

## **An Exploratory Study of Outcomes of Interdisciplinary Activities in an Engineering Orientation Course**

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## **An exploratory study of outcomes of interdisciplinary activities in an engineering orientation course**

**Abstract:** We emphasize the interdisciplinary curricula of the mechanical engineering (ME) and electrical engineering (EE) programs since we transitioned from a dual degree program to a 4-year engineering department in 2015 fall. In our department, we have more students in ME than in EE. However, it is imperative for all students to have the basics of EE in order to work on the robotic projects. In this case, we mix students from two programs together in the engineering orientation course. “What topics should be covered in this course?” is always a question and a challenge for the instructors. After 3-year practices and continuous improvements, we decide to cover not only the basics of ME and EE but also diverse soft skills trainings especially the project management trainings. Three teaching assistants (two juniors from EE and one junior from ME) are assisting a professor in the lab sections. This paper studies the outcomes of several activities such as the ethics debates, self-identities, career track surveys, project-based learning, a field trip and peer-to-peer supervising and learning. Especially, we are exploring the student learning outcomes of interdisciplinary projects when we mix students from ME and EE in the same team. Several surveys are given to students and teaching assistants through the semester to explore students’ outcomes and feedback about diverse activities. Results show that students prefer learning and working cross the fields. They do not just learn the basics of ME and EE but also gain a lot of soft skills from different activities. We find such a course gives freshmen especially those who do not know what EE is a better idea about EE. A couple of students decided to transfer to the EE major or be double majored in both ME and EE after they start working on the course project. Our findings would be useful for other similar small programs at other universities.

**Keywords:** Interdisciplinary, Robotics, Peer-to-peer supervising and learning, Project-based learning, ethics debate

### **Introduction**

Interdisciplinary curriculum aims at combining various disciplines around common themes, issues or problems [1-2]. The curriculum has an emphasis on projects, make use of a wide variety of source material (not just textbooks), highlights relationships among concepts, and consists of thematic units. [2]. In the engineering related fields, many studies have been done about the interdisciplinary courses among different disciplines [3-7]. Many universities/colleges have fused the ethics training, and field trips into their engineering curricula [8-11]. However, few are about a series of assessments corresponding to various interdisciplinary activities, especially including the career track component in this introductory course and their outcomes in the engineering orientation course. In this paper, we will focus on the study of outcomes of the interdisciplinary activities in ME/EE 100 engineering orientation at our university.

Our department at a small private university includes two programs—ME and EE. We were engineering dual degree program for 43 years. Students of this program can get two Bachelor of Science degrees, one from our university and the other from one of our affiliated universities such as Columbia University, Institute of Georgia Technology and the University of Florida. We

transitioned from the dual degree program to a 4-year engineering department because of the student needs since 2015 fall. Our curricula of both programs emphasize the interdisciplinary in terms of both curricular and co-curricular activities. There are several ME cross listed courses and projects spanning from the freshmen year to the senior year. One area of emphasis is mechatronics which is an interdisciplinary field. In order to prepare students having the interdisciplinary training through years, we start emphasizing the interdisciplinary training since the first engineering course.

Before 2015 fall, we covered general topics about the engineering in the engineering dual degree program. We learnt that the project based learning was the most favorite part of this course. So we still keep the course project element in the engineering orientation which focuses on the mechanical engineering and electrical engineering.

The course description: Cross-listed with EE 100. Three hours per week. Co-requisite: MATH 110 or MATH 140. General information on engineering disciplines, common engineering practices, engineering profession, engineering education, engineering design including creativity and innovation, team design projects, engineering ethics and engineering opportunities will be provided by the instructors and/or invited professionals. Credit cannot be awarded for both ME 100 and EE 100.

Besides the basics of both majors, we also include a 6-week course project which is about the design and development of a robotic system. Each team consists of students from both majors. In addition, the course includes several activities such as the ethics debates, self-identities, career track surveys, a field trip and peer-to-peer supervising and learning. Table 1 lists interdisciplinary activities we have this course.

**Table 1 A summary of interdisciplinary activities**

Activity	Description
Course project	Design and develop a robotic system Cost constraint: less than \$100 Time constraint: 6 weeks Tasks: weekly journals, proposal, final report, presentations, peer evaluation Team: 3 or 4 students each team. Students from ME, EE and non-engineering students are mixed in each team
Ethics debate	Debates about an NASA failed launch project Requirement: the NSPE ethics code must be used to support the debates Team: 3 or 4 students each team. Students from ME, EE and non-engineering students are mixed in each team
Homework	Group study is conducted. Each team has a mix of ME, EE and non-engineering students. They help each other on basic questions of ME and EE. They work together on some mechatronics related questions
Field trip	A field trip to Medtronic Groups: 3 groups. Each group has a mix of ME, EE and non-engineering students. They are asked to find engineers cross the fields and ask some questions both inside and outside their fields

Career track	Woofound survey done by our career resource center Group discussion: the members of each team mixed with students in different majors show each other the possible career paths
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In this paper, we introduce a couple of projects first. Then we explore the student learning outcomes of interdisciplinary projects when we mix students from ME and EE in the same team. Several surveys were given to students and teaching assistants through the semester to explore students' outcomes and feedback about diverse activities. Finally we summarize the work.

### Course Project

In our department, we have more students in ME than in EE. However, it is imperative for all students to have the basics of EE in order to work on the robotic projects. In this case, we mix students from two programs together. The freshmen were assigned to adopt and adapt a robotic system as the final course project. They did not need start a project from scratch since they did not take other engineering courses. They have the freedom to choose a robotic system they would like as long as the system includes three main elements: sensor, actuator and microcontroller. During the last 6 weeks, students were required to submit a proposal including a discussion of the design with several considerations and constraints, a specified budget plan and a timeline first. Students then researched on the difference between mechatronics and robots to further develop their insights on the interdisciplinary among mechanical engineering, electrical engineering and computer engineering. They spent 4 weeks to build the prototype. Finally each team presented their work and submitted a final report.

One team of four students (two in ME, one in EE and one double majored in ME and music) constructed a robot which solved a three by three Rubik's cube in 24 moves. The robot illustrated in Figure 1 was built with the use of a LEGO Mindstorms construction kit and programming environments. The group employed the use of three actuators, two sensors and a controller to enable their robot function effectively and accurately. They made use of two infrared sensors where one sensor detected the presence of the cube in the robot while the other sensor scanned all six faces of the cube. The EV3 Mindstorms brick from the LEGO construction kit was used as the controller for the robot. The program to solve the Rubik's cube puzzle was installed in the controller (EV3). The EV3 received inputs from the infrared sensors, processed the information and sent output signals to the actuators. The actuators in the robot were built using parts in the LEGO construction kit. Two actuators were used in rotating the cube around its axis and flipping it vertically while solving the Rubik's cube. The third actuator moved the infrared sensor which scanned the faces of the cube. The movements of the actuators were programmed into the controller (EV3). The robot was successfully completed and presented to the instructor. The rubik's cube solver successfully solved the puzzle in 90 seconds faster than a regular human would take to solve the cube.

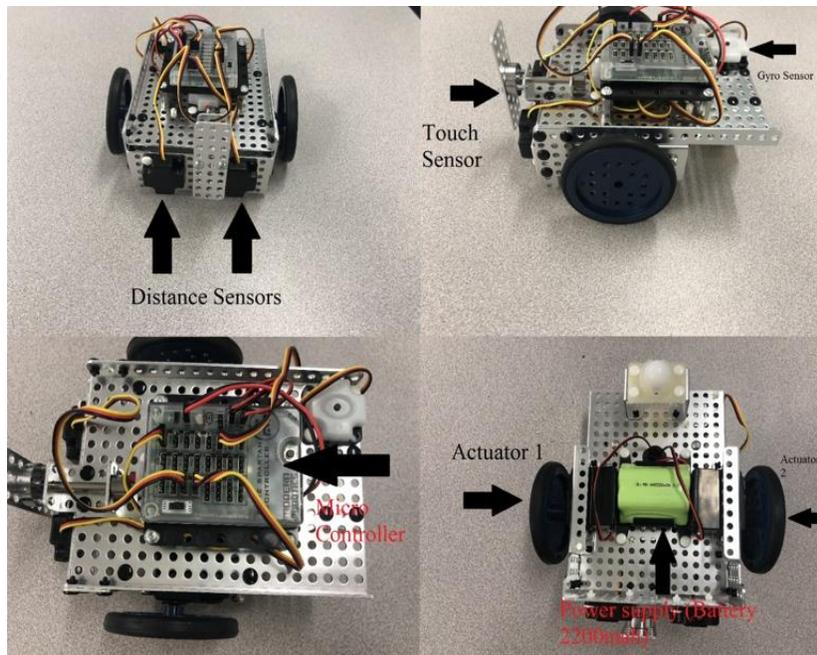
Another team including one in EE, two in ME and one majored in business but minored in ME worked on a project named as "The Subjugator Robot," which was designed with the intent to navigate through an environment while avoiding collision. The robot as shown in Figure 2 consisted of 7 parts—the frame, distance sensors, touch sensors, actuators, power supply battery,

wheels and the microcontroller. The distance sensors were able to detect an object within a close proximity, the touch sensors detected physical contact and the actuators propel the robot. The actuators were controlled by the microcontroller and were coded to move at a specific speed. The power supply was a 2200mAh battery that powered the microcontroller, actuators and the sensors. The microcontroller acted as the brain of the unit and received signals from the different components, and reacted according to how the students coded.

The success of these two projects along with other team projects emphasized the importance of the interdisciplinary knowledge being taught to freshmen engineering majors.



Figure 1 (a) Infrared sensor attached to an actuator to rotate a cube; (b) EV3 Mindstorms Brick (Controller)



**Figure 2 The Subjugator Robot**

**Exploration of outcomes**

Through the semester, we used different assessments to explore the outcomes of various activities. We conducted several anonymous surveys to explore the student outcomes of several interdisciplinary activities. The following table 2 illustrates different outcomes of various activities using assessments. We also conducted interviews of TAs to explore their feedback about the peer to peer mentoring. A Liker scale (1-10) was used to explore students’ favorite activities. A word cloud was also produced based on a question about students’ favorite keywords to describe the course.

**Table 2 A summary of assessments corresponding to activities**

Activity	Outcomes	Assessment
Course project	<ol style="list-style-type: none"> <li>1. Students will be able to understand the concepts and their operational principles of a sensor, an actuator, and a microcontroller;</li> <li>2. Students will have the hands-on experiences;</li> <li>3. Students will learn the process of a project and the project management;</li> <li>4. Students will learn how to work in a team and especially work with others cross the fields.</li> </ol>	Proposal grading; project achievements with rubrics; project journal grading; presentation grading; final report grading; peer evaluation; TA evaluation; survey about their favorite projects
Ethics debate	<ol style="list-style-type: none"> <li>1. Students will be able to understand the ethics codes defined by the NSPE;</li> <li>2. Students will be able to debate following the NSPE ethics in a professional way.</li> </ol>	Presentation grading with rubrics including peer evaluations to elect people to the semi-final and final rounds, and TAs’ evaluations
Homework	Students of both majors will understand the basics of the general engineering principles such as the Newton’s 2 <sup>nd</sup> law, and Ohm’s law.	Grading Note: students from both majors will be assigned the same homework, but the weightings of the grading corresponding to some parts of the homework will be different for students in ME and EE.
Field trip	<ol style="list-style-type: none"> <li>1. Students will learn the mission, product/service and culture of a company;</li> <li>2. Students will learn what an engineer’s typical day looks like;</li> </ol>	Survey



Course project	80% of students got 70% of scores or above.
Ethics debate	Students used the NSPE ethics codes to debate.
Homework	77% of students got 70% of scores or above.
Field trip	One question: what is the most favorite part of the field trip at Medtronic? Answer: the same number of students vote for two parts—the automatic product line and the mission of the company
Career track	Most students agreed that the Woofound survey described their personality traits correctly. They like the suggestions about their career match.
Favorite activities	Based on the Liker scale, the following three activities got the highest scores: 1. Course project 2. Field trip 3. Ethics debate

Results in Table 3 show:

1. The interdisciplinary project has been proved as an efficient way to let students cross the fields to work in the same team beyond the technology trainings [3-5]; The result show that 80% of students can achieve the outcomes.
2. including ethics debate with the real case study is an efficient way to 1) understand the ethics code, and 2) bridge the gap between the theories and the daily professional life [8-9];
3. Homework is a traditional way to assess students' outcomes in many courses. Our results show that 77% of students got 70% of the scores or above which is a common standard of the ABET accreditation;
4. The field trip is a direct way for students to interact with the real world [10-11]. We always heard the good feedback from students during the past years;
5. To our knowledge, the career track piece is unique in this introductory course. Students showed their interests in this Woofound survey and qualitatively provided positive feedback about the results of the survey.

A couple of students' comments about the teamwork they learnt from this course are cited as follows:

Student A comments: "The materials provided by the instructor was helpful. The materials provided helped me understand the nature of job I was getting into. Another aspect of my academic life that improved is my critical thinking skill."

Student B says: "Definitely, we notice that one of the main purpose for the project is to build teamwork among group members as well as the project management. During the cause of this project, we were expected to meet in class once a week to work on their project. In addition to

that, we were scheduled to meet with the instructor to discuss current situations of project. Before the project kicked off, we conduct the research about the nature and working principle. Our work was shared among each team member and each person was awarded a task. The team always sent the current status of their project every week to the instructor.”

It is our first time to include TAs in this course because of the increasing enrollment and lack of faculty in our department. So it would be interesting to learn what three TAs’ feedback in terms of the peer-to-peer mentoring and their observations. We excerpt the interviews from three TAs.

TA1 says: “Throughout the course of the semester, I observed that the business major student who excelled in communication and presentation, aided his teammates in this regard. His role as the leader became prominent to the group’s success. The two students with the Robotics and programming background contributed heavily towards the functioning of the robot. Both students took the time to make detailed changes to the initial program using Python. Although the team succeeded in the end, the road to that success was not easy. At the beginning of the semester, the team did not start the project with much interest. However, with time they came to realize that this assignment precedes future projects they will work on in courses much tasking that ME/EE100.”

TA2 says: “The orientation class proved to be the most effective way to introduce freshmen engineering majors into various fields of engineering more specifically the fields of mechanical, electrical and computer engineering. However, throughout the course of the semester, I observed that students were more interested in project related activities and less interested in homework assignments and in class exercises. In my opinion, more project related activities in the class would help improve student’s participation and feedback.”

TA3 says: “As a TA, it was rewarding to see both myself and the students grow. I had the pleasure of observing how students interacted with each other on projects and also how they reacted to assignments given. Through this observation, I came to realize the areas I am strongest and weakest in a group. Therefore, in future group projects I work on I know which areas I need to work harder on. The students tend to ask question pertaining to the courses I am taking now, how well I manage my time and so forth. I found that they were more comfortable getting feedback from a fellow student and sought room for improvement. As a result, this position served as a learning course for myself which I am very fortunate to have experienced.”

## **Summary**

This paper introduces an exploratory study of outcomes of interdisciplinary and various activities in one introductory engineering course. We introduce several assessments of outcomes corresponding to various interdisciplinary activities through the semester. Results show that students prefer the robotic projects. They do not only learn the basics of ME and EE but also gain a lot of soft skills from different activities such as communication skills and teamwork skills especially when working with people cross the fields. Our TAs’ positive feedback proves the peer-to-peer monitoring is an efficient method for both students and instructors. We find such a course gives those who do not know so much about EE a better idea about this field. A couple of students decided to transfer to the EE major or be double majored in both ME and EE after they started working on the course project. We believe the assessments vs interdisciplinary activities

in this engineering orientation course offered to students from ME, EE and non-engineering major but minored in ME or EE will provide an insight for other similar small engineering programs at other small universities.

In the future, we will keep these various activities in this course. But we will a couple of changes: 1) we will give one more week to this robotic project so that some students will have enough time to finish it; 2) besides Woofound, we in collaboration with our staff at CRC, will design surveys of their career interests and matching careers.

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