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Preliminary Analysis of Implementation of the ”Design Your Process of Becoming a World-Class Engineering Student” Project in Introduction to Engineering Course

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WIP: Preliminary Analysis of Implementation of the "Design Your Process of Becoming a World-Class Engineering Student" Project in Introduction to Engineering Course

Introduction

The "Design your Process for Becoming a World-class Engineering Student" (DYP) approach, first introduced by Landis in 2013, was developed to enhance the quality of the first-year engineering student experience [1]. The goal of the DYP approach is to train and empower students to take ownership of their learning process and to make the most out of their engineering education. The DYP approach provides students with skills needed to become effective and successful World Class Engineering Students (WCES).

Original Course Curriculum

The Introduction to Engineering course at Wentworth Institute of Technology has been offered each fall semester to around 400 first-year students. The course is delivered in sections of around 65 students each, representing all engineering majors. This one-credit lecture module met once per week, for fifty-minute lectures, twelve times during the semester. The original sequence of topics covered is shown in Appendix A. The course taught skills related to engineering practice, such as unit systems, dimensional analysis, and technical communications. While these skills are important for engineering students to master, learning them outside of any specific application was not as engaging or as applicable for students. Furthermore, the content and delivery format of the course did not allow for much "face-time" to cover the topics in enough detail or with opportunities for exploration or application in context. In addition, students conducted assignments individually, with minimal collaboration. Assessments were memorization based using multiple choice questions and with not much opportunity for reflection. The final paper that students had to submit, based on their choice of one National Academy of Engineering Grand Challenge, was burdensome for students to write and for the instructors to grade [2]. Overall, instructors and students felt that the course did not provide enough opportunities for application, reflection, or meaningful contextualized learning.

Motivation for Course Redesign

Several factors motivated the redesign of the introduction to engineering course. The main ones include the following:

- To address attrition of first year engineering students, the university embarked on an "engineering reimagined" strategy to bolster student success and improve retention.
- One of this paper's authors, and an instructor in the course for three years prior to the redesign, noticed early on that it was difficult to provide enough depth for the concepts presented within the course delivery format.
- Delivering the course online at the height of the COVID-19 pandemic during the fall of 2020, made it even more apparent that new and meaningful ways to engage students were needed.

To address these factors, the course was refocused into "helping students build skills to become an effective and successful engineering student" by implementing the Landis approach. The DYP approach has been shown by Peuker to be effective at supporting goals such as ours: engaging students and improving retention [3]. The course had been using the Landis textbook

since 2016 and the instructors were familiar with the content but had not adopted the DYP approach in full. This seemed like the right opportunity to do so.

Course Redesign Process

Per the DYP approach, the focus of the course shifted from delivery of hard skills to preparing students to become effective and successful engineering students. In the spring of 2021, one of the authors was selected to redesign the course. This was an ambitious but achievable goal – to develop a redesigned course in four months for delivery in the fall of 2021. In collaboration with an instructional designer, a reimagined course was developed. This instructor delivered the course as twelve weekly lectures to 319 students, broken up into five sections of around 60 students each. The course was implemented on the D2L-Brightspace learning management system (LMS), utilizing its engagement, collaboration, attendance tools, and its rich-media features. The LMS made the course manageable in delivering the course content, communications, assignments, reflections, peer reviews, attendance, and grading for the large number of students enrolled in the course.

Implementation Highlights

Course Content

The reimagined course focuses on development of *soft skills* including collaboration, reflection, peer review, and time management; skills which are increasingly recognized as an important part of student development and success in engineering education [4].

Learning Objectives of Redesigned Course

- *Develop a working knowledge of various engineering disciplines.*
- *Increase awareness of what successful completion of an engineering degree requires.*
- *Create a plan for success as an engineering student.*
- *Articulate interests and challenges you may encounter as a first-year student. Identify the appropriate resources and opportunities to contribute to your educational experience, goals, and campus engagement.*
- *Demonstrate strategies to explore real world problems, questions, and challenges inside and outside the classroom from an engineering perspective.*
- *Explain processes, methods, and evidence that engineers use to explore and address real-world, contemporary problem or answer a compelling question.*

Course lectures and activities covered the following topics: (new are in bold)

Week 1: What is engineering? Famous engineers
Week 2: Course Description, Mechanics, and Goals. Major engineering failures
Week 3: The Engineering Profession: Education, Benefits, Disciplines
Week 4: Engineering Research and Library Resources
Week 5: Engineering Design Process, Map your Visual Journey
Week 6: An EDP Approach to becoming a World Class Engineering Student
Week 7: Grand Challenges in Engineering
Week 8: Mastering the Learning Process

Week 9: Making the Most Out of How You Are Taught
Week 10: Informational Interviewing and the WCES Journey
Week 11: Academic Honesty
Week 12: Engineering Ethics
Week 13: WCES ePortfolio assembly and review
Week 14: Course Wrap-up, Project, Evaluations

Course delivery innovations

(1) ***In-class activities:*** To increase collaboration and engagement, each lecture now contains at least two active learning interventions. These are typically performed in small local groups using collaboration tools including shared google docs, accessed via links on LMS and QR codes. In this way, students could join in and participate from any device.

Example: Create a Google Jamboard to Describe one Engineering Discipline: Students explore various engineering disciplines in groups of 5 students, typically from different engineering majors. Through this activity, students learn about each other's engineering disciplines, while researching important aspects of engineering projects and careers. On the jamboards, students can use text boxes, pictures, or any other visual elements they choose to define and reflect upon. At the end of the activity, each group presents their jamboard to the rest of the class so that everyone can benefit from their findings.

(2) ***Discussion posts on LMS with peer review:*** Every week, students reflect on a given topic and share with others. To encourage collaboration and mutual learning, the policy for discussion posts was set up so that after students post their own entry, they then are required to post a comment/response to at least two other students' postings. Examples of discussion topics include the following:

- *Introduce yourself, name, hometown, why you are interested in engineering.*
- *Visual journey: students document their interest in engineering with an annotated collage. Address what motivates you to become an engineer.*
- *Engineering Design Process (EDP): Students reflect on how they can apply the EDP to their own journey to become a WCES.*
- *Prepare for informational interview: students formulate questions to ask during an informational interview. They also identify at least one practicing engineering professional to interview, to be conducted no later than the Thanksgiving holiday.*
- *Students post their findings and what they learned from the informational interview they conducted.*

(3) ***ePortfolios:*** At the start of the semester, each student creates an individualized ePortfolio from a Google site template, which they share with the rest of the class through the LMS. The portfolios become one of the primary ways students document their work. The ePortfolios and discussion posts are linked together via the LMS. As the semester progresses, students document their activities and build up their ePortfolio. Topics and content on ePortfolio includes the following:

- *Introduce yourself, name, hometown, why you are interested in engineering.* (Week 1)
- *Visual journey: students document their interest in engineering with an annotated collage.* (Week 3)

- *Engineering Design Process: how can they apply it to their own DYP journey to WCES.* (Week 5)
- *Prepare for informational interview: students formulate questions to ask during an informational interview. They also identify at least one practicing engineering professional to interview, to be conducted no later than the Thanksgiving holiday.* (Week 9)
- *Summary of informational interview responses.* (Week 12)

The completed portfolio is the main end of semester deliverable. Students are encouraged to use their ePortfolio as a repository of useful information and resources to use after the course is finished. In particular, the informational interview questionnaires and networking contacts.

Thematic Analysis Methodology

The effectiveness of the reimagined course will be evaluated using a thematic analysis approach, following established methods, with themes identified solely based on collected data without pre-existing code sets [5-7]. Thematic analysis provides a way to systematically analyze qualitative data. Thematic analysis is performed as a five-step process: data acclimation and familiarity; line-by-line coding; initial theme identification; further theme expression; review of themes based on the complete data set.

Data Sources

The data elements collected to perform the thematic analysis, include the following:

ePortfolios and discussion postings: the accuracy, quality, detail, and clarity in describing the activities and findings can be indicative of how well students internalize and apply concepts.

Classroom observations: help assess engagement, participation, and collaboration.

Surveys: with questions rooted in a metacognitive approach designed to evaluate how students internalize concepts as well as their transference to other courses [8]. Sample survey questions include the following:

Q1: What do you hope to take from this class with you to your other courses in your engineering major? (Think - "How has this course affected my understanding of my specific major and what it requires?") Some topics to consider...

What skills here may you see elsewhere in engineering?
What skills here may you see elsewhere in your specific engineering major?
What skills do you feel you may never use, but are good to be familiar with?
How has learning new skills made you appreciate engineering majors that are not your own?

Q2: The course incorporated multiple active learning interventions, such as the visual journey, jamboards, discussion posts, commenting on other's discussion posts. Please describe what you found valuable in participating in these activities. You can also comment on what you found not being valuable.

Q3: Now that you have completed the course, (1) how would you define a World Class Engineering Student (WCES) and (2) what would you say is required to become an effective WCES?

Q4: Please provide your key learnings from conducting the informational interview with an engineer.

Preliminary Results

This instructor offered the course again in fall of 2022 to 167 students in 3 sections. Data from this offering was used for preliminary analysis. The two authors reviewed comments from end of semester course evaluations from one hundred and one respondents. Preliminary themes were identified by each author independently. Following thematic analysis protocol, the two authors performed a secondary analysis, then combined similar themes, and performed another review of and consolidated their data into combined theme sets.

The three most represented themes identified were: *Learning about Studying / Working hard; Value of Active Learning Interventions;* and *Learning from Informational Interview*. Each of these relates to curricular components of the course and it is encouraging that students recognized them and reported them in their responses.

Theme 1: *Learning about Studying/Working Hard,* students relayed their attitudes about what it takes to be a World Class Engineering Student. For example, *it has taught me to get my assignments done on time and swiftly*, and *I learned that I need to become more disciplined in order to be successful in this field of study* not only speak to core curricular elements the course hopes to instill, but the students themselves have begun to internalize this positive attitude into their educational experience.

Theme 2: *Value of Active Learning Interventions,* students conveyed the perspective that the active learning interventions helped their understanding of lecture content. For example, *Visual journey was the most valuable because it made students reflect* on their progress and *Jamboards were messy but fun to collaborate with other students* indicating that not only were they effective, but they bolstered secondary effects, such as group collaboration. A few students self-reported that they are shy and don't typically participate in class but were surprised by how much more they participated in this class because of the large number of low-stakes opportunities to collaborate and participate they were exposed to.

Theme 3: *Learning from Informational Interview,* students expressed a variety of lessons learned from the informational interview process. For example, *the interview was extremely helpful in understanding the field and applying the content learned in this class* and *My key learnings from my informational interview are that there is always the business aspect to engineering* indicate that students believe there is inherent value in developing *soft skills* such as professional communications. This is also positive because students realize that there is a more human component to being successful in engineering, and that collaboration and communication with others are important to their future success in the field of engineering (or any other profession).

Other significant themes: The three least-represented codes observed are *Learning about Critical Thinking*, *Learning from Transference*, and *Learning Appreciation for Engineering*. While these three codes may be more closely related to abstract or meta-concepts, it was hoped that students would have reported more from the course concerning all three themes. All three of these codes are relevant to the university where this research takes place, as preparing students for co-op internships and full-time jobs is a core mission of the institution. For example, for *Learning Appreciation for Engineering*, students expressing they have learned a general

appreciation for their discipline is a highly positive outcome in a course such as this. One student noted, *I found that the field I'm in is actually very enjoyable*, and it was hoped more students would have directly conveyed such a revelation at the end of the course.

Discussion

Initial observations and preliminary results presented above indicate that, overall, the reimagined course seems to have been effective in achieving its goals: most students were engaged and actively participated in lectures, collaborated on activities, and shared their thoughts and insights through reflections and peer review. In particular, the informational interview activity was very well received, and students were pleased (and often surprised) with what they discovered and learned about their chosen field of engineering and the types of jobs and projects they may encounter when they graduate. It is also significant that students identified informational interviewing as a lifelong skill which everyone should master to advance in their profession.

One key component we had not considered exploring is the effect of the Learning Management System (LMS) on course effectiveness and outcomes. While the LMS certainly could make the delivery of certain materials more or less efficient, there were no student comments suggesting that the LMS played a role in any way. Furthermore, from what we observed, we believe that the course, even with a minimalist LMS or a different LMS entirely would have had similar outcomes. The content and delivery approach are what matter.

Conclusions and Further Work

While not definitive yet, the research seems to indicate that adoption of the DYP approach has been effective. Preliminary thematic analysis indicates that the main course objectives of bolstering student awareness of the work ethic and level of professionalism required to succeed in engineering, as well as developing soft-skills, including communication and interviewing skills were achieved. Plans for improvements in assessment of course effectiveness includes adding photovoice analysis of student reflections about their DYP process experience, as well as collection of more data sets [9-10].

References

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Appendix A

Course Lecture Sequence Through Fall of 2020 (topics removed are crossed off **in bold**)

Planned Lecture Topic Schedule	
Week Number	Topic
1	General Course Introduction/Introduction to the Lab
2	'What is Engineering?' – Academic Honesty
3	Engineering Education and the Engineering Profession
4	Engineering Design Process
5	Societal Trends and an Engineer's Role
6	Societal Trends Case Study and Research
7	Research Techniques / Library Workshop
8	~~***Engineering Analysis (Dimensions)***~~
9	~~***Engineering Analysis (Units)***~~
10	~~***Basic Data analysis and Excel***~~
11	Engineering Ethics and Professional Responsibility
12	Engineering Ethics Case Studies
13	Thanksgiving break (No lecture)
14	~~***Technical Writing and Final Exam Preparation***~~
15	Final Exam