6-22-2020

Work in Progress: Development of a General Education First-Year Design Course

Courtney Hollar
Boise State University

Sondra M. Miller
Boise State University

Publication Information

Hollar, Courtney and Miller, Sondra M. (2020). "Work in Progress: Development of a General Education First-Year Design Course". *ASEE Annual Conference and Exposition, Conference Proceedings, 2020-June*, 30145-1 - 30145-10. https://dx.doi.org/10.18260/1-2--35627

Work in Progress: Development of a General Education First-Year Design Course

Dr. Courtney Hollar, Boise State University

Dr. Courtney Hollar is a lecturer in the Department of Mechanical Engineering within the College of Engineering at Boise State University. Hollar earned a B.S. and M.S. in Mechanical Engineering from Boise State University and a Ph.D. in Mechanical Engineering from the University of Idaho. She is passionate about methods to attract and retain women and underrepresented minorities in STEM fields.

Dr. Sondra M Miller, Boise State University

Dr. Sondra M. Miller is an associate professor in the Department of Civil Engineering within the College of Engineering at Boise State University. Miller earned a B.S. in Civil Engineering and a M.S. in Environmental Engineering from the State University of New York at Buffalo, and a Ph.D. in Environmental Engineering from the University of Iowa. Her educational research interests are focused on methods to attract and retain women and underrepresented minorities in STEM fields.

Work in Progress: Development of a General Education First-Year Design Course

Introduction

We discuss the development of a new first-year engineering course at Boise State University in this Work in Progress paper. ENGR 180 Communication in Design Thinking, was developed in order to emphasize the importance of communication throughout the design process. Communication with the client at the start of the design process occurs in order to understand the problem to be solved. The team and other stakeholders continuously communicate in order to work toward developing a prototype to solve the problem. The ability to effectively communicate is equally as important to the design of the final product. The development of ENGR 180 emphasizes this skill by encouraging students to work in trans-disciplinary teams. Students in majors across the University are welcome to learn about the significant role communication plays in the design process because ENGR 180 has no prerequisites. Through various projects and in-class activities, students are made aware of the significance. As a result of the course's learning outcomes, oral communication is the focus of the class rather than technical writing.

Boise State University has not previously offered a course that focuses on communication throughout the design process. The State Board of Education has requested for undergraduate students to graduate with specific competencies in oral communication. ENGR 180 was designed to emphasize the importance of oral communication as an engineer.

In early 2018, the State Board of Education (SBOE) mandated the four state universities in Idaho require a Foundations of Oral Communication (FC) course that could be seamlessly transferred between institutions and accessible to incoming students (i.e., no prerequisites). Such oral communication courses are required to focus on effective speech, both as a speaker and listener. Many of our undergraduate programs within Engineering require 124 to 129 semester credit hours for degree completion, well above the 120 semester credit hours also mandated by the SBOE. The SBOE does allow programs with specific accreditation requirements, such as ABET for our undergraduate programs, to exceed this maximum. We saw an opportunity to maximize semester credit hours by creating a course that addressed SBOE requirements while revitalizing our first-year engineering experience.

Our university has a General Education Committee (GEC), composed of faculty members who represent our diverse program offerings, responsible for overseeing which courses satisfy SBOE requirements for general education. We also have a set of University Learning Outcomes (ULOs) centered on the principles of "know, do, become". Initial response from the GEC in November 2018 to our proposal for ENGR 180 designated as FC was that Engineering lacked the expertise to design a course rooted in communication theory. Our proposal, along with two other proposals from Communication and Sociology, was eventually approved by the GEC. Our proposal was eventually not approved in December 2018 at the Provost level due to concerns about staffing and financial resources required to accommodate our first-year engineering students in addition to other incoming students.

ENGR 180 had already replaced our previous first-year engineering course through the parallel University Curriculum Committee (UCC) process. Three of our six undergraduate programs chose to drop ENGR 180 once it was not designated as FC. We moved forward in summer 2019 designing ENGR 180 to begin offering in the fall 2019 semester, the results of which will be discussed in this paper.

ENGR 180 serves as a freshman-level course to introduce students to engineering. This project based course is one of the only opportunities for lower level undergraduates to experience a hands-on approach to the design process. Through this class, students work to become more proficient in public speaking, communicating within teams, and to develop empathy towards their clients.

Structure of Communication in Design Thinking Course

Our course designer completed the Center for Teaching and Learning Course Design Institute 1.0 during summer 2019. Through this institute, the castletop method is utilized to develop the course and ensure that LOs are closely tied to course activities and assessments.

The ENGR 180 LOs that a student must be able to meet after successful completion of the course were:

1. Analyze a communication situation to determine the audience and their information needs
2. Identify the appropriate rhetorical approach to use (or that is in use) in that situation
3. Apply the design process to generate a solution that addresses an identified user problem or need
4. Work effectively as a team with a clearly defined goal and document team activities
5. Assess the validity of individual and team assumptions about the design problem and client needs
6. Articulate the design tradeoffs that arise from these sustainability, safety, and ethics issues that relate to a specific design problem
7. Apply oral communication theories and concepts to the design process

Based on these LOs, several open educational resources were identified to be used as textbooks for ENGR 180. Various team based projects were developed as part of the formative and summative assessments used to ensure that the LOs were being met.

Project Examples

Cookie Sandwich Project

One of the team based projects students work on is referred to as the Cookie Sandwich Project. The goal of this activity is to develop an assembly process and procedure for creating the most bags of cookie sandwiches, given the quality control constraints, in ten minutes. Students go

through the design process to develop a prototype and procedure used to effectively communicate and train two volunteers who will assemble as many cookie sandwiches as possible.

Student teams first work to develop specifications as a form of quality control. These specifications are then used to determine the success of their procedures once the assembly test has been performed. Once the specifications have been developed, the teams begin to explore different assembly methods through market research. During this step, teams brainstorm and explore different approaches to dispensing frosting onto the cookie (i.e. knife, frosting bag, frosting syringe, etc.). A prototype, written procedures, and safe food handling plan is then developed to be used for creating cookie sandwiches. The teams are then provided a small quantity of cookies and frosting in order to perform a test.

Prior to the two volunteers performing the assembly test, teams are given ten minutes to train the volunteers however they see fit. The purpose of utilizing volunteers during the assembly test is to help students determine if the procedures are clear, if any assumptions have been made, and if they effectively communicated with the volunteers. Oftentimes, teams quickly realized that there were assumptions made in the procedures developed, such as neglecting to inform the volunteers to open a second can of frosting and continue to make cookie sandwiches if there is time remaining and the first can of frosting has been emptied.

Volunteers are instructed to follow the information they have been given during the ten minute training period. During the assembly test, students are instructed to observe the volunteers without giving them additional feedback or corrections about how the procedures should be followed. It is during this time that students began to mention that communication was not as clear to the volunteers as originally intended. In most cases, the students would find that their procedures did not truly account for each step that was required to correctly assemble a cookie sandwich that would meet all of the quality control requirements. In other cases, the approaches used to teach the volunteers (lecture v. demonstration) during the training period would cause the volunteers to be confused or forget information about each person's role. Throughout the project, communication topics such as learning styles and intercultural communication were discussed in class to prepare students for the training period and assembly test. The goal of this project was for students to experience the importance of effective communication. A final presentation and report provided an opportunity for the teams to reflect what went differently than they had anticipated in the Cookie Sandwich Project and what revisions they would make to the project if they could do it again.

Adaptive Project

The second project, referred to as the Adaptive Project, focuses on empathy and the importance of adaptability in the design of everyday household items through human centered design. Student teams are introduced to their fictional client who is a retired, elderly man who recently had his dominant arm amputated at the shoulder. Teams are given the choice to develop a device to help the client button and zip their clothes or a cutting board to help him gain independence with everyday tasks.

Prior to the start of the Adaptive Project, the students read some background information about their client. From this reading, students began to understand that their client is feeling discouraged about transitioning from an independent lifestyle to relying on a caretaker to visit him every day. As a result, the client would like a device that can help him gain some independence with buttoning and zipping his own clothes, as well as a cutting board that would allow him to cook. Based on class discussion, students indicated understanding that the client is more isolated since the amputation of his dominant arm and now relies on a caretaker to help him with daily tasks. From there, students were given a chance to button shirts, zip jackets, and cut food using their non-dominant hand. After the role playing activity, class discussion indicated that students had a better understanding of how frustrating and time consuming these daily tasks become when the dominant hand can no longer be used. The purpose of spending time introducing the client and doing role playing activities was to show students the importance of gaining empathy for their client in order to follow a human-centered design process.

The Adaptive Project is a seven-week project that allows students to go through the design process in more detail. As the students perform market research, they noticed that some of the devices on the market are too expensive for the client's budget. From there, teams brainstorm concept designs and develop two viable concept designs that are then presented to the class. During the concept design presentation, the class provides feedback that the teams then use to influence their decision for which concept design to turn into their initial prototype.

For the first round of prototyping, students are provided materials as a way to encourage quick, inexpensive prototyping. This gives students an opportunity to create a physical device that can be presented to the class in order to gather feedback. Teams also test the initial prototype to determine what aspects of the design need to be improved. Based on the specifications developed earlier in the project, teams develop three tests that they will perform. These tests should focus on different functions that each device should be able to accomplish. The feedback that the teams receive from the class when they present their initial prototype and three tests helps to provide different perspectives of how the devices could be used. For example, teams that created cutting boards had to consider the range of food shapes and sizes as well as the variety of cutting techniques. By frequently presenting to the class throughout the Adaptive Project, this allowed the teams to take a step back from their project to analyze the big picture.

The purpose of having students go through the iteration phase of prototyping was to demonstrate the final product is not going to be created in the first try and can always be improved. During this process, students go back to the concept design phase to change aspects of their first prototype. Oftentimes, engineering courses will allow students to build a prototype, however rarely is there enough time set aside to iterate the prototype. However, iterating a prototype is an extremely important step in the design process. Through this project, students are given an opportunity to not only go through the design process, but to perform one iteration of their prototype.

The culminating activity for ENGR 180 consisted of the students presenting their final prototypes and a summary of their design process. An example of a buttoning/zipping device is

shown in Figure 1. Students used the testing results and the feedback from their classmates to improve the initial prototype. In this instance, the team created interchangeable button hooks, so that the device would be able to button clothing with various sized buttons. Furthermore, a retractable cord was embedded within the handle and a plastic extension part was attached to the end of the cord which could be stepped on in order to provide the tension necessary for zipping up a jacket with one hand. Finally, the team worked to develop a portable prototype so that the client would be able to store it in their pocket.

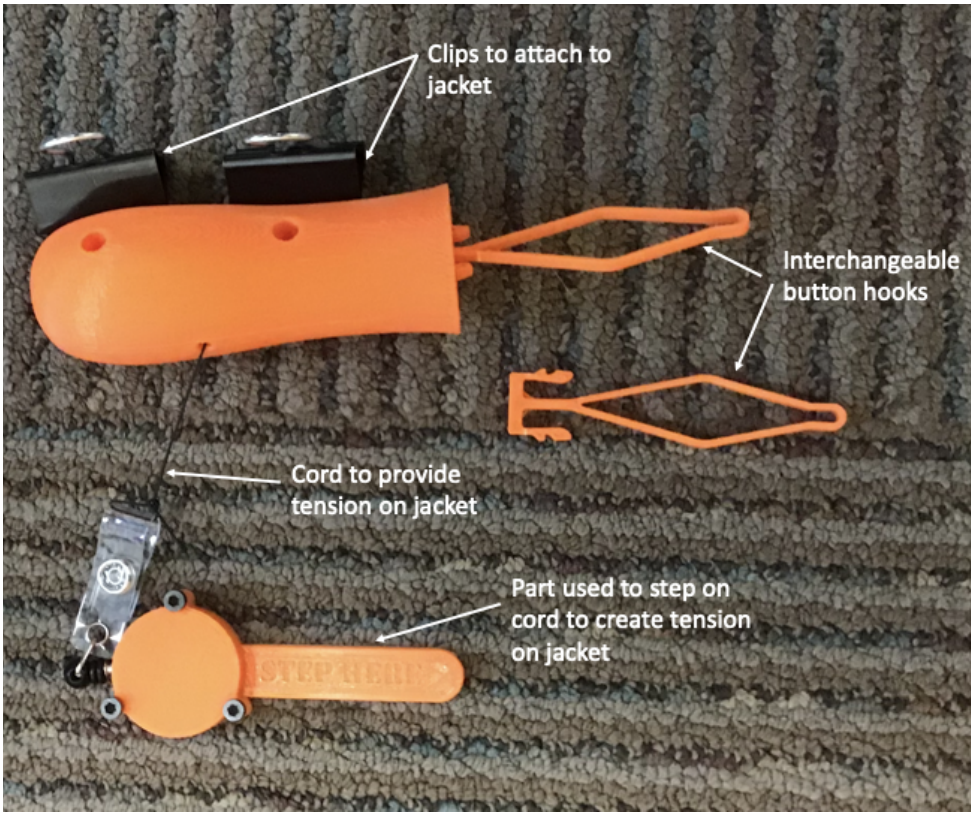

Figure 1. Final prototype of buttoning/zipping device

An example of the final prototype of the cutting board is shown in Figure 2. For this device, students included several options of cutting food. Depending on the food's hardness and cutting needs, the spikes could be used. This feature would work best for food types and cuts such as cutting an apple into wedges or cutting an onion in half. If the food was more delicate, the adjustable clamp could be used. In this case, the sidewalls and the clamp were used to hold the food in place while it was cut. Slicing bread or chopping herbs could be done with this feature. The clamp can also be used for horizontal cuts, such as dicing. The teams were mindful of the client having one arm, so they used lightweight wood or plastic and included a handle for ease of transport.

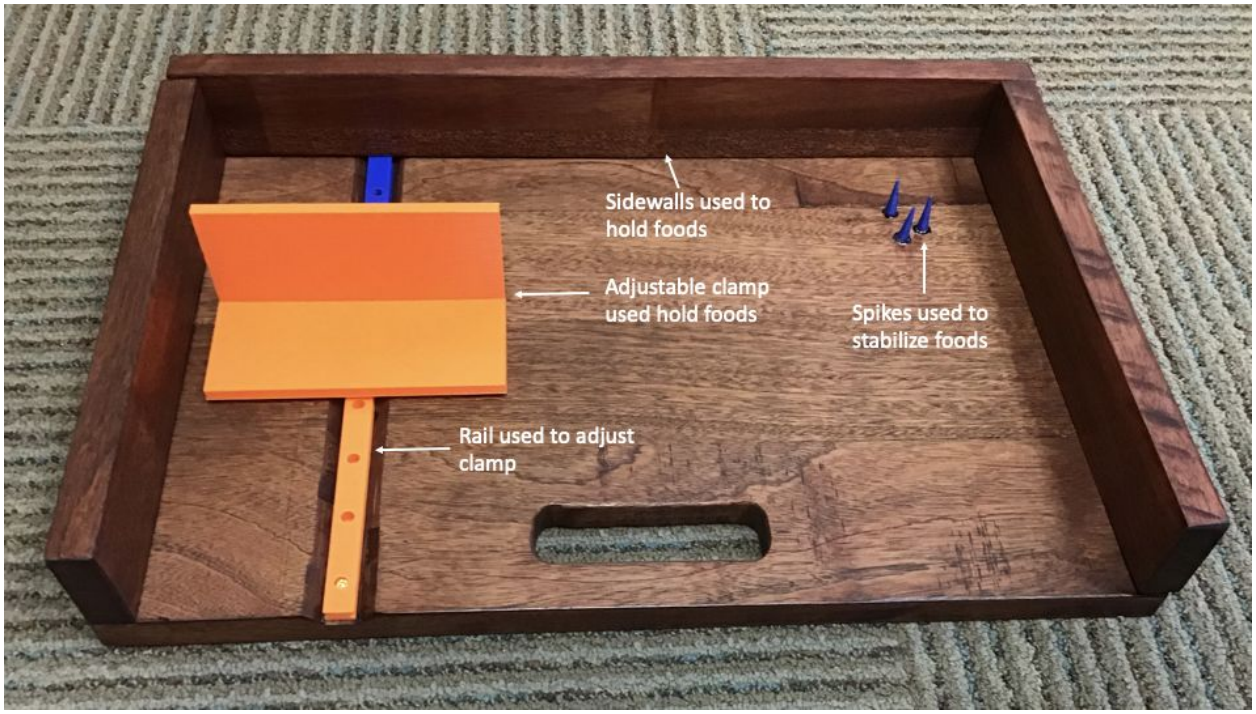

Figure 2: Final prototype of cutting board

For future semesters, we plan to widen the scope of the Adaptive Project by including other projects to work on. By including various projects, students will have to rely more heavily on their market research rather than the ideas their classmates develop. In addition, this will allow classmates to view each design as a potential consumer during presentations and provide students with more feedback about which aspects of the design should be iterated. Furthermore, more emphasis will be placed on the importance of testing the first prototype. During the first time this course was offered, students had a difficult time wanting to test their initial prototype. Rather, they were more interested in testing the iterated prototype, thereby defeating the purpose of working on an iterated prototype. Overall, the purpose of this project was for students to understand the importance of communication. They realized the difficulties of communicating with their teammates and learned that they need to be more intentional about the way they communicate with each other.

Methods

In addition to creating a course that addresses the SBOE requirements and revitalizing our first-year engineering experience, we saw this as an opportunity to develop a course that integrates the arts and humanities with engineering. The National Academies of Sciences Engineering Medicine published a book discussing the importance of integrating the humanities and arts with science, engineering, and medical fields. It was reported that courses who integrated these various fields experienced increased student motivation and engagement. Furthermore, they found that this type of course integration shares a relationship with high order thinking, the ability to solve problems creatively, and improve communication and teamwork skills [1].

Throughout the course, students read, watch videos, and take quizzes pertaining to oral communication theories. These oral communication theories are then explored in class through a variety of in-class activities, group based projects, or in-class discussions. Some of these activities include students learning how to lead a meeting, interviewing a client, establishing empathy toward the user, and considering adaptability as part of the design process. Formative assessments include individual and group based reflections, discussion questions, and peer and self assessments. Through the process of these formative assessments, students are given a chance to spend time evaluating what aspects of communication did and did not work for various assignments. As summative assessments, reports and oral presentations were used to evaluate student success.

More than 150 students enrolled in the first offering of ENGR 180. The demographic characteristics of the students are summarized in Table 1.

Table 1. Demographic characteristics of ENGR 180 students

Gender	**Ethnicity**
Male: 78%	White: 57%
Female: 22%	Hispanic/Latino: 18%
	African-American: 2%
	Asian: 4%
	Other: 2%

Results and Discussion

End of semester course evaluations were used as a measure to assess the effect of the new course. Student comments revealed that they enjoyed the in-class exercises, which they believe helped build communication and teamwork skills. Other comments mentioned that the high amount of group work helped strengthen their communication with others. As for the various types of presentations given throughout the semester, student feedback revealed that they gained more confidence in public speaking. Furthermore, they learned the importance of clearly presenting to their audience using effective visual aids. A large majority of comments made by students indicated that public speaking and presentations were helpful in being able to more clearly communicate with various people and how to communicate as an engineer. Students also mentioned that empathetic design, hands-on projects, and working in teams were some of the most valuable learning experiences gained from this course. Overall, students who completed ENGR 180 understood the importance of communication in group based projects, the design process, and problem solving.

Through the success of this course, students will have a more thorough understanding of the design process and how it relates to communication. The various projects and in-class activities emphasize the importance of effective communication. Students spend time analyzing their audience when preparing to give presentations or feedback. Furthermore, students are taught the importance of effective feedback in relation to discussing the design of different products. Overall, this class combines the oral communication theories of a traditional COMM 101 class with an introduction to the design process.

We are currently collaborating with Arts and Sciences and have two goals. First, redesign ENGR 180 to include a specific focus on communication theory while maintaining activities centered on design thinking and the principles of "know, do, become". Second, rewrite our proposal to have ENGR 180 be approved by GEC and designated as FC. We believe this collaboration will set the stage for unique general education course offerings created between colleges.

The current challenge to recruiting students hinges on ENGR 180 obtaining FC designation. One of the three undergraduate programs who required ENGR 180, removed it from their curriculum, effective fall 2020 because it does not fill a University or accreditation requirement. The two remaining programs continuing to require ENGR 180 hinges on whether or not it becomes designated as an FC course. We believe that once ENGR 180 becomes designated as an FC course, enrollments will include those of our incoming engineering students and again as many students from the general population.

Conclusions

Through this course, students will be given an opportunity to explore theories of communication in a project-based learning environment. Various projects highlight the importance of understanding effective communication and how it relates to the design process. Already feedback from the first semester of ENGR 180 has demonstrated that students leave the course having a better understanding of how important the role of communication and empathy is throughout the design process. Once ENGR 180 is designated as an FC course, this will become a valuable course for not only engineering students, but also students from other majors.

References

[1] National Academies of Sciences, Engineering, and Medicine 2018. The Integration of the Humanities and Arts with Sciences, Engineering, and Medicine in Higher Education: Branches from the Same Tree. Washington, DC: The National Academies Press. https://doi.org/10.17226/24988.