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

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I received my Mechanical Engineering undergraduate degree from the University of Wisconsin-Madison. During my schooling, I explored many opportunities to apply my engineering degree. I was involved with the Formula One Racecar Team, did a semester long co-op working on fume hoods, did a summer internship at Kimberly Clark designing a HVAC system, and did another summer internship at General Electric designing anesthesia equipment. As a senior, I got involved in research doing finite element analyses of a prosthetic foot. This immediately got me hooked on applying engineering to medical applications. I obtained my Biomedical Engineering PhD at the University of Wisconsin-Madison. My work focused on computational biomechanics. More specifically, developing musculoskeletal models of the body to simulate movement and see how surgery and soft tissue injury affects movement. During my graduate work, I was also a teaching assistant for Introduction to Biomechanics where I developed a love for teaching. I then did postdoctoral research at the University of Kentucky where I experimentally measured movements (e.g running form), which provides data that can be used to validate the models I build. At Gannon University, I built computational models with a focus on the knee to optimize surgical techniques (e.g. ACL reconstruction) to restore normal function after injury. At UW-Stout, my research area is on 3D printing techniques. Specifically I am working on the reliability of the 3D printing process to create functional parts. When I'm not doing research, I enjoy going swimming, camping with my kids in Scouts, and playing my violin.

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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.

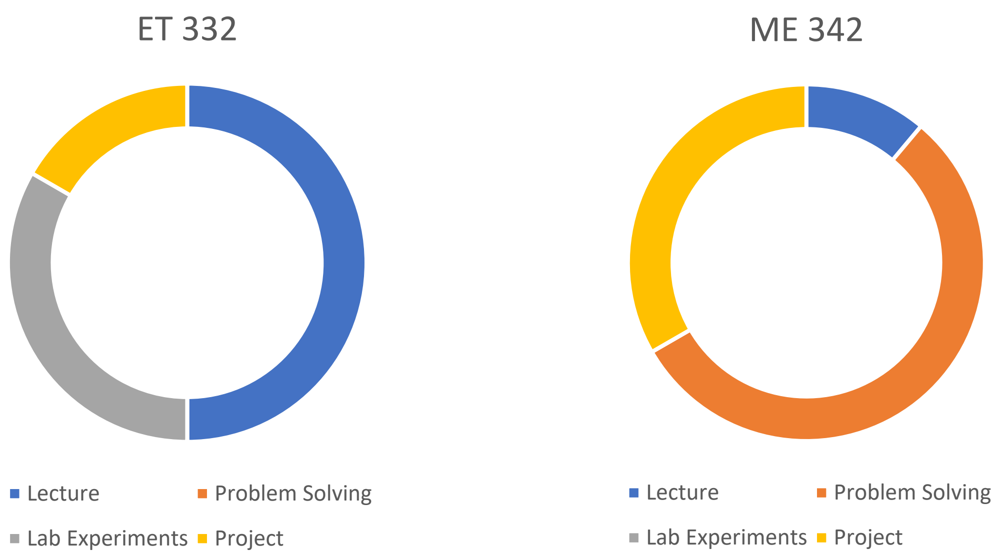

Figure 1: Chart showing the distribution of in-person class time across different course activities.

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 Reponses 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."

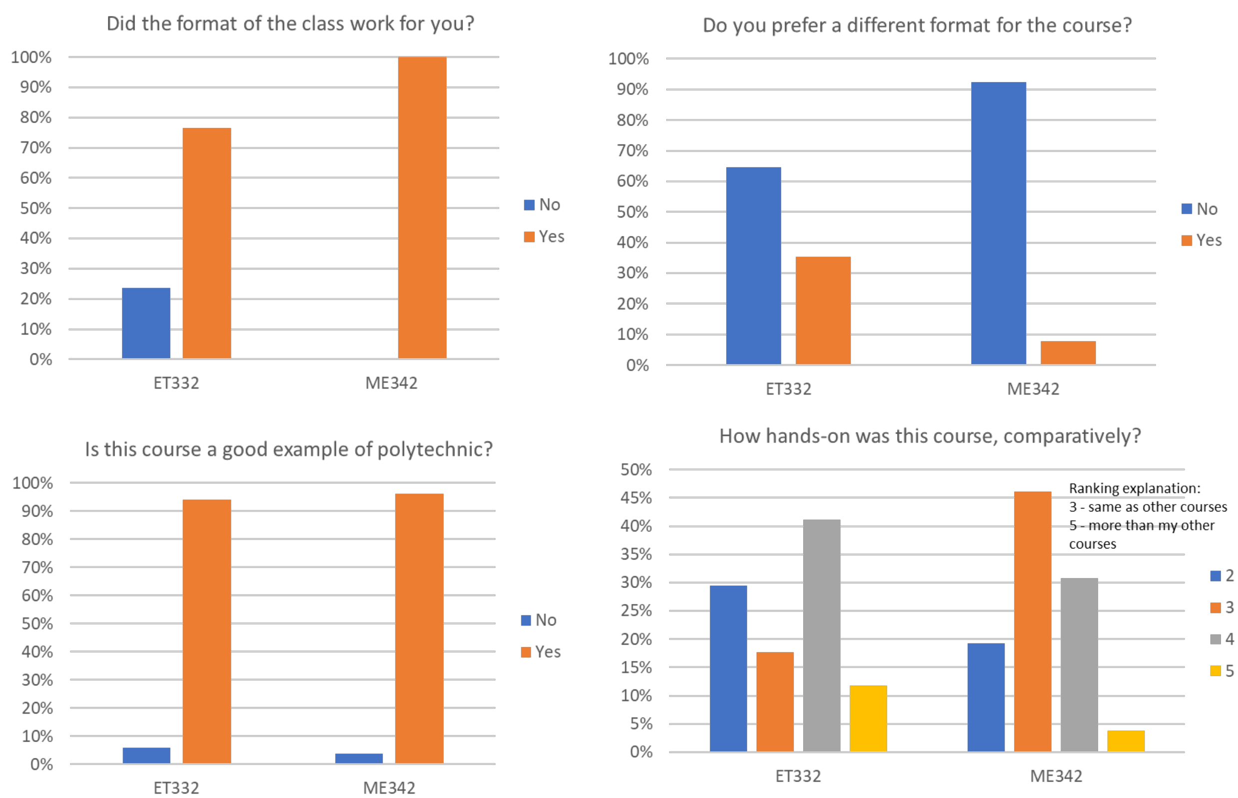

Figure 2: Results of the "yes/no" and quantitative questions of the student survey.

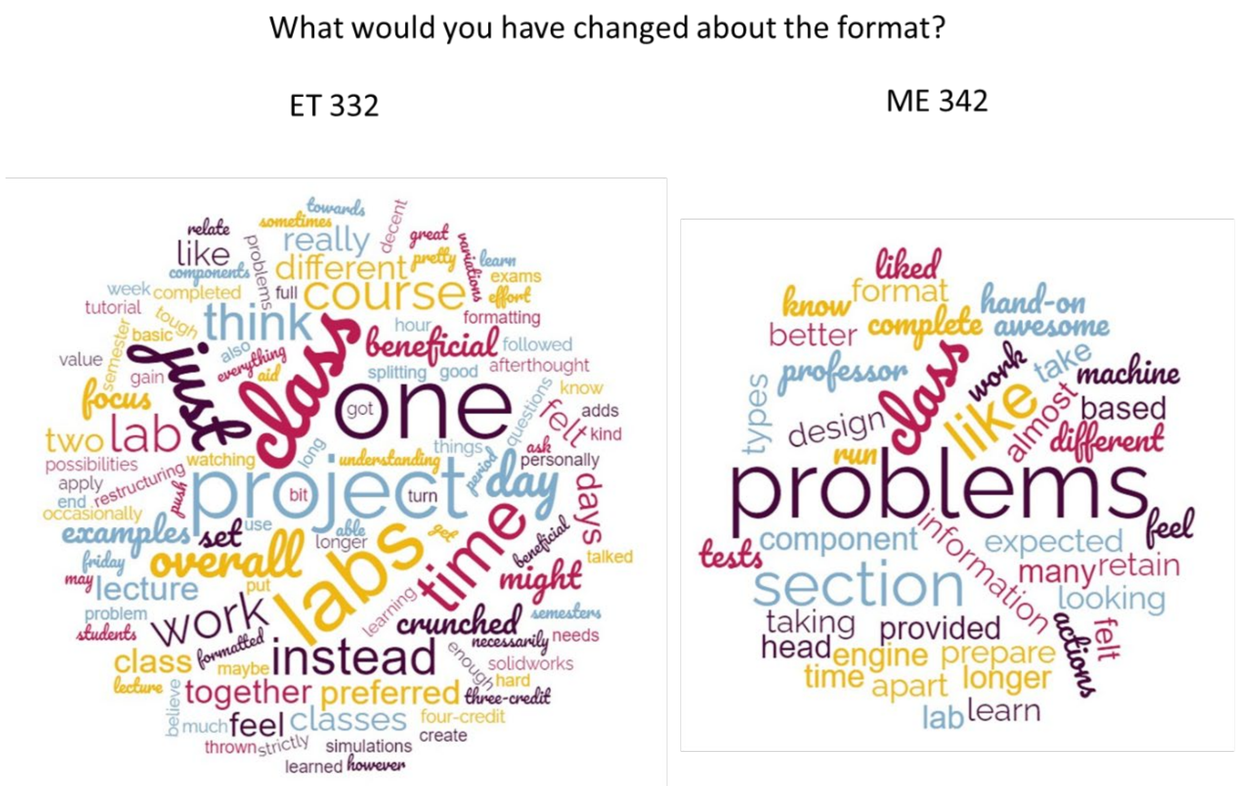

Figure 3: Word cloud of text responses to the open-ended question about how students would change the format of the course.

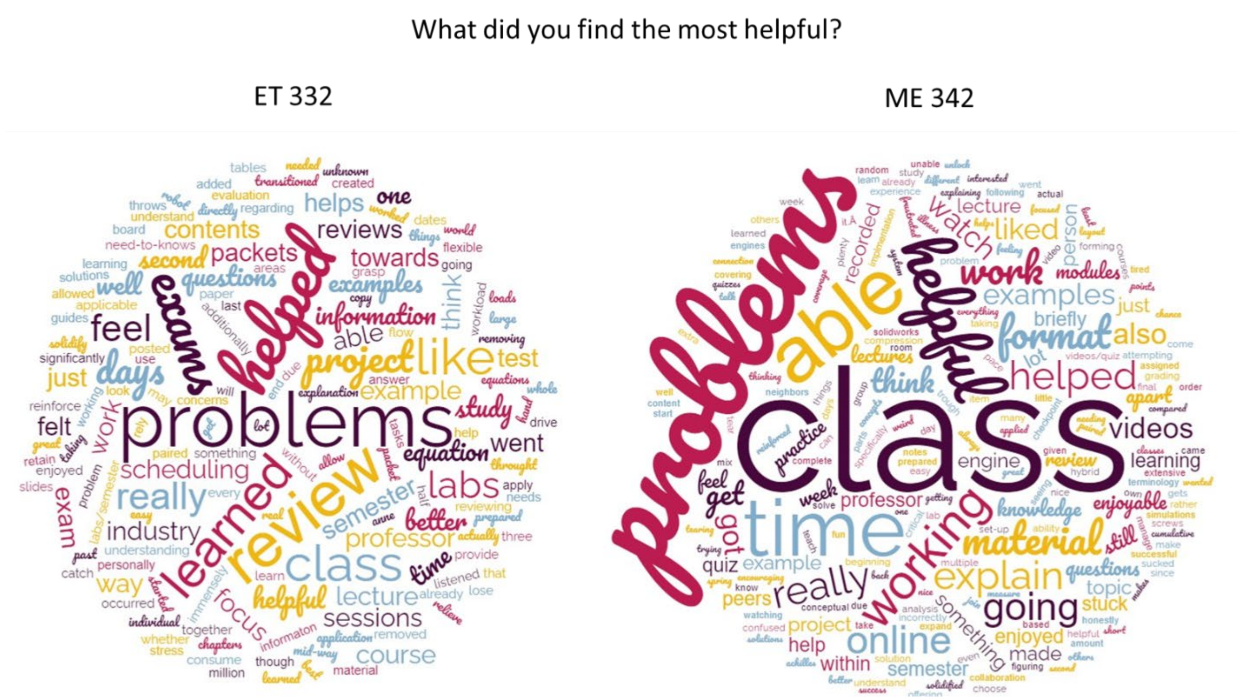

Figure 4: Word cloud of text responses to the open-ended question about what students found the most helpful.

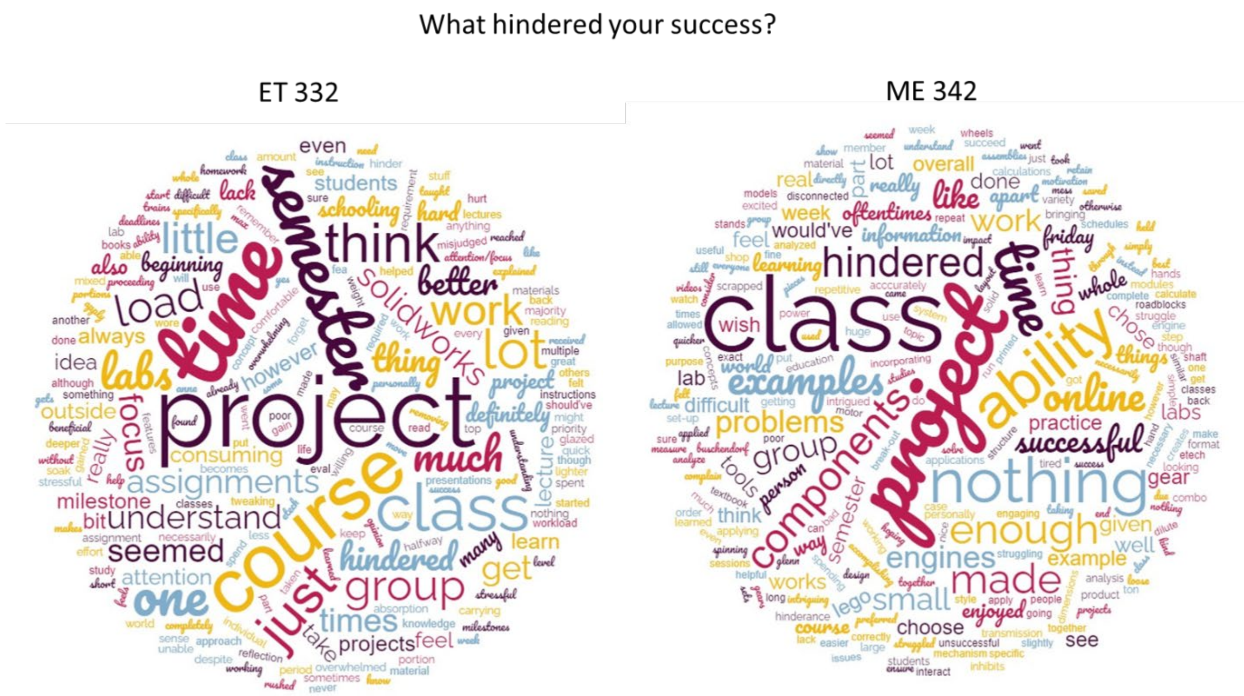

Figure 5: Word cloud of text responses to the open-ended question about what most hindered student success.

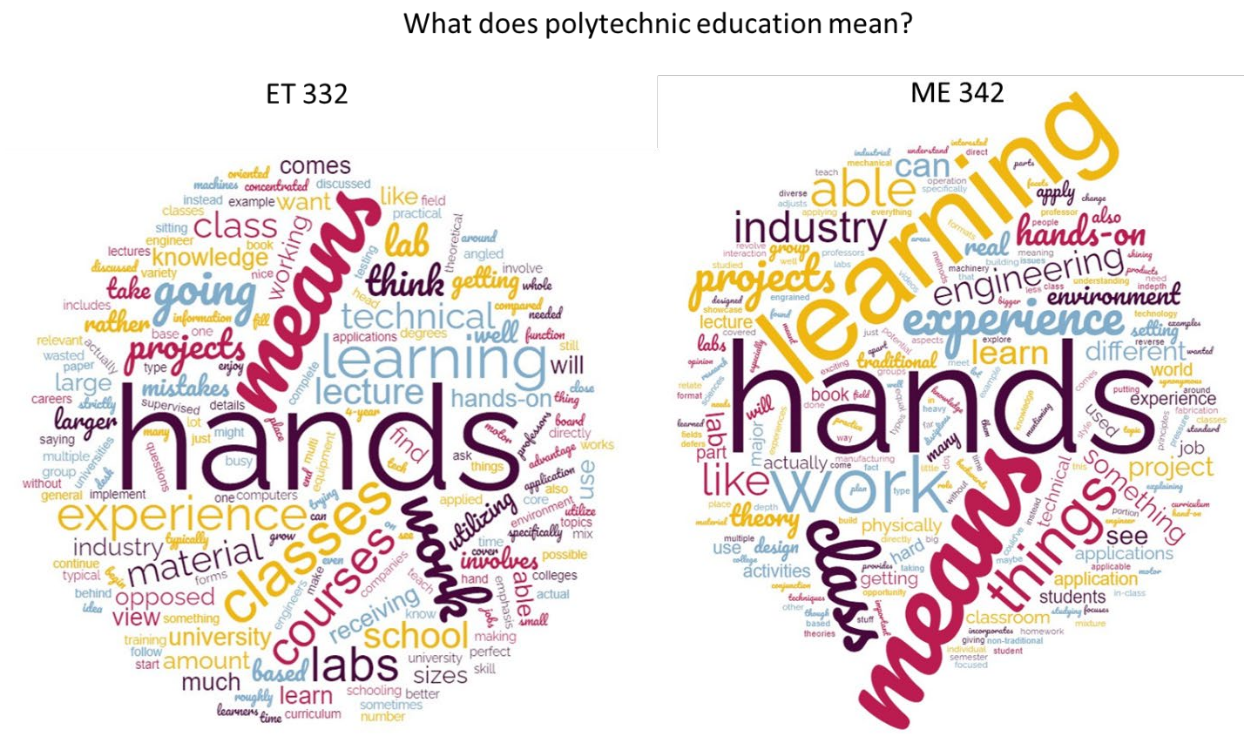

Figure 6: Word cloud of text responses to the open-ended question about how students define polytechnic education.

Discussion

The objective is 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".

References

[1] J. Bishop and M. A. Verleger, "The Flipped Classroom: A Survey of the Research," Jun. 2013, p. 23.1200.1-23.1200.18. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/the-flipped-classroom-a-survey-of-the-research

[2] B. Kerr, "The flipped classroom in engineering education: A survey of the research," in *2015 International Conference on Interactive Collaborative Learning (ICL)*, Sep. 2015, pp. 815–818. doi: 10.1109/ICL.2015.7318133.

[3] J. S. Thomas and T. A. Philpot, "An Inverted Teaching Model for a Mechanics of Materials Course," Jun. 2012, p. 25.176.1-25.176.26. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/an-inverted-teaching-model-for-a-mechanics-of-materials-course

[4] A. K. T. Howard, "Flipped Classroom – Ten Years Later," presented at the 2019 ASEE Annual Conference & Exposition, Jun. 2019. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/flipped-classroom-ten-years-later

[5] A. K. T. Howard and M. T. Stimpson, "Online-Only Statics Compared to a Flipped Classroom," presented at the 2017 ASEE Annual Conference & Exposition, Jun. 2017. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/online-only-statics-compared-to-a-flipped-classroom

[6] G. Rideout, "Challenges and Logistics in Flipping a Large Classroom for Junior-year Mechanical Vibrations," presented at the 2016 ASEE Annual Conference & Exposition, Jun. 2016. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/challenges-and-logistics-in-flipping-a-large-classroom-for-junior-year-mechanical-vibrations

[7] S. R. Maalouf and O. Putzeys, "Blended Statics: Finding an Effective Mix of Traditional and Flipped Classrooms in an Engineering Mechanics Course," presented at the 2020 ASEE Virtual Annual Conference Content Access, Jun. 2020. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/blended-statics-finding-an-effective-mix-of-traditional-and-flipped-classrooms-in-an-engineering-mechanics-course

[8] L. S. Lee, R. K. Hackett, and H. Estrada, "Evaluation of a Flipped Classroom in Mechanics of Materials," Jun. 2015, p. 26.694.1-26.694.12. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/evaluation-of-a-flipped-classroom-in-mechanics-of-materials

[9] M. H. Holdhusen, "A 'Flipped' Statics Classroom," Jun. 2015, p. 26.135.1-26.135.8. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/a-flipped-statics-classroom

[10] C. S. White, "Replacing Graded Homework Assignments in Statics," presented at the 2020 ASEE Virtual Annual Conference Content Access, Jun. 2020. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/replacing-graded-homework-assignments-in-statics

[11] A. Badir, R. O'Neill, J. Liao, and G. I. Papkov, "A Blend Flex Engineering Mechanics Course," presented at the 2021 ASEE Virtual Annual Conference Content Access, Jul. 2021. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/a-blend-flex-engineering-mechanics-course

[12] Y. Hu, J. M. Montefort, and M. Cavalli, "Comparing Blended and Traditional Instruction for a Statics Course," presented at the 2019 ASEE Annual Conference & Exposition, Jun. 2019. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/comparing-blended-and-traditional-instruction-for-a-statics-course

[13] M. Cavalli, J. J. Neubert, D. McNally, and D. Jacklitch-Kuiken, “Comparison of Student Performance and Perceptions Across Multiple Course Delivery Modes,” Jun. 2014, p. 24.300.1-24.300.10. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/comparison-of-student-performance-and-perceptions-across-multiple-course-delivery-modes
[14] E. Davishahl, R. Pearce, T. R. Haskell, and K. J. Clarks, “Statics Modeling Kit: Hands-On Learning in the Flipped Classroom,” presented at the 2018 ASEE Annual Conference & Exposition, Jun. 2018. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/statics-modeling-kit-hands-on-learning-in-the-flipped-classroom
[15] P. Cornwell, “Interactive Videos and ‘In-Class’ Activities in a Flipped Remote Dynamics Class,” presented at the 2021 ASEE Virtual Annual Conference Content Access, Jul. 2021. Accessed: Nov. 11, 2021. [Online]. Available: https://peer.asee.org/interactive-videos-and-in-class-activities-in-a-flipped-remote-dynamics-class
[16] G. B. Johnson, “Student perceptions of the Flipped Classroom,” University of British Columbia, 2013. doi: 10.14288/1.0073641.
[17] L. Ogden, “Student Perceptions of the Flipped Classroom in College Algebra,” *PRIMUS*, vol. 25, no. 9–10, pp. 782–791, Nov. 2015, doi: 10.1080/10511970.2015.1054011.
[18] S. McLean and S. M. Attardi, “Sage or guide? Student perceptions of the role of the instructor in a flipped classroom,” *Active Learning in Higher Education*, p. 1469787418793725, Aug. 2018, doi: 10.1177/1469787418793725.
[19] J. L. Jensen, T. A. Kummer, and P. D. d. M. Godoy, “Improvements from a Flipped Classroom May Simply Be the Fruits of Active Learning,” *LSE*, vol. 14, no. 1, p. ar5, Mar. 2015, doi: 10.1187/cbe.14-08-0129.
[20] S. Koska and L. Condra, “More Time for Hands-On Learning: Flipping the Engineering Classroom in a Polytechnic,” *Proceedings of the Canadian Engineering Education Association (CEEA)*, Dec. 2018, doi: 10.24908/pceea.v0i0.12973.
[21] R. C. Juvinall and K. M. Marshek, *Fundamentals of Machine Component Design*, 7th ed. John Wiley & Sons, Inc., 2019.
[22] A. Schmitz, “Do More Labs Lead to Increased Student Learning?,” *Transformative Dialogues: Teaching and Learning Journal*, vol. 14, no. 2, Art. no. 2, Sep. 2021, Accessed: Jan. 29, 2022. [Online]. Available: https://journals.kpu.ca/index.php/td/article/view/1455
[23] B. Tessem, S. Bjørnestad, W. Chen, and L. Nyre, “Word cloud visualisation of locative information,” *Journal of Location Based Services*, vol. 9, no. 4, pp. 254–272, Oct. 2015, doi: 10.1080/17489725.2015.1118566.
[24] J. Bringardner, C. Leslie, G. W. Georgi, and A. M. D’Apice, “Improving Efficacy in Group Projects with Teamwork Agreements,” presented at the 2016 ASEE Annual Conference & Exposition, Jun. 2016. Accessed: Feb. 01, 2022. [Online]. Available: https://peer.asee.org/improving-efficacy-in-group-projects-with-teamwork-agreements
[25] P. M. King, “William Perry’s theory of intellectual and ethical development,” *New Directions for Student Services*, vol. 1978, no. 4, pp. 35–51, 1978, doi: 10.1002/ss.37119780405.
[26] M. J. Pavelich and W. Moore, “Measuring maturing rates of engineering students using the Perry model,” in *Proceedings of IEEE Frontiers in Education Conference - FIE ’93*, Nov. 1993, pp. 451–455. doi: 10.1109/FIE.1993.405483.