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Enabling Hands-On, Team-based Project work during COVID-19

Dr. Brian Dick P.Eng., Vancouver Island University

Brian Dick is Chair of the Department of Physics, Engineering, and Astronomy at Vancouver Island University, and instructs its first-year engineering design curriculum. He is past-chair of the BC Council on Admissions and Transfer (BCCAT) Engineering Articulation Committee, and led development of the common first-year engineering curriculum recently implemented in British Columbia.

Enabling Hands-On Group Project work during COVID-19[1]

Abstract

COVID-19 has impacted delivery of the first-year engineering design curriculum throughout the post-secondary system. At Vancouver Island University (VIU), instruction of the first-year curriculum shifted to an entirely remote learning environment where students were not expected to be in physical contact at any point during the term. This presented a significant challenge to delivering its learning outcomes and activities, particularly hands-on, team-based project work.

At VIU, students typically complete a cornerstone design project in the second term of their first-year of studies. Due to COVID-19, this project was modified to allow for completion within a virtual learning environment. Teams of three or four students were tasked to cooperatively create a rolling ball structure, built in isolation, but delivered and assembled at the University campus by the course instructor and its technician. This structure was required to form a path for a rolling ball, and interact with its neighbouring structures to create seamless track. Collectively, all team structures (a total of ten) formed a ring allowing for continuous ball movement once started. These pass-off points between each structure were determined collaboratively between both teams and individuals.

The design-build project had four Milestones:

Milestone #1 (Concept Sketch) - Students worked individually and independently to create designs responding to the problem statement, and evaluate their pros and cons.

Milestone #2 (Design Proposal) - Teams combined individual concept sketches into final design (i.e. sub-structure), broken into three or four modules (one of which each team member would be responsible for constructing). Teams negotiated with their neighbours to inform their final design, and developed a project proposal including a scope, time, and cost baseline.

Milestone #3 (Progress Report) - Student constructed one of the modules within their team sub-structure. Changes to the module design were required to be submitted by the team collectively, and approved by the instructor through a formal change request, providing details on how that change would impact scope, schedule, budget, and (potentially) the neighbouring teams. A progress report was produced at this stage.

Milestone #4 (Final Report) - Each student delivered their module to the University campus. Teams provided suitable instructions for the instructor and technician to combine the structures within a set period of time. A final report on the team project was produced including a virtual class and community presentation.

This paper describes how a team-based cornerstone project experience was managed, and its impact on the student experience.

Introduction

Vancouver Island University (VIU) is a teaching intensive university, which offers a one-year, Engineering Transfer certificate aligned to the British Columbia (BC) Common First-Year

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Engineering Curriculum (CFYEC) [1]. This certificate, which includes courses in Science, Math, English and Engineering Design, provides a pathway for students to start their engineering education at VIU and transfer seamlessly into nearly all engineering schools in BC[2], as well as the University of Alberta.

All students within the certificate are traditionally arranged in cohorts to encourage the building of a learning community, increase collaboration, and motivate peer support [2,3,4]. Due to the impact of COVID-19, VIU shifted to an entirely on-line instructional model for its first-year curriculum. Although the cohort model was maintained in this environment, students were not expected to meet face-to-face; all interactions between students and their instructors would take place virtually. This paper specifically focuses on the cornerstone project, one of the key deliverables of the second-term engineering design course (ENGR 121). It describes how this project was adapted to allow for individual students within teams to be isolated during their work, and provides reflection on the impact of these changes on the student learning experience and development of specific graduate attributes required by the Canadian Engineering Accreditation Board (CEAB) [5]. Further investigation to better qualify the impact will take place over the next year.

Project Approach

Project Description

At the start of the Jan-Apr term, the ENGR 121 class was asked to design and build a rolling ball sculpture[3] that allowed for a stainless-steel ball to roll continuously within it. This project was inspired by the rolling ball structures located outside many local science centres (e.g. TELUS World of Science in Vancouver, BC). The class was randomly split into ten student teams (either three or four members per team), and assigned a portion (hereafter referred to as a sub-structure) of the overall class structure. Figure 1a illustrates how each of these sub-structures (labelled as 'A' through 'J') was arranged in the larger class structure, as well as the path the stainless-steel ball was intended to follow (shown by an arrow). For example, the sub-structure designed and built by Team I was to receive the ball from Team H and pass the ball to Team J.

As COVID-19 did not allow for members of each team to meet physically during the term, each sub-structure was to be designed by that team such that it could be broken up into three or four modules. Each team member was responsible to construct one of these modules. Figure 1b shows an example of a 2D sketch drawn by a student team that illustrates the ball's intended path through their sub-structure. In this case, the ball is received by the first module (labelled as Module L), travels through Module Z, X, and B in succession, and is subsequently delivered to the next team.

At the end of the term, each team member was required to deliver their constructed module to the University campus; each team was to provide sufficient instructions for the course instructor and technician to combine the individual modules into the intended sub-structure.

[2] University of British Columbia, University of Victoria, University of Northern British Columbia, and Thompson Rivers University.

[3] Referred also by such terms as Kugelbahnen, or, less accurately, kinetic structures

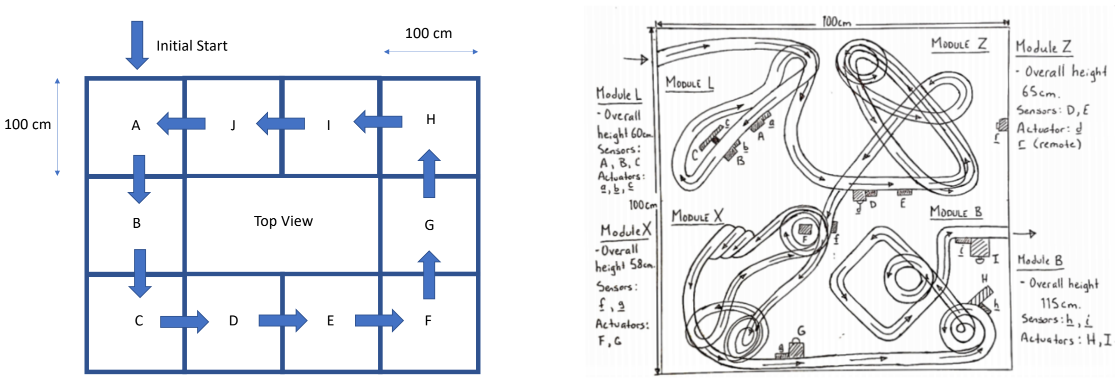

Figure 1. (a) Arrangement of Team Sub-structures within the Class Structure and (b) a 2D Sketch of the Ball's Travel through the Modules of a Team Sub-structure

Project Requirements
The project requirements were applied at three levels: Class, Team, and Individual. The specific requirements for each level are shown below:

- Class Level – Neighbouring team sub-structures must interconnect physically to allow for smooth transition of the stainless-steel between them.
- Team Level – Team sub-structures must show creativity. The stainless-steel ball must smoothly travel between all the sub-structure modules through effective use of mechanical interconnects between those modules. Finally, the following technical requirements must be met by at least one of the team modules:
    - The stainless steel-ball was to be raised over a given change of height
    - A deliberate sound connected to the ball bearing's motion was to be emitted.
    - The number of ball bearings passing a given point in the sub-structure was to be displayed.
- Individual Level – Each module had imposed physical constraints (e.g. minimum size, primary load elements, minimum total drop/gain in ball height) and component constraints (e.g. use of an Arduino UNO, number of sensors and actuators)

Project Supplies
Each student was provided a remote lab kit consisting of common supplies to aid with their project. This kit included common sensors (e.g. sonic sensor, push buttons) and actuators (e.g. small geared motor, LEDs), wire, resistors, a breadboard, wire strippers, pliers, 1000 popsicle sticks, a motor controller board, and a printed circuit board (PCB). The PCB was designed and produced by the department technician, and consisted of an Arduino UNO and several connected components (e.g. small breadboard, LEDs, 7-segment displays, light dependent resistor, push-buttons). The PCB, tools, and motor controller board were provided on loan to students, and returned to the University (by mail or drop-off with their final project) after the course completed.

Project Progress
The project was split into design and build phases, consisting of four milestones over the entire term (approximately three months).

The design-phase included two Milestones over the first four weeks of the term:

Milestone #1 (Concept Sketch) - Students worked individually and independently to create concept sketches responding to the problem statement, and evaluate the pros and cons.

Milestone #2 (Design Proposal) - Teams combined individual concept sketches into a final design (i.e. sub-structure), broken into three or four modules (one for each team member). Teams negotiated with their neighbouring teams to inform their final design, and developed a project proposal including a scope, time, and cost baseline. Self and peer reviews were undertaken.

The build-phase included two Milestones over the last eight weeks of the term:

Milestone #3 (Progress Report) – Each student constructed one of the modules within their team structure. Suggested changes to the module design were required to be submitted by the team collectively, and approved by the instructor through a formal change request. Each request provided details on how that change would impact scope, schedule, budget, and (potentially) the neighbouring teams. A progress report was produced at this stage. Self and peer reviews were undertaken.

Milestone #4 (Final Report) - Each student delivered their module to the University campus for assembly by the course instructor and technician. A final report on the team project was produced including a two- to three-minute video that was to sell and/or explain the team structure to the assessors. Self and team reflections were completed.

This framework is illustrated in Figure 2.

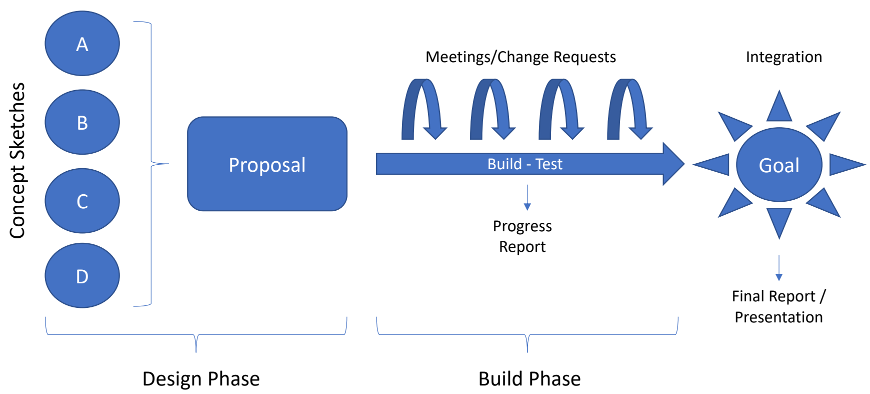

Figure 2. Design-Build Project Framework

Throughout the term, teams were to have a minimum of one meeting each week. Minutes were recorded in a shared Google Doc with the course instructor, both to define action and responsibilities within the team, as well as to allow for monitoring of team progress. Formal team check-ins were scheduled bi-weekly with the course instructor, and took place virtually via Zoom. A Discord channel created for the class had designated team rooms to provide for internal and external team communication, although participation on this forum was optional. All course communication and submissions took place via VIULearn, a variant of the Brightspace Learning Management System.

Results and Discussion

Technical Requirements

All team projects were received at the end of the term, excluding two modules from individuals who did not continue with the course, and another module from a student who was located overseas. For each of these three cases, a simple bridge connecting the drop-off / pick-up point for the ball on adjacent modules was implemented by the technician supporting the course. Evaluation of the module for the student residing overseas took place via Zoom.

The class goal of having a stainless-steel ball roll continuously through all the team sub-structures was not achieved; however, in most cases the ball rolled successfully between modules within teams. The ball was also able to travel between three team sub-structures (representing 12 different student modules) with limited assistance. As a primary project deliverable, the interfacing between and within teams was generally achieved.

The central technical challenge observed was reliable operation of the lifting device intended to raise the ball over the height difference demanded by the team design requirements. This failure was typically due to difficulties interfacing between the motor and its controller). To continue evaluating the overall operation of the module and team sub-structure, the assessor bridged the lift component (usually by physically lifting the ball to height). Some students were also found to have challenges interfacing both sensors and actuators to the Arduino UNO.

General Reflection

A survey of students was undertaken at the end of the project with responses based on a Likert scale. The results are shown in Figure 3.

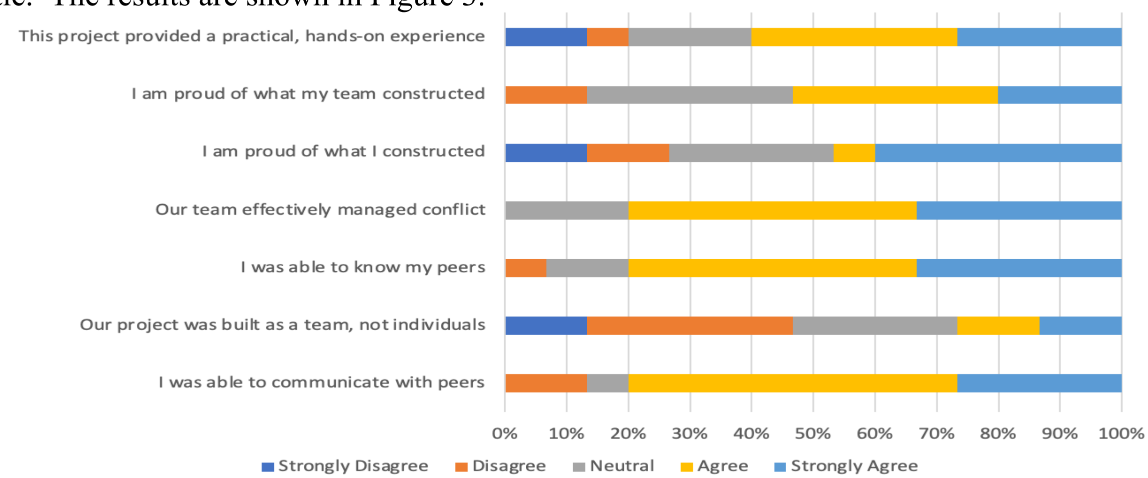

Figure 3. Student Survey Results

In general, despite only meeting within a virtual environment, over 80% of students either agreed or strongly agreed with statements on effective conflict resolution, productive communication, and getting to know their peers. More concerningly, less than 30% of students described the resulting construction as a product of their team, and barely half of students were proud of what their team built (less than half were proud of what they individually constructed). This result was not surprising; often during the term, students referred to their modules in the first person, suggesting individual as opposed to collective ownership.

A cornerstone project has been part of the first-year engineering curriculum for almost ten years, which, until recently, took place face-to-face; hence, a comparison between the current instance and previous offerings could be made. In contrast to the in-person project work pre-COVID, the author observed increased challenges related to time management and peer support when the project was completed by students in physical isolation. Student reporting and perception over the term tended to overstate their progress, which led to a compressed delivery schedule at the end of the term. The active monitoring process used by the instructor proved inadequate for all students, and will need to be modified if a similar project is to be undertaken again.

The peer support environment also differed considerably from that which existed in previous years. Pre-COVID, the lab studio was treated as a common area, and students had unrestricted access to that space for most of the day and evening. As such, they were able to schedule times when all their team could work together on projects and assignments. During COVID-19, this shared, physical space was not available, and students were required to work individually at home on their projects, and interact through virtual tools (e.g. Discord). The author observed that more students struggled with technical skills (e.g. electronics, programming), and collectively exhibited a broader response when it came to delivered quality i.e. far more students choose to meet the minimal project requirements than in previous years.

Lessons Learned

The challenges presented by providing a team-based, project experience to students during COVID-19 are considerable, but did suggest possible improvements to future iterations of this project (either offered face-to-face or remotely). These include:

- Create short term, verifiable project deliverables to aid student time management
- Enhance tutorial sessions and improve collaboration between disciplines (e.g. Computer Science) to mitigate gaps in technical background
- Continue support of online tools (e.g. Discord) to add value to the student experience, and community building.
- Split the design-build phases between separate teams [6] to encourage better communication between teams and collective ownership of the final product.

Acknowledgment

The author would like to thank David Moss, the VIU Engineering technician, for creating tools and processes that enhanced student engagement under rapidly changing conditions.

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