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# Game on! Utilizing analogous context immersion to introduce critical engineering concepts to first-year students through board games

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## Introduction

Understanding an application of the engineering design process as well as development of project management skills are critical for student success in an engineering degree, and introduction of these concepts and skills in the first year of an engineering curriculum reinforces their foundational nature. As first-year students enter university with a wide range of backgrounds, it can be difficult to create an immersive and engaging introductory experience that reinforces these foundational skills without relying on a deeper understanding of technical material. In fact, for some students, introductory projects with roots in highly technical material may be alienating, damaging to student confidence, and ultimately detrimental to measures of academic success and degree persistence. It has been shown that student confidence in their own academic ability is affected by self and peer performance [1],[2] and the first year of a student's university experience impacts measures of academic success [3],[4]. These factors served as the impetus for the development of an innovative introductory engineering course that introduced critical concepts and skills without alienating students based on perceived ability or actual preparedness levels. This paper explores the introduction of "analogous context immersion" as a means of fully immersing student learning of an unfamiliar concept into a familiar context – in the case of this work, fully immersing learning of the engineering design process and project management skills into the context of designing a tabletop (i.e. board, card, etc.) game. This term-long project was piloted in the Winter of 2024 in a civil engineering section of ENGR 102: Introduction to Engineering II at Oregon Institute of Technology.

The first-year introductory course, co-taught by instructional faculty, focused on project management skills and design concepts by tasking civil engineering students with creating tabletop games that could be used in outreach events to teach civil engineering concepts to young audiences. The introductory course was organized so that, each week, students were introduced to and gained experience with a step in the engineering design process. Reinforcing the concept that the engineering design process is critical to practicing civil engineering, relevant examples from practice were used to connect steps in the design process to the field. Upon completion of the project, teams presented to their peers fully playable tabletop games that met given design constraints and included technically written instruction manuals.

## Course Overview & Background

As enrollment and retention continue to challenge universities and engineering programs, special attention has been given to first-year courses in the Civil Engineering program at Oregon Institute of Technology. All Civil Engineering students are required to enroll in a two-part introductory sequence, consisting of Introduction to Engineering I (ENGR 101) and Introduction to Engineering II (ENGR 102), offered in the Fall and Winter terms, respectively, of students' first year. ENGR 101 aims to help students be successful in their transition to a university-level engineering program and aims to introduce students to each of the civil engineering disciplines. ENGR 102 aims to provide a more in-depth opportunity for students to work together in teams and develop project management and problem-solving skills. Each 2-credit-hour course consists of one lecture hour per week and 3 lab hours per week. Both courses are co-taught by a team of two faculty not only to structurally incorporate new faculty training but to dedicate a model of continuous improvement to the course as well.

The focus of this work is the second course in the introductory sequence, ENGR102, which, in line with a similar introductory engineering course [5], has the following goals: (1) develop student interest in civil engineering, (2) encourage critical thinking and problem solving, and (3) develop skills needed by professionals in the civil engineering field. The course goals are accompanied by four objectives.

Upon completion of ENGR102, students should be able to:
1. Function effectively in a group setting to solve engineering problems,
2. Follow design constraints and adhere to changing specifications and/or requirements,
3. Use oral and written communication skills to present technical material effectively, and
4. Use engineering problem solving methods, experimentation, and common engineering tools.

Though not explicitly mentioned, the engineering design process and development of project management skills are implicit in the fourth course objective and, as such, in the Introduction to Engineering II curriculum. Historically, a project-based approach was taken with the course, giving students hands-on introductions to the engineering design process and project management skills, while achieving course goals and objectives. This was done through student completion of real-world civil engineering term projects. Recent examples of ENGR 102 projects include the design and construction of a tiny house and resurfacing of a trail with local volcanic ash as a supplementary cementitious material. These projects were generally completed in groups, where individual groups were assigned tasks that contributed to the completion of the overall assignment.

Previously implemented ENGR102 projects, while effective at providing tangible opportunities for students to apply the engineering design process, were challenging in multiple ways. Not only did they require first year students to have advanced understandings of technical concepts, but they also tended to favor one subdiscipline of civil engineering over another. For example, certain aspects of the trail resurfacing project required knowledge of cement chemistry that students typically would not be introduced to until the third year of their program. While many students can learn these concepts, even at an early stage in their education, there are others who may feel frustrated, isolated, and incapable of progressing in their education. Second, it is challenging to find a real-world project that evenly incorporates aspects from the various subdisciplines of civil engineering, and moreover, it is even less likely that first-year students can be expected to take on an advanced level of understanding of technical concepts across that broad range (This expectation is more appropriate when presented to students in our senior design courses).

The authors of this paper (the current instructors of this course) felt these technical challenges were inhibiting students' abilities to focus on the actual course objectives, which were not, in fact, highly technical. Thus arose the idea of incorporating "analogous context immersion" as a means of fully immersing student learning of unfamiliar concepts into a familiar context. In the case of this work, the engineering design process and project management skills were explored through the context of designing a tabletop game.

Analogous context immersion is built on the theory of situated cognition and takes advantage of the way humans and living beings naturally learn. For example, lessons learned "authentically" (i.e., walking out into a rainstorm teaching the lesson that rain makes you wet) are more likely to stick than those learned "inauthentically" (reading about rain in a book without ever actually experiencing it). This concept [6] provides support for teaching foundational introductory engineering concepts and skills in an immersive learning environment. Implementation of an immersive learning environment allows for more student engagement with the material, which has been shown to positively impact academic achievement [7]. Learning foundational engineering-related concepts and skills within the highly technical contexts in which they are traditionally used may cloud an introductory-level student's ability to take advantage of situated cognition, negatively impacting academic performance and student experience. Another principle foundation in the development of analogous context immersion is the method of context familiarity, or, using real-world examples to pull theoretical concepts into applied settings and enhance student comprehension. The educational benefits of context familiarity have been studied for over a century [8], [9]. This work introduces "analogous context immersion" as a pedagogical approach which marries the theory of situated cognition to context familiarity as a means of enhancing student comprehension and engagement in an introductory engineering course.

## Course Structure and Assessment

This section provides a deeper look into the Introduction to Engineering II course, presenting the Winter 2024 course offering as a case study. The authors discuss how the engineering design process operates as a keystone principle for the course, around which all course objectives are met. Following the overview of the course structure, the authors provide detailed information regarding student and course assessment.

### *Course Structure*

ENGR 102 is a 2-credit-hour, 11-week course (10 weeks of instruction + 1 final exam week). The course consists of one lecture hour and 3 lab hours per week. The 11-week schedule followed during the Winter 2024 term is given in **Table *1***. In the Winter 2024 term, the class had an enrollment of 22 first-year civil engineering majors. Throughout the term, students were introduced to the engineering design process and asked to carry out the various steps of the process in order to complete their term projects. Instructors used a seven-step model to represent the engineering design process, shown in Figure. Table 1 demonstrates how each phase of the design process was represented by one or more of the weekly course topics.

**Table 1. 11-week schedule for ENGR 102**

| Week | Topic | Design Process Phase |
|---|---|---|
| 1 | Syllabus, Design Process, Design Problem | 1) Define the Problem |
| 2 | Group Formation & Initial Scope | 1) Define the Problem |
| 3 | Anatomy of a Board Game | 2) Do Background Research |
| 4 | Designing a Solution | 3) Brainstorm Solutions |
| 5 | Prototyping | 4) Develop and Prototype Solution |
| 6 | Testing | 5) Test & Evaluate Solution |
| 7 | Iterative Improvements | 5) Test & Evaluate Solution<br>6) Optimize Design |
| 8 | Iterative Improvements | 5) Test & Evaluate Solution<br>6) Optimize Design |
| 9 | Communicate Results | 7) Communicate Solution |
| 10 | Final Thoughts & Project Reflections | |
| 11 | Final Exam Period: Final game playthrough | 7) Communicate Solution |

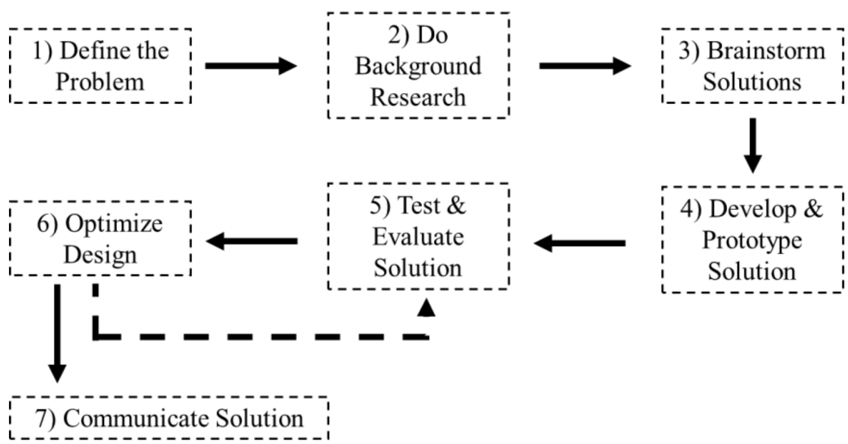


**Figure 1. Graphical representation of the engineering design process used in ENGR102**

The remainder of this section is dedicated to describing how each step in the design process was introduced in the class, and how each step relates to the course objectives.

Step 1: Define the Problem

At the start of the term, students were introduced to the engineering design process as a whole, were given a broad overview of the course objectives and final project, and completed an introductory survey to gauge student perceived academic strengths and level of exposure to tabletop games. Instructors used survey responses to guide the formation of 3-4 student project groups in week 2. Because ENGR102 is the second course in the introductory civil engineering course sequence, instructors had prior knowledge about each student and had observed students work in groups with their classmates during ENGR101. This knowledge, combined with the survey results, allowed for intentional grouping or separation of students, balancing personalities and skill levels within each group.

Groups were then provided with a project solicitation containing a detailed project motivation, overview of design constraints, and specific deliverable requirements. The project motivation described how the Oregon Institute of Technology Civil Engineering Department was in search of innovative and engaging means of outreach to inspire the next generation of civil engineers, and thus the students were tasked with developing civil engineering themed, educational tabletop games. Initial design constraints included restrictions on theme and audience. Even though groups were informed about these constraints, specifics were not provided until the following week to keep them from prematurely engaging in the brainstorming process. Finally, three final project deliverables were assigned: 1) a fully playable tabletop game that meets given design constraints, 2) a physical instruction manual that thoroughly outlines gameplay, and 3) a presentation of the final product to peers.

Step 2: Do Background Research

The third week of the term focused on the "background research" step in the engineering design process.  At this point, groups were given specific design constraints pertaining to the theme and audience of their game. Each group was assigned a civil engineering subdiscipline (i.e. water resources, transportation, geotechnical, structural) to incorporate into their game as a foundation for its theme. Second, groups were assigned age ranges for their intended audience. In the Winter of 2024, there were 6 project teams. Table 2 outlines their (randomly assigned) design constraints.

**Table 2. Summary of project teams and their constraints**

| Team | Target subdiscipline | Target age group |
|---|---|---|
| 1 | Geotechnical Engineering | 10+ |
| 2 | Water Resources Engineering | 10+ |
| 3 | Structural Engineering | 10+ |
| 4 | Water Resources Engineering | 6+ |
| 5 | Structural Engineering | 6+ |
| 6 | Transportation Engineering | 10+ |

The goal of the week was for students to become familiar with tabletop games in general and, specifically, ones that fit their design constraints. This week also presented an opportunity for students to conduct preliminary background research on their assigned civil engineering subdiscipline, to which they previously had limited exposure.

In an activity titled "Anatomy of a Boardgame," student teams were given a set of exploratory questions to answer and a selection of tabletop games with which to answer them. The example games selected included a variety of age ranges, mechanisms, physical components, and playstyles. Students were asked to conceive and answer their own exploratory questions in addition to the ones provided. In conclusion, teams drew similarities and differences between the games, focusing especially on target age groups. This group assignment was supplemented with a similar individually assigned activity allowing further investigation into already existing games in alignment with students design constraints.

While not structured as an assignment, students were tasked with conducting background research related to their assigned subdiscipline and the concepts within it. Students were directed to potential resources through which to gather more information, including textbooks, online resources, and access to subject matter experts. The course instructors have expertise in transportation and water resources engineering, and helped provide guidance to the teams focusing on those areas. Other civil engineering faculty with backgrounds in structural and geotechnical engineering took the time to confer with the remaining teams.

Step 3: Brainstorm Solutions

In the fourth week of the term, students used information gathered during the background research phase to brainstorm initial designs for their final products. Up until this point, brainstorming had been intentionally discouraged in an effort to emphasize the importance of not creating a solution to a problem that isn't fully understood. With the purpose of generating a variety of ideas, students individually conceived elements of a potential game, prompted to consider things like who the game is for, how the players should feel, what sort of mechanisms align with the player experience, and how a player wins and share these ideas with their teams. As a result of the brainstorming session, groups finalized initial designs and presented design pitches to the class, meeting the content requirements outlined in **Error! Reference source not found.**. Teams were required to include logistical and thematic information about their proposed game, as well as proposed schedule.

**Table 3. Content requirements for initial design pitches**

| Logistical Info | Thematic Info | Schedule Info |
|---|---|---|
| Game Name | Game Objective | Timeline for Development |
| Number of Players | Game Theme | |
| Age Range | Design Concept | |
| Estimated Playtime | Gameplay Mechanisms | |
| Equipment | | |

Step 4: Develop and Prototype Solution

In week five, students developed prototypes of the games that they pitched. The class was introduced to the concept of the "minimum viable product" (MVP), essentially the simplest prototype that can be developed to simulate a playtest of the game. The purpose of the prototype is to be functional but stripped to its essential elements so that it can be easily adjusted and improved upon as issues with the game are revealed. Discussion emphasized that game elements should be cheap, easy to construct, and easy to replace. To demonstrate a realistic example of an MVP, the instructors constructed an MVP-version of an existing familiar board game, Hasbro's Candy Land™. The commercially produced version of the board game consists of a game board, plastic pawns, and cards with various colored shapes and objects. The instructors recreated a playable version of the game with paper and colored markers, shown in Figure 2.

**Figure 2. Example Minimum Viable Product presented to students**


As a class, students brainstormed low/no-cost alternatives for various components of their own games. A supply of low-cost supplies (paper, colored markers, etc.) was provided to the class, and they were also encouraged to use or repurpose materials they already had on-hand. Teams used provided materials to construct playable MVPs for use in the testing phase of the project. An example of one MVP is shown in Figure 3.

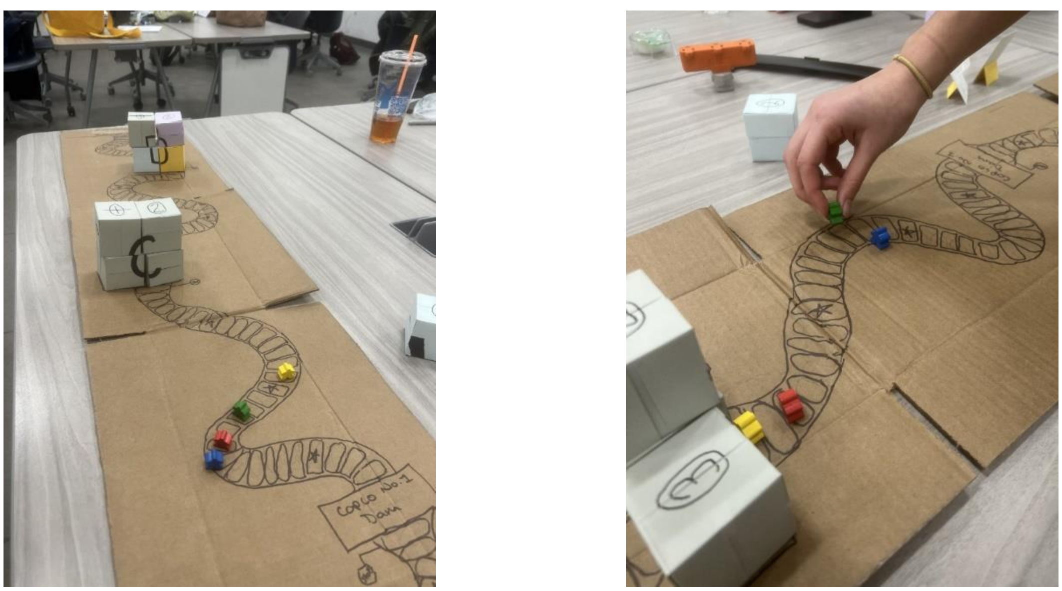

**Figure 3. Minimum viable product produced by one of the student groups**

Steps 5 & 6: Test and Evaluate Solution & Optimize Design

With MVPs to test, weeks six through eight of the term were dedicated to an iterative cycle of testing, evaluation, and design optimization. With an emphasis on real-world engineering projects, students were introduced to the idea of testing a design or product, assessing performance, and then making strategic improvements. Specifically, students were given a brief overview of a simple water distribution system and its design objectives, which were to maintain certain pressures and velocities. Given results from a hydraulic model, students were asked to brainstorm potential ways to improve the system (increase pipe sizes, add pumps or storage tanks, etc.). The class walked through an optimization process, until the water distribution system met desired performance metrics. With this in mind, students were introduced to this process of continual improvement for their games.

Over three weeks, students engaged in three distinct rounds of testing, outlined in **Table *4***. These testing rounds tend to be consistent among board game creators, though they generally occur at a greater volume and over a longer period of time than was implemented in this course. The lab portion of the course, over this three-week period, provided the time to conduct testing, while the lecture portion of the course focused on ways to meaningfully implement feedback gathered during the testing process.

**Table 4. Overview of types of testing**

| Round | Testing Type | Description |
|---|---|---|
| 1 | Internal | Groups testing their own products |
| 2 | Local | Classmates testing their peer’s products |
| 3 | External | Volunteers from outside of the class testing products |

Week six of the course was dedicated to internal testing, in which the teams themselves were to test the MVP that they had just developed. The goal of this phase is typically to ensure that the game is functional and presentable before sharing it with a wider audience. In this exercise, designers-turned-players were generally able to quickly recognize elements of their games that worked and elements that didn’t. Many teams were able to make simple adjustments to their games in response to their discoveries.

In week seven, testing shifted to include playtesters outside of the teams’ original design groups. For local testing, teams were tasked with testing the other games in their lab section. Depending on which lab section teams were in, they had either two or three other groups play through their games. In this round of testing, while written gameplay instructions were required, teams were allowed to answer questions and guide players through rounds of gameplay. Teams were tasked with collecting two forms of feedback: (1) written feedback, in which testers answer specific questions about their experience during or after game play, (2) observational feedback, in which the game designers watch players and take note of common occurrences, logistical information, and patterns (i.e., play time, winners/losers, etc). To aid in collecting this feedback, teams developed feedback forms to provide to testers and encouraged to be consistent with observations in order to identify patterns. This round of testing resulted in further adjustments to each of the games.

In week eight, the external round of testing, junior- and senior-level students as well as staff from the Civil Engineering program and department were recruited to attend labs and play the groups games. In this final round, testers were only provided a set of written instructions to inform their gameplay, without any guidance from the team of game designers. Teams recorded the same forms of written and observational feedback as they did in the previous round of testing. This process proved particularly enlightening for student teams – many of the groups were surprised at the variety of ways in which their written instructions could be interpreted, and thus it was a particularly valuable lesson in the importance of clarity in written communication.

Step 7: Communicate Solution

The final weeks of the term were focused on completing a final prototype and communicating the results of the final design. By the end of the term, teams submitted a written report, and delivered a summative oral presentation, similar to their initial design pitch, describing their final prototype and the process of its development and completion.

*Final Products*

The term culminated in an opportunity for teams to showcase their games to their peers, faculty, and to students outside their class. Teams were required to have a playable game prototype (complete with an instruction manual), to be introduced and played during the course's scheduled two-our final exam period. Students and faculty from within and outside of the Civil Engineering Department attended to play the games. The end result of the term's projects were 6 distinct games, described and shown in the appendix of this paper.

*Student Assessment*

As discussed in the course structure section of this paper, students were assessed on both individual and group levels throughout the term, leading to the completion of final project deliverables. The majority of assignments completed during the term were completed at the group level. Individual assignments were used to supplement those completed in groups when the instructors felt students would benefit from exposure to specific topics. Table 5 presents an overview of the group and individual assignments that were assessed during the term. In the middle of the term, student knowledge was tested by having them create unique graphical representations of the engineering design process. This low-stakes, formative assessment showed strong levels of student understanding of the design process, and is discussed more in depth in the Lessons Learned section of this paper.

Note that the group contract assignment was not linked to a step in the engineering design process. This assignment was included because instructors considered it an essential first step in meeting the first objective of the course: "function effectively in a group setting to solve engineering problems". Note also the absence of the seventh step in the engineering design process: "communicate solution". This ultimate step in the engineering design process was realized through the final deliverables of the course, as seen in **Table *6***.

**Table 5. Overview of Individual and Group assignments and their targeted course objectives and steps in the engineering design process**

| Group Assignment | Individual Assignment | Targeted Course Objective | Targeted Step in the Engineering Design Process |
|---|---|---|---|
| Project Scope Statement | | 1 | 1 |
| Group Contract | | 1 | |
| Anatomy of a Board Game | Background Research | 4 | 2 |
| Design Pitch Presentations | Brainstorming Activity | 2,3 | 3 |
| Minimum Viable Product | | 2 | 4 |
| Testing Feedback Forms | Iterative Improvement Activity; Engineering Design Process Graphic | 2,3,4 | 5,6 |
| Testing Feedback Summary | | 3 | 5,6 |

**Table 6. Overview of Cumulative Project Deliverables and their targeted course objectives and steps in the engineering design process**

| Cumulative Project Deliverable | Targeted Course Objective | Targeted Step in the Engineering Design Process |
|---|---|---|
| Final Prototype | 2,4 | 1-7 |
| Completed Instruction Manual | 3 | 7 |
| Final Report | 3 | 7 |
| Final Presentation | 3 | 7 |

*Course Evaluation*

At its conclusion, students were prompted to complete course evaluations, using the Campus Labs "IDEA Center course evaluation system". This course evaluation process, implemented university-wide, allows instructors to select three to five objectives from a set list, deeming them "important" or "essential" for the course that is being evaluated. 81% of students enrolled in the course completed the evaluation and provided feedback on several prompts, shown in **Table** *7*. For comparison, similar course evaluation data for the Winter 2023 offering of ENGR102 is also presented in **Table** *7*. As discussed previously, the relevant course objectives remained largely unchanged when the analogous context immersion curriculum was implemented in the Winter 2024 offering. Thus, it is worth comparing student perception of the course before and after the implementation. There are two differences of note between the Winter 2023 and Winter 2024 evaluation data. Differences are observed in student perception of progress and in overall satisfaction with the course.

**Table 7. Comparison of relevant student evaluation of Winter 2024 and Winter 2023 ENGR102 offerings**

| Relevant Objectives | Course Offering | % None | % Slight or Moderate | % Substantial or Exceptional |
|---|---|---|---|---|
| | | *Student Perception of Progress* | | |
| *Progress in Objectives Deemed "Important" or "Essential" by Instructors* | | | | |
| **[I]:** "Learning to apply course material (to improve thinking, problem solving and decisions)" | W24 | 0 | 26.5% | 73.5% |
| | W23 | 14.3% | 0 | 85.7% |
| **[I]:** "Developing creative capacities (inventing; designing; writing; performing in art, music, drama, etc.)" | W24 | 0 | 29.4% | 70.5% |
| | W23 | 0 | 71.4% | 28.6% |
| **[I]:** "Developing skill in expressing myself orally or in writing" | W24 | 0 | 29.4% | 70.5% |
| | W23 | 0 | 57.1% | 42.9% |
| **[E]:** "Acquiring skills in working with others as a member of a team" | W24 | 0 | 17.6% | 82.4% |
| | W23 | 0 | 57.1% | 42.9% |

| Evaluation Prompt | | % Neg. | % Neutral | % Positive |
|---|---|---|---|---|
| *General Feelings Towards Course* | | | | |
| "Overall, I rate this course as excellent" | W24 | 11.8% | 17.6% | 70.6% |
| | W23 | 0% | 28.6% | 71.4% |

First, student perception of progress in relevant objectives. The majority of students perceived substantial or exceptional progress in all four relevant objectives during the Winter 2024 offering, when the analogous context immersion curriculum was implemented. Conversely, the majority of students perceived slight or moderate progress in three of the four relevant learning objectives in the Winter 2023 offering, prior to the major curriculum change. A significant difference is observed when comparing student perceptions of their ability to apply course material before and after the curriculum change. While the majority of students perceived substantial or exceptional progress in both the 2023 and 2024 course offerings, a number of students perceived no progress in the objective prior to the curriculum change. This could indicate the analogous context immersion curriculum offers students more opportunity to develop this specific skill.

Second, overall student satisfaction with the course. Prior to the curriculum change, there were no negative responses when asked how students felt about the course, with a majority of responses indicating students enjoyed the course. Following the curriculum change, while the majority of students still indicated feeling positively about the course, a couple of students expressed the opposite. Along with the qualitative evaluation responses, some students added comments. The majority of comments were positive, and focused on how the course was fun and how the instructors made learning the concepts enjoyable. One student expressed discontent with the term project because they believed it wasn't appropriate in an engineering class. One student indicated their group had difficulties with the time constraints of the project. The qualitative portion of the course evaluations leads the instructors to assume the sense of student dissatisfaction stems from students feeling like their expectations for the course weren't met or having a few bad experiences throughout the term. Both of these negative comments will be addressed in the challenges and lessons learned section of this paper.

## Challenges and Lessons Learned

The results section of this paper is dedicated to the challenges instructors faced during the course. The discussion section is dedicated to outlining the lessons learned during and after the course.

### *Challenges*

Three main challenges include student perception of course, group dynamics, and time constraints.

#### Challenge 1: Student Perception of Course

Student perception of course ended up being the most significant challenge faced by the instructors. As discussed previously, only two students discussed their negative perception of the course on their course evaluation, however, instructors also received the following comments during the term.

The following three concerns were raised at some point during the term:
1. Is the course relevant to the civil engineering degree?
2. Why is the class an engineering course if it is not technical in nature?
3. Is the course a good use of student tuition?

It is worth noting that all three of these concerns were raised by the same student. Because many students may have had similar concerns left unvoiced, the authors found this individual's comments worth addressing. In response to these concerns, the instructors are making changes to the curriculum to provide more blatant examples of the engineering design process in the field of civil engineering, as well as purposefully highlighting the importance of "non-technical" engineering skills. This solution is approached in depth in the "lessons learned" section of this paper.

#### Challenge 2: Group Dynamics

As is the case with any group project, issues with group dynamics are expected and, perhaps, inevitable. Because the course centers on effective group work, this challenge is important. Instructors observed these challenges through student observation and received feedback from students on end-of-term group evaluations. The main challenges observed involving group dynamics are as follows:
1. Self-guided work
2. Management of group expectations
3. Under/Over involvement

First, instructors observed issues with groups completing self-guided work. Due to the nature of the project, a large amount of time spent in the lab was dedicated to groups completing “project work”. The idea behind this is to dedicate unstructured time for groups to make continued progress towards the project deliverables instead of expecting the majority of project work to be completed outside of class. Because the course is only worth two credit hours, the instructors did not want to burden students with a significant amount of homework related to the final project deliverables. Some groups thrived in this flexible environment, and some did not. Occasionally, group members or entire groups would leave during the lab period and state they were planning on meeting later. It is unclear whether groups met outside of class or did not meet at all. The instructors purposefully put the task of group management into the hands of each group, having them write and sign group contracts at the beginning of the term.

Second, closely related to the issue of self-guided work, groups had difficulties managing expectations. The group contracts were assigned so students could clearly outline expectations for group members as they related to completing the course project. Some groups did not take the assignment seriously, or did not think they would need to use the group contract at any point in the term. Groups light-minded approach to the contracts lead to issues when group members weren’t meeting others’ expectations, but, because those expectations were not expressed in the group contract, dissatisfied group members were left without a way to formally confront their poorly performing counterparts.

In response to these first two challenges, the instructors intend to add more structure to the group contract assignment. Originally, the contracts were written and agreed to by group members only. Moving forward, the contracts will require instructor approval as well. This will allow instructors to have group by group discussions about expectations, hopefully allowing groups to avoid some issues altogether or, at the very least, give group members agency to handle conflicts should they arise over the course of the project.

Finally, groups experienced issues with both under and over-involvement of members. Occasionally, students will stop attending class, leaving their group members to fill the void left by their absence. On the other hand, some students take control in their groups and leave other members feeling like they aren’t able to provide input on their own projects. In both situations, students are left feeling frustrated and are likely to develop negative feelings about group work in general. This challenge, while more difficult than the first two, may also be settled by way of structuring the group contract assignment.

Challenge 3: Time Constraints

Finally, the ten-week timeline for project completion caused some challenges regarding time constraints. Specifically, during the sixth, seventh, and eighth week of the term, groups were focused on testing and improving their prototypes. During these weeks, lab time was dedicated to the testing process, leaving the improvements to be completed outside of class. In future iterations of the course, the lab time will be divided between testing group work so students do not feel as rushed to improve their prototypes and can feel confident in their final products.

*Lessons Learned*

Upon reflection, multiple principles were identified that will be considered in future course offerings. The five key takeaways are as follows:

1. Making references to civil engineering projects in every class may help students make stronger connections between the course material and their degree.
2. Frequently referencing the course learning objectives may provide students with clarity on why the term project is not technical in nature.
3. Standardizing formative assessment techniques will allow for measuring student progress with learning the engineering design process.
4. Refining project expectations and adding more structure to assignments may alleviate some of the self-guided group work issues observed.
5. Allowing for more opportunity for student feedback may encourage reserved students to speak up about positive or negative experiences within the course.

The first two principles are intended to address the challenges with student perceptions of the course identified previously. It is believed that continued reference to the civil engineering field and specific projects will enforce the fact that the engineering design process is fundamental knowledge for civil engineers, no matter how it is introduced.

The third principle is relevant to the mid-term individual assignment where students drew a graphical representation of the engineering design process. The original intention of this assignment was to have an informal "check in" on student understanding. Moving forward, not only will this assignment bookend the course, it will be assessed using a rubric so instructors can quantify how student understanding of the engineering design process changed from the beginning of the course to its end. The formalization of this assessment could also help provide insight into the effectiveness of the "analogous context immersion" curriculum developed and implemented by the instructors.

The fourth principle is intended to address the challenges with group dynamics identified previously. It is believed that providing more structure will allow students to make continuous progress towards the larger project deliverables. This principle will be specifically applied to the group contract, to build a stronger foundation for group work at the start of the project, as well as the background research, brainstorming and initial prototype processes, requiring students speak, at length, with faculty before finalizing a theme for their final product. Further development of group formation technique may be considered in future course offerings. The instructors maintain that students should not choose their own groups for this course, so developing an effective group formation technique is essential when trying to limit issues related to group dynamics.

Finally, because the curriculum is in its infancy, student feedback is essential in refining and improving the course. Therefore, creating more opportunities for student feedback in the course will hopefully encourage students to provide positive and negative comments, giving them a sense of agency.

## Conclusions

Introductory courses in engineering programs are critical for student success and retention. The focus of this work is on an experimental course curriculum in an introductory civil engineering course. The curriculum used analogous context immersion to help students feel comfortable engaging with unfamiliar concepts. Specifically, first year civil engineering students were introduced to the engineering design process through the context of tabletop game design. This curriculum targeted the issue of introductory level students feeling overwhelmed or ostracized when introduced to highly technical information. The goal of the course was to create an environment that engaged all students, regardless of their prerequisite knowledge of civil engineering.

An eleven-week, two-credit hour course was presented, in detail. The course schedule was built around the course's four learning objectives, and a seven-step engineering design process. Upon the course's introduction, students were presented with a project solicitation, introducing them to the design problem of creating outreach materials for the civil engineering department. Given design constraints and project teams, groups followed the engineering design process week by week to complete the term project.

Formal student evaluations of the course show students perceived progress in multiple objective areas and enjoyed the course overall. These evaluation outcomes were then informally compared to those of a previous iteration of the course before the implementation of the curriculum centered on the idea of analogous context immersion. This direct comparison of evaluation results showed an improvement in student perception of progress with the new curriculum. Although we did observe two negative responses regarding course enjoyment versus all neutral or positive from students in the previous course iteration, the authors do not believe this to be indicative of the quality of the course overall and rather, attribute this response to a few frustrated students. This comparison leads the authors to the conclusion that the change in curriculum did not inhibit student progress in identified objective areas or student enjoyment of the course.

Course reflection of challenges and lessons learned helped instructors build a framework allowing for improvement of future course offerings. The main avenues for improvement exist in the areas identified as lessons learned: intentional connections between engineering design process and civil engineering, frequent references to course objectives, standardized assessment of student understanding of the engineering design process, refining expectations for and improving the structure of assignments, and solicitation of student feedback. Further investigation into the use of analogous context immersion is essential to gain a better understanding of its potential impacts on student conceptual understanding and feelings of belonging in the introductory civil engineering course. Future work may include an analysis of student assignments and feedback, as well as a more sophisticated comparison of student performance before and after the implementation of the analogous context immersion curriculum.

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**Appendix**

Final products included the following six, fully playable tabletop games (pictured in Figure 4 and Figure 5):

1. "Pipe Panic" – a fast-paced network-building board game in which players attempt to strategically connect water distribution pipes from a source to far-away homes, while navigating hazards like pipe bursts or schedule maintenance

2. "Shepherd's Crossing" – a game of economic strategy, in which players must optimize the design of a truss bridge to rescue a missing sheep (Kevin) from his herd

3. "Salmon Trail" – a game of chance, in which the first player to navigate downstream along the Klamath River is awarded by announcing to the salmon that the four major dams along the river have been removed (not pictured in Figure 4)

4. "Tech Dirt Dash" – a simulation game in which players must answer trivia questions in order to progress through a career in geotechnical engineering, while simultaneously unlocking professional achievements like passing the F.E. exam, obtaining licensure, and retirement

5. "The State Race" – a resource-gathering board game in which teams assume the roles of the Oregon and Washington Departments of Transportation, racing to become the first state to complete their interstate system

6. "Bridge Battle" – a deck-building game, in which players must collect each of the key members of a truss bridge while navigating construction challenges like poor weather, natural disasters, and Occupational Safety and Health Administration (OSHA)


**Figure 4. Final designs**

**Figure 4. Students and faculty playing final prototypes during the final exam period**