to these questions over the three years, or six semesters, were then compared to see if there was a trend in the responses.

Background

Over ten years ago, Michigan State University created a first-year program that included both an academic program and a residential, co-curricular component [1]. The academic, first-year program consisted of two courses that students take as they begin their engineering curriculum. One of those courses is EGR 100, an Introduction to Engineering Design course, and subject of this examination. The goal of this course was to prepare the incoming students for the engineering coursework needed to obtain the degree, by providing a strong foundation in design, communication, teamwork, ethics, and professionalism. These are all outcomes of the ABET Engineering Criteria, and formed the basis of preparing students for both their academic and their professional careers.

The first-year program at Michigan State University was created to teach students about the importance of the engineering profession in solving society's most challenging problems, while making a positive impact on the world around them through the application of the skills learned in EGR 100 [2]. Since the challenges that engineers will be faced with upon graduation will be global in their scale, it is important for these future engineers to be exposed to multicultural, multidisciplinary teams early on. Also, these future engineers need to gain the experience of being faced with difficult open-ended problems within this team environment, having to work

together in these teams to solve the problems they are faced with, and then come together to communicate their design results. All of these experiences form the foundation of the objectives of EGR 100 [3], [4].

In addition to these skills, there is an emphasis in EGR 100 to prepare students for the engineering coursework needed to complete the degree by covering the fundamentals of mathematics, physics, and problem solving within the course. It is important for students to understand the relevance of these skills in their application to engineering design solutions. Also, for these future engineering students to be successful in their careers they need to understand how to prepare their resume, interview well, obtain an internship, and work in the industry on diverse, interdisciplinary teams, while making an ethical impact with their work.

Through the design projects in the course, students are exposed to industry sponsored projects, as well as have a chance to present their work alongside the seniors at the Michigan State University Design Day. These opportunities prepare students for their future professional career, but also emphasize the importance of working well with other and maintaining grit and resilience in the face of adversity [5], [6].

Course Framework

There are some distinct characteristics of EGR 100. There is both an emphasis on team building and team performance assessment and resilience that is unique. Both grit, or resilience, and team interactions are emphasized throughout both the lecture and the lab. Students solve challenging, open-ended design problems in teams and communicate these solutions in formal written reports. These topics are discussed in lecture and the students put these skills into practice in the laboratory environment. Through the exposure to this material, the learning objectives of the course are met.

In lecture, a discussion of grit, and the Duckworth et al. (2007) [7] study, is conducted to inform the students of grit or resilience. Not only is grit explained, but there is also a discussion of how to develop grit. This discussion is moderated to allow the students to contemplate the circumstances where grit is essential to their success. Failure, and how one responds to failure, is a key part of this discussion, along with a discussion of growth mindset from the studies of Elliott and Dweck (1988) [8] and Murphy and Dweck (2010) [9]. Seeing failure as an opportunity to learn and improve, instead of a judgement on one's character, is essential to developing the growth mindset approach to resilience in times of failure during both academic and professional engineering careers. Especially since finding ways to navigate these paths is necessary when considering retention of students through graduation and beyond in the engineering field. The discussion of retention is also conducted as part of exploring the topic of grit. The academic and professional engineering paths of students is filled with difficult decisions and experiences, and understanding the tools that can aide them through this process is essential.

The open-ended design problems put the students' knowledge of grit, or resilience, into practice. As engineers, these students will be faced with society's most challenging problems. These open-ended design problems will be so difficult to solve that a team of engineers will be needed to discover a solution. For this reason, the students need to build their teaming skills. In lecture,

students perform a self-assessment of their personality using a Myers Briggs Type Indicator (MBTI) personality inventory tool. This is used as a guide to help students navigate difficult situations both in the design process within their team, but also in navigating their engineering career. This personality assessment improves the students' abilities to communicate within their team during the design and report writing process. Being able to communicate well with others is essential to these two other objectives of working in a team and solving design problems. In the study by Engel et al. (2014) [10] from MIT, it was found that empathy influences whether problem solving in a team environment produces successful results. In EGR 100, students are not only accountable to each other for the solution of the design problems, but also accountable to each other for the learning process, which is shown to be beneficial to problem solving within a team, as shown by Jones (1996) [11] and Seat et al. (1996) [12].

Course Assessment and Discussion

To assess the ability of the course to meet the core engineering objectives, a survey was delivered at the end of each semester for the past six semesters the course was taught before the 2020 academic year. The main objectives of EGR 100 are a focus on open-ended problem solving, the ability to work in teams, the development of communication skills, and the exposure to the engineering profession and curriculum. An average of 142 students took this survey each semester, resulting in a total of 850 students responding to the survey over the six semesters. Based on the responses of the students, 39% of students in the course strongly agreed, and 39% of students agreed that the course met the objective of improving the students' ability to work in teams, as seen in Figure 1. While working in teams is challenging for the students in the two projects, the setup of the course where students are allowed to switch teams between the two projects may have improved the experience for the students, and is a consideration into a further study of the approach to teamwork in EGR 100.

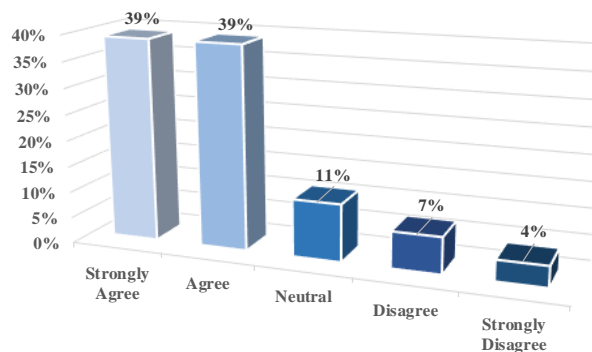


Figure 1: Student responses to the assessment of whether EGR 100 met the course objective of developing their ability to work in teams.

The results of an assessment of the objective of the course to improve the students' communication ability was slightly lower. Based on the EGR 100 student responses, 31% of the students strongly agreed, and an additional 32% of the students agreed, that the course objective of improving the students' communication ability was met, as found in Figure 2. Around 23% of the students had a neutral response. While this is better than disagreeing, improvement can be made in assisting the students in their communication skills. Again, this can be a challenging objective in an engineering course, especially with the students writing four team reports, two per project, throughout the semester. Each report has a detailed rubric with formatting requirements, and a template for the reports is also provided, but additional assistance with quantitative analysis and technical writing could be useful for the students based on this feedback.

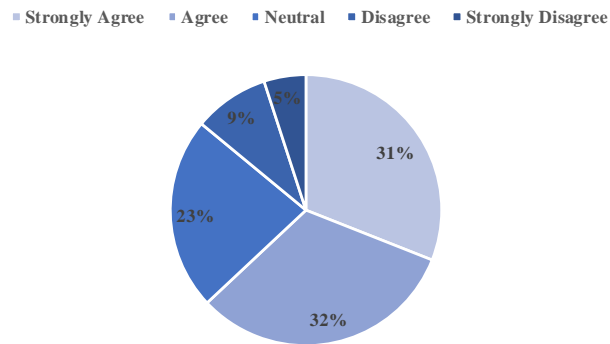


Figure 2: Results of the student assessment of whether EGR 100 met the course objective of improving their communication skills.

When looking at the course objective of developing the students' ability to solve open-ended problems, the results found in Figure 3 reveal an increase in favorable responses from the students, as compared to their assessment of the development of their communication skills. 30% of students strongly agreed, and 38% of students agreed, that this objective was met. Although there were still 21% of the students providing a neutral response. Possible improvements to the course to increase the positive responses from the students may involve an additional guided aide to approach the open-ended problems that the students are posed with.

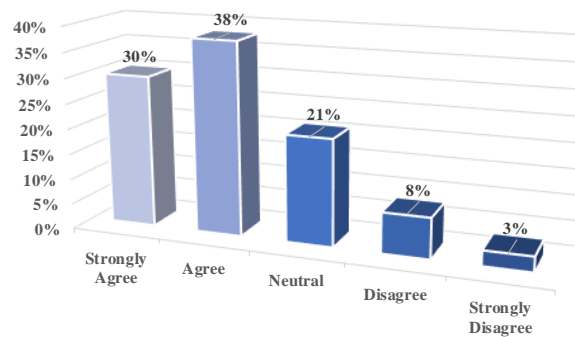


Figure 3: An assessment from the students of EGR 100 on whether the course met the objective of improving the students' abilities to solve open-ended problems.

Finally, Figure 4 below outlines the results from the assessment of the course meeting the objectives of helping the students to understand the engineering profession and curriculum. Understanding the engineer profession received 34% strongly agree responses and 40% agree responses from the students, while understanding the engineering curriculum received 37% strongly agree responses and 40% agree responses from the students. Overall, the majority of the students provided positive responses for all the course objectives, with some objectives receiving more favorable responses than others, and signaling that improvements to the course should be made in those areas.

■ Strongly Agree ■ Agree ■ Neutral ■ Disagree ■ Strongly Disagree

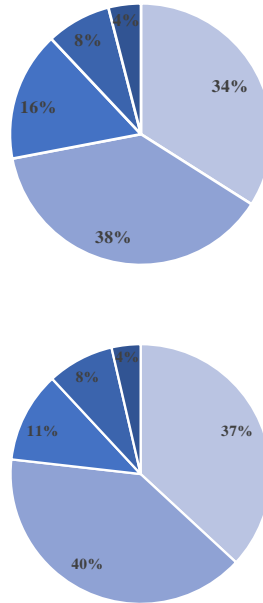


Figure 4: Responses to the assessment of whether EGR 100 met the course objective of understanding the engineering profession (above) and the engineering curriculum (below).

Conclusion

EGR 100 is part of a first-year program that was created to prepare students for their academic and professional careers. As part of this preparation, course objectives were created to focus the course on developing the students' abilities to work in teams, solve open-ended problems, understand the engineering profession, improve their communication skills, and understand the engineering curriculum. All incoming first-year engineering students are required to take this course as they begin on the path to becoming an engineer, and they are exposed to these course objectives while completing the two main design projects in EGR 100. In the course, the students learn the fundamentals in lecture, and practice these skills in the laboratory environment. Based on the results of the assessment, the course objectives of developing the ability to work in teams and understanding the engineering profession and curriculum were found to be achieved by the students in the course. The course objectives of developing the ability to solve open-ended design problems and improving their communication skills were still found to be achieved, but to a lesser degree and needing improvement.

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