

Work-in-Progress: Polytechnic Perceptions of the Engineering Classroom Experience

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Abstract

In this paper, we examine student perceptions of different delivery modalities used in two sections of a course in machine component design. This is an undergraduate course required for mechanical engineering and engineering technology students. The goal of this study is to investigate how an instructor's chosen pedagogy relates to a student's perception of a course, within the context of a polytechnic institution. Students in two sections of the course, taught by two different instructors, were surveyed using both qualitative and quantitative questions to compare between two pedagogical approaches. One approach utilized open-ended problem solving and another focused more on structured lecture and laboratory activities. The results suggest that student perceptions of the polytechnic nature of a class did not significantly differ between the two pedagogical approaches. Students found each class to be representative of a polytechnic nature because hands-on, physical labs were utilized. It did not matter if the lab activities were open-ended or structured. This aligned with the students' definition of what polytechnic education means: "hands-on".

Introduction

Classroom delivery modality has received much attention in recent years as institutions navigate changes in higher education funding and student preparation for learning [1]. One approach that has been employed in the engineering classroom is to flip the class, by which traditional lecture content is delivered online and homework or other forms of problem solving are completed during scheduled class time [2]. The flipped classroom approach has received much attention specifically in the mechanics classroom, with many researchers describing their experiences using a variety of pedagogical approaches [3]–[9]. Similarly, many faculty have explored portions of the flipped classroom approach in which aspects of the traditional classroom experience are blended with those of the flipped classroom in a variety of ways [10]–[14]. Regardless of the particular pedagogical choices made by any individual instructor, the flipped classroom approach is ill-defined. Therefore, all of these flipped classroom variations taken together cannot be considered as complete alternatives to the traditional classroom approach [15].

Student perceptions of the flipped approach are generally positive [16] with students reporting that the in-class time provided more opportunities for asking questions [17] and having more positive, meaningful interactions with the instructor and with their peers [18]. However, it is not particularly clear if the positive student perceptions can be attributed specifically to the flipped approach or more generally to the likely increase in hands-on activities that often accompanies the flipped approach [19]. When attempting to relate these results published in the literature to the context of the authors, we found limited discussion of how these results might apply or relate to the experiences of students at polytechnic institutions, where a hands-on approach is often

specifically prescribed as part of the institutional culture. However, we did find one study which addressed the use of a flipped classroom from a polytechnic perspective and reported that the flipped classroom provided more time for hands-on experiences, but that this increased time did not lead to a more positive student experience or significantly improved performance [20].

Our institution carries a “polytechnic” designation. The institution’s interpretation of that designation has been to promote a “hands-on, minds-on” style of pedagogy. Specifically, this style emphasizes career-focused or hands-on experiential learning and a laboratory-rich educational experience. Students who are recruited to and ultimately attend our polytechnic institution have often been the recipients of years of targeted, local marketing and campus tours of the laboratory spaces. This marketing shapes their view of what the higher-education classroom experience should look like at our institution. However, the actual experiences they encounter in the polytechnic classroom may vary widely from the vision that has been put before them because instructors employ their unique pedagogy as time and resources allow. The goal of this study is to investigate how an instructor’s chosen pedagogy relates to a student’s perception of a course, within the context of a “hands-on, minds-on” driven polytechnic institution.

Methods

We examined student perceptions of different delivery modalities used in two sections of a course in machine component design. This undergraduate course is required for mechanical engineering and engineering technology students. Anecdotally, these two populations do not differ meaningfully in preparation, i.e. prerequisite knowledge. The course curriculum covers stress analysis of various machine components along with multiple failure models: gears, pulleys, chains, bearings, clutches, impact loading, fatigue, etc. This course is taken during a student’s junior or senior year. Therefore, a mechanics of materials course is a prerequisite. These machine component design sections have been taught by the same instructors over the last three years and both sections also use the same textbook [21] so there is no difference in technical content covered.

In the one section of 27 mechanical engineering students (ME 342), course content delivery relied on in-person class time spent almost entirely on group completion of homework-style problems (approximately 55% of the weekly 6 hours of in-person class time), which were neither collected nor assessed. Outside of class, students were expected to review the course curriculum using materials collected online through the course’s learning management system. An additional 2 hours of laboratory time was provided with little structure and instead provided opportunity for students to work in groups on an open-ended, semester-long project. A breakdown of the use of in-person class time is shown in Figure 1.

In the second section of 25 engineering technology mechanical design students (ET 332), more structured class time was spent on lecture of theory [22]. The course also met 6 hours a week. Half of this time, 3 hours of class time, was structured lecture discussing theory and example problems. One third of this time, 2 hours of class time, was devoted to lab activities (e.g. engine dissection, valve spring testing, benchmarking experiments with simulations, etc.) using a structured laboratory procedure and reporting process. Finally, the last hour of class time was devoted to the completion of an open-ended project that lasted throughout the semester. Students

were not expected to review curriculum outside of the class time, i.e. no flipped content. Rather outside of class time was devoted to homework problems and completing lab reports.

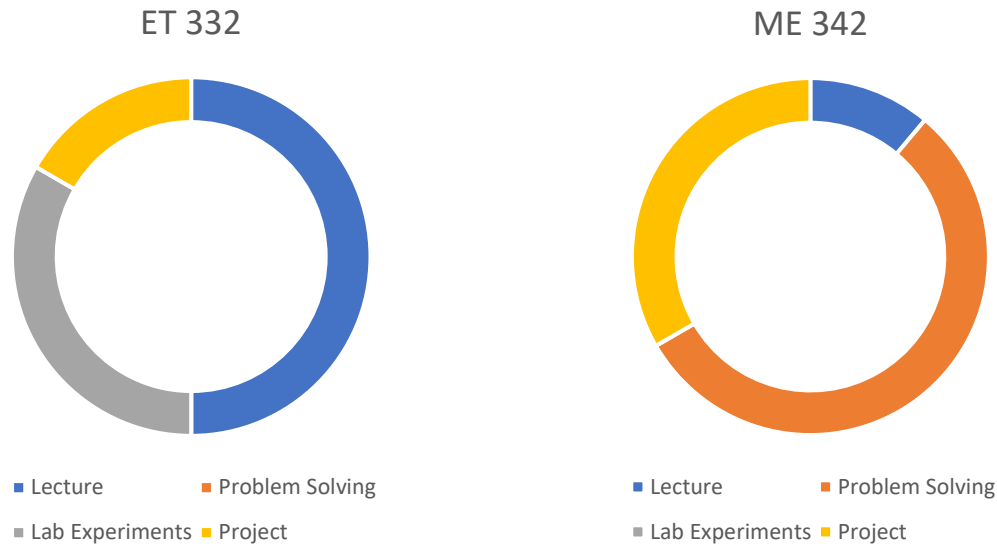


Figure 1: Chart showing the distribution of in-person class time across different course activities.

At the end of the course, the study hypothesis was tested by surveying students from both sections with the following questions that focused on the day-to-day operations of the courses. The questions with yes/no or quantitative answers were directly compared plotting the percentage of responses for each answer (e.g. percentage of responses that were “no”). The more open-ended questions with text were analyzed by creating word clouds of the responses. This creates a visual histogram of the text with words that occur more often presented in larger font (e.g. [23]).

- Do you feel that the format used in this course worked for you this semester? Specifically, the way that class time was structure and the types of instruction used.
- Would you have preferred a different format for the course? If yes, please explain your reasoning in the next question. If no, answer NA in the next question.
- If you answered “yes” in the previous question, please explain here. If you answered “no” in the previous question, please type NA.
- What one thing that we did this semester do you feel most helped you to be successful in this course?
- What one thing that we did this semester do you feel most hindered your ability to be successful in this course?
- In your own words, what does “polytechnic education” mean to you?
- Do you feel that this course was a good example of what you would expect from a polytechnic education?
- Using the scale below, please compare this course with other courses that you have completed at this university in terms of how hands-on the course was. (5-more hands on than other courses, 4, 3-about the same as other courses, 2, 1-less hands-on than other courses).

Results

Of the 27 students enrolled in ME 342, 26 completed the survey. All respondents reported that the course format worked well for them, and two respondents (~8%) reported that they would have preferred a different format, with one noting that they would have preferred more structure to the lab time and the other that they felt like they would have preferred the style of the other instructor. The respondents seemed to find the general structure of the course helpful and particularly noted the group practice problems as supportive (Table 1, Figure 4). On the other hand, responding to the question about something that hindered their success, student most frequently commented on the open-ended project completed during lab time (Figure 5). A few students also mentioned the use of a flipped format for the delivery of course theory as creating difficulties due to lacking motivation or time to review the content prior to class. Only one respondent (4%) stated that they didn't feel that the course was a good example of the polytechnic experience and most students (77%) responded that the course was about the same (3 out of 5) or slightly more (4 out of 5) hands-on than other courses that they have taken (Figure 2).

In ET 332, 17 of the 25 students responded to the survey. Most students found the structured class format worked for them (76%) and would not have preferred a different format for the class (65%) (Figure 2). Those that did prefer a change to the format recommended removing the open-ended course project (Table 1, Figure 3). Students found structured example problems to be most helpful (Figure 4) and the project to be a hindrance to their success (Figure 5). The students perceived this course as a good example of a polytechnic course (94%) that was a little more hands-on than other courses they had taken (41% scored the course a 4 out of 5). The students from both sections defined a polytechnic education as having those physical, hands-on lab experiences with real-world applications (Figure 6).

Table 1: Representative Responses from the Open-Ended Questions

Question	ME 342 Representative Response	ET 332 Representative Response
Would you have preferred a different format for the course? If yes, please explain your reasoning in the next question. If no, answer NA in the next question.	“I would have liked to have more hand-on problems we could work on in the lab time provided.”	“I don't necessarily believe that the course project adds any value overall. I think the time and effort could be put more towards labs and examples that push students to ask questions and work together as a class.”

What one thing that we did this semester do you feel most helped you to be successful in this course?	“Working on engines in the lab. Going through the example problems in the modules.”	“Examples and past exam study guides that are worked through, whether it be in class, or posted solutions.”
What one thing that we did this semester do you feel most hindered your ability to be successful in this course?	“The only thing that hindered my ability to be successful was myself if I didn't watch the videos before class.”	“The semester project did not necessarily hinder my ability however, not much was gained from the semester project...”
In your own words, what does “polytechnic education” mean to you?	“It means to work with your hands/ learning something by doing it. Not only studying theories and actually putting them into practice.”	“It means to be able to learn with my hands rather than a book. It means going out and trying something to see if it will work rather than sitting behind a desk saying it will work.”

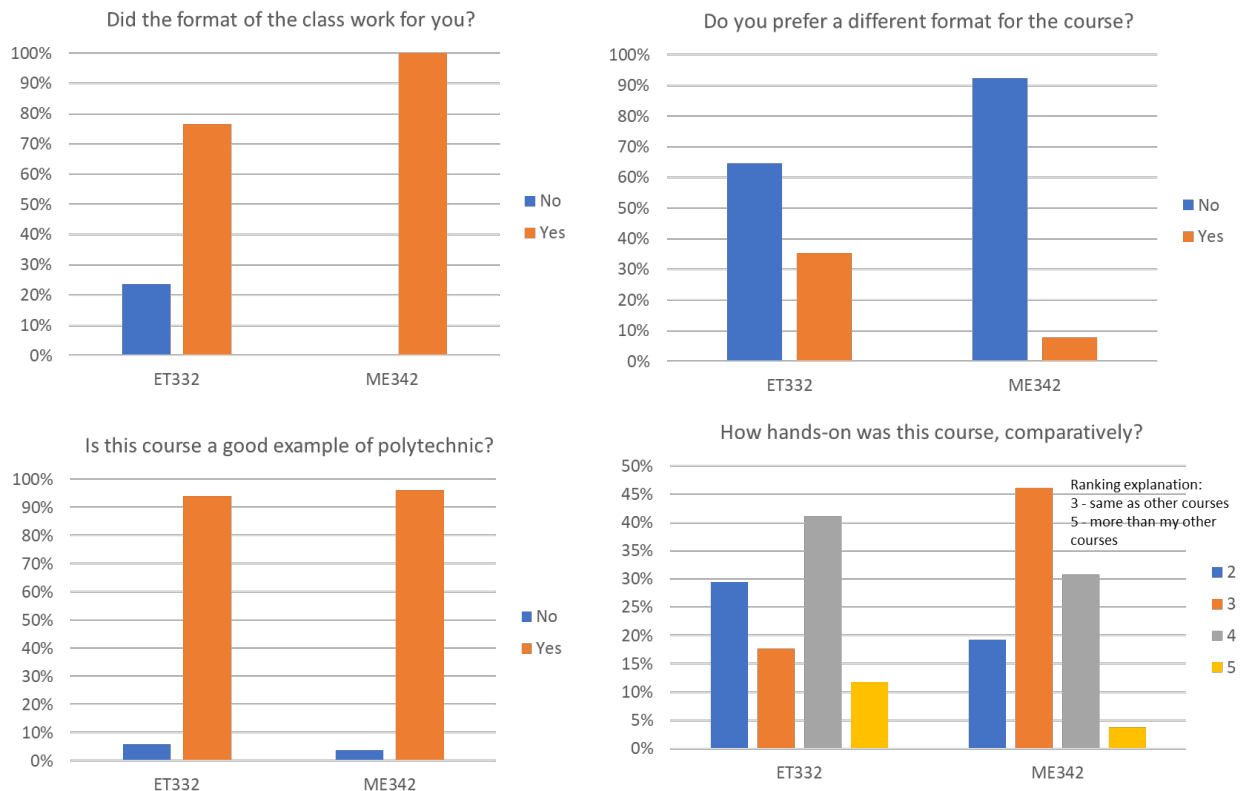


Figure 2: Results of the “yes/no” and quantitative questions of the student survey.

Discussion

The objective of this work was to investigate how course pedagogy relates to a student's perception of the polytechnic nature of a course. The main difference between the two course sections of this study was the structure of the class time. The mechanical engineering section utilized the class time for open-ended problem solving in a flipped classroom format while the engineering technology section utilized a structured lecture and lab time (Figure 1). Regardless of the pedagogy, a majority of the students in both sections found the format appropriate and a good example of a polytechnic course (Figure 2).

The student respondents to our survey were fairly uniform in their definitions of a polytechnic education, focusing on hands-on classroom experiences. Our results indicate that students found that working problems, either as example problems presented by the instructor or worked in groups, to be helpful for their learning. Additionally, students from both sections reported that the course project challenged their ability to be successful, which we conjecture either because it lacked sufficient structure or because there were difficulties working on an open-ended project in a group setting. The exact reasoning is not known for this cohort as students did not provide that level of detail in their survey responses. Common group project issues and possible solutions have been previously addressed in the literature [24] and implementing some of these interventions may improve the project experience in core engineering courses such as these. Specifically, groups who develop team contracts agreeing on responsibilities and expectations of team members, independent of the project's technical content, tend to work more efficiently as a team and have a better experience (i.e. satisfaction).

These comments about the course project can also be viewed within the context of Perry's theory of intellectual and ethical development [25]. Perry purports that intellectual development starts at dualism, where problems are clearly defined with right and wrong answers. These types of problems can typically be found in freshmen and sophomore level courses, e.g. math courses, statics, dynamics, etc. Intellectual growth then progresses towards problems rooted in relativism and commitment. At these stages, students take a more open-ended problem and work to further define the problem using justified assumptions and provide evidence-based answers.

Transitioning to these higher levels of cognition is challenging for students [26]. Therefore, as students transition from dualism to relativism in our junior/senior level courses, the comments against the open-ended course project could further reflect this cognitive transition as opposed to the actual content of the project.

In conclusion, we found that student perceptions of the polytechnic nature of a class did not differ as pedagogy was differed, i.e. flipped versus structured in-class lecture. Students found the class representative of a polytechnic nature because hands-on, physical labs were utilized. It did not matter if labs were open-ended or structured. This aligned with the students' definition of what polytechnic education means: "hands-on".

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