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Teaching in the Era of COVID-19: A Reinvented Course Project for an Ocean Engineering Course

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Abstract

Experiential, team-based course projects, with an emphasis on designing and building physical products, are increasingly being adopted across many engineering disciplines, including wide use in ocean engineering courses. COVID-19 presents new challenges to pedagogies that rely heavily on physical production and face-to-face teamwork. While collaborative, hands-on projects, such as designing and building ROVs, have many documented educational gains—deepening content understanding and improving motivation, to name a few—these once beneficial activities are currently infeasible. The complications brought on by the pandemic necessitate the creation of new course projects that heed social distancing guidelines, minimize touch, and accommodate remote learners, all while continuing to enhance student learning.

In the Fall of 2020, our small liberal arts university reopened its classrooms for in-person teaching and learning. While most students elected to return to the physical classroom, some chose to learn remotely, resulting in a large number of hybrid course offerings. The potential for a spike in COVID-19 cases in the campus community meant that courses could pivot to fully remote teaching and learning at any moment. In response to this new pedagogical framework, the semester-long course project for an upper-level ocean engineering course was reinvented. The project was inspired by Wired Magazine's video series "5-Levels" in which experts explain a topic to a child, teenager, undergraduate, graduate student, and an expert in their field. This fall, students worked individually to create a video series in which they explained a self-selected advanced topic in ocean engineering to three distinct audiences of their choosing. The success of the new course project is assessed through analysis of students' videos, reflection papers, peer evaluations, and course surveys. More specifically, the aim of this work is to explore the efficacy of the project in meeting a variety of learning outcomes, including enhancing 21st century skills in audiovisual communication, and deepening the students' knowledge of ocean engineering concepts. Finally, this paper shares lessons learned and provides recommendations for future implementations of this course project.

Introduction

Experiential learning has gained ample traction in engineering education for its efficacy in motivating students [1], increasing understanding of content [2], strengthening innovative thinking [3] and boosting self-efficacy [4], among other benefits. A wide range of pedagogies fall under the umbrella of experiential learning, which share similar benefits, but are also challenged by the current pandemic. Experiential learning often entails group work, interaction with technical equipment, and collaboration with individuals outside of our campus. These types of activities have become more difficult as we've entered an era of social distancing, remote learning, and other COVID-19 safety protocols.

These teaching and learning strategies are being employed and assessed both inside and outside of the classroom. One approach from outside the classroom is student participation in inter-university design competitions which provides opportunities for hands-on, team-based work which motivates and enhances soft skills development [1], [5]. Service learning, or community engagement projects, have gained popularity for their documented ability to improve communication and collaboration skills, while challenging the students to apply their engineering knowledge in a real-world setting [6], [7], [8], [9]. While the ability to travel for inter-university design competitions and meet face-to-face with community partners are challenged by the current pandemic, creative measures are being employed such as virtual competitions and online collaboration.

Inside the classroom, the same challenges exist to implementing successful experiential learning activities, especially when those classrooms are remote or hybrid. Project-based learning (PBL) is frequently employed in first-year survey courses as well as senior capstone courses, for its demonstrated strength in promoting skill development and deepening content understanding. PBL is shown to improve student self-efficacy through challenging students to solve real-world problems in a collaborative environment [4]. Furthermore, PBL facilitates the creation of learning communities [10] and strengthens bonds between students [11]. Design-build projects, sometimes a subset of PBL, has gained popularity as it can increase student interest in content material while also teaching manufacturing skills [12], [13], [14], [15].

Many universities taught courses entirely online in the Fall 2020 semester, and even the schools that planned to reopen for in-person learning could not guarantee how long students would be able to remain on campus [16]. Remote learning poses hurdles to the use of lab equipment and machine shops. Moreover, even for students learning on campus, the need to social-distance often stood in the way of face-to-face collaboration. Creativity on the part of faculty, students and administrators was necessary in confronting these challenges to learning.

Various developmental theories on experiential learning are adopted in this work. McCormick, et al, describe the work of Dewey [17], [18], [19], [20], Piaget [21], Kohlberg [22] and Kolb [23] comprehensively in their assessment of an international service-learning project, though the theories are more broadly applicable to experiential learning in general [8]. Dewey pioneered the theory, arguing that reflection is necessary for gaining new knowledge [17]. Piaget built upon this theory, arguing that overcoming struggle is required to gaining understanding [21]. Kohlberg contends that the challenge must be moral in nature [22], while Kolb's approach is more holistic in nature [23], arguing the need for continual challenges and regular reflection. In particular, this work grounds itself in the importance of self-reflection in cementing content knowledge and acknowledging skill development [24], [25], [26].

This paper aims to explore the efficacy of the reinvented course project for the Fall 2020 semester – which sought to work around the challenges of the pandemic – as well as provide materials for other instructors to implement this or a similar project at their institution, and provide suggestions for improvements to future deliveries of this project.

Project Overview

This fall, an upper-level elective course about ocean engineering was offered for undergraduate engineering students. The course roster was comprised of seniors specializing in mechanical or electrical engineering. A previous offering of the course required students to collaborate on small teams to design and manufacture interactive displays appropriate for a science museum that would educate the public about an application of ocean engineering. Due to health and safety guidelines necessitated by the impacts of COVID-19, and the potential for returning to fully remote teaching and learning, this hands-on, group based project required rethinking.

Our university offered primarily in-person courses in the Fall 2020 semester. However, some students opted to take courses entirely remotely. Additionally due to social distancing requirements and the limitation of classroom size, not all in-person students could attend every lesson in the same classroom as the professor. Instead, the in-person students rotated between a main classroom and an "overflow" classroom down the hall, where the lesson was broadcast via Zoom (best described as a hybrid format). The diversity of class attendance methodologies complicated teaching and learning considerably, including the ways in which group projects could be implemented.

A new semester-long course project was designed in response to the new constraints of teaching in a global pandemic. The assignment would need to be amenable to social distancing, adaptable to a return to remote learning, while also being valuable for students learning and skill building. Moreover, the project should fulfill various course learning outcomes, including training students to thrive in 21st century careers that require ample digital collaboration.

The Inspiration

The course project was inspired by Wired Magazine's video series called "5 Levels" [27]. The twelve episode series invites experts in a wide range of areas – from laser physics to musical harmonies to sleep science – to explain an advanced topic to five audiences (a child, teenager, undergraduate, graduate student, and colleague). The videos include sequential discussions with an individual from each level, beginning with child and growing in complexity until the expert meets with a colleague. The videos vary in length between just under 10 minutes to just over 30 minutes.

The concept of the video series poses a great challenge, not only in terms of communication but also content. To be able to explain an advanced topic across audiences requires a very strong understanding of the topic, as well as an ability to draw parallels to more familiar concepts and minimize jargon for younger audiences. While the experts in the videos are not required to handle the challenge of recording themselves, this added hurdle would be required of students, further enhancing the learning opportunities. As such, asking students to create their own video series would be a challenging, but hopefully fulfilling exercise in deepening their understanding of a specific topic in ocean engineering.

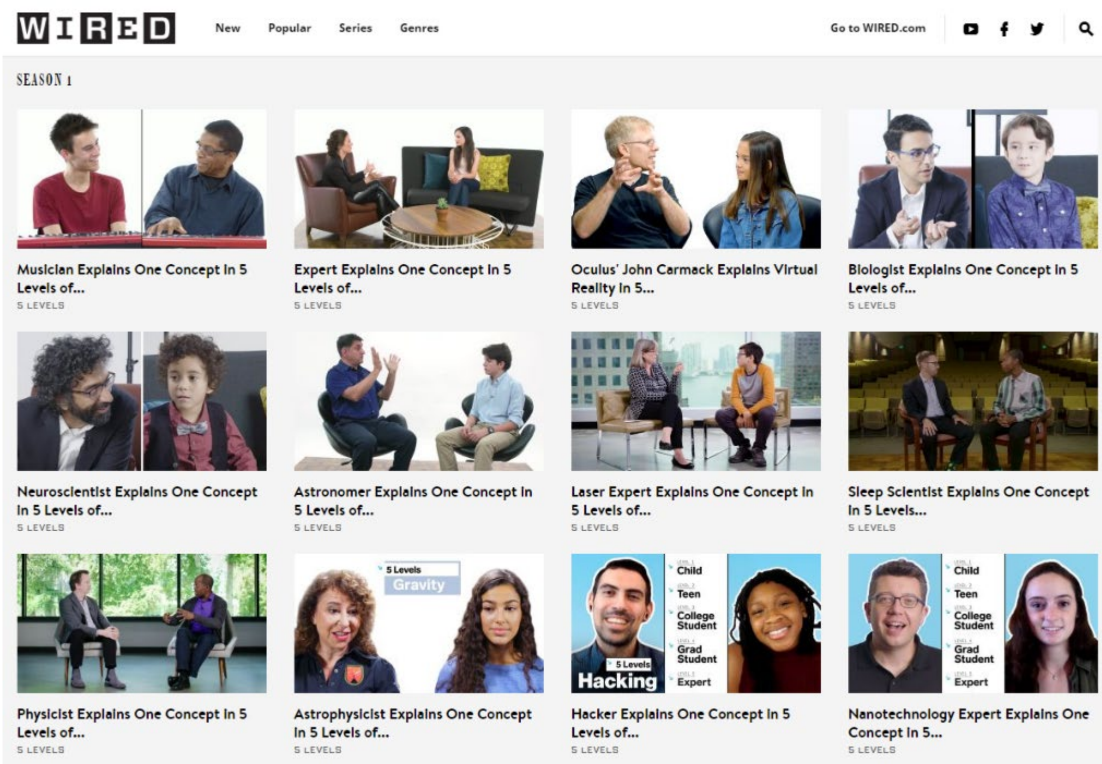

Figure 1. *Screenshot of Wired Magazine's "5-Levels" webpage, including twelve videos featuring experts explaining a topic to five unique audiences.*

Finally, this format is largely amenable to the constraints imposed by COVID-19. With a few adjustments the idea of a video series could be adapted for a course project during a semester of teaching in mixed modalities with remote, hybrid, and in-person students.

The Assignment

For the project, students would work individually to create a video series about a self-select advanced topic in ocean engineering. Instead of requiring students to explain their topic to five audiences, the expectation was lowered to just three audiences. It did not seem appropriate to ask students to explain their topic to any audience levels above their own training (graduate students or experts, for example). Instead of speaking directly to their audience – which would add the challenge of identifying specific individuals and potentially breaking social distancing requirements – students would create one-sided videos featuring only themselves. Students were encourage to develop visual aids, whether that be props, slides, drawings, etc. Finally, videos were recorded with Panopto [28], as it is provided freely through our university's course management system [29].

The assignment was introduced to students in the sixth week of the semester. The project was split into four milestones, each comprised of multiple parts. The milestones, their timelines, and deliverables are presented in Table 1. The milestones were designed to keep students on-track with project progress throughout the second half of the semester, with the ultimate goal of watching, evaluating and reflection on their peers' videos at the end of the term.

Table 1. Project milestones, including due dates and deliverables.

Milestone	Due Date	Part	Project Deliverables
1 [25 pts]	Week 7	A	Watch two videos from Wired website and respond to a series of reflection questions.
		B	Pick your topic, write a brief description, and identify your three levels (audiences).
2 [50 pts]	Week 9	A	Demonstrate progress on your research by performing a literature review and writing an annotated bibliography.
		B	Create a 30 second demo video to demonstrate working understanding of Panopto tool.
		C	Complete a self-reflection of your progress.
3 [75 pts]	Week 13	A	Upload your final video to the Panopto tool on course website
		B	Prepare a 90 second elevator pitch to share in class
4 [50 pts]	Final Exam Week	A	Watch three of your peers' videos; summarize the topic, evaluate their work, and brainstorm follow-up questions.
		B	Complete a self-reflection of your work on this project.

The first milestone was designed to familiarize the students with the Wired Magazine video series, as well as task them with identifying their project topic. In addition to introducing the video series, the aim was to also enhance students' appreciation and understanding of effective methodologies for explaining a complex topic to an array of audiences. Students watched two videos and responded to a series of reflection questions designed to prompt evaluation of the efficacy of the videos and inspire approaches that they might adopt for their own videos. The reflection questions are presented in Table 2.

During this milestone, students also needed to select their project topic. Selecting their project topics early in the assignment would allow them to begin conducting research right away. The hope was that each student would select a unique project topic such that by the end of the term the class would present a suite of videos over a wide range of ocean engineering applications. Additionally, students needed to identify their three audiences.

Table 2. Reflection questions included in Part A of Milestone 1, in which students watched and reviewed two videos from the Wired Magazine video series "5 Levels".

Milestone 1 – Reflection Questions	
Part A	Watch two videos from Wired website and respond to the following questions: • Who was the expert? • What was the topic? Can you explain it in a few sentences? • What specific differences did you notice between their levels of explanation? Give examples. • In general, what worked well? What didn't work so well? • What did you see in the video that you might adopt for your own video?

Milestone 2 served to check-in on students' progress. Part A tasked the students with created an annotated bibliography with at least three articles from scholarly journals. Each annotation required two paragraphs, summarizing the work and discussing how the article would be useful for their project. Additionally, students were to provide a draft of speaking points for each audience.

The next part of the second milestone was designed to ensure a working understanding of Panopto as a tool for recording video. Students needed to create and upload a 30 second demonstration video. Finally, Part C included a series of reflection questions for the students to self-assess their own progress thus far. The questions are presented in Table 3.

Table 3. *Reflection questions designed for students to self-assess their progress after completion of Milestone 2.*

Milestone 2 – Reflection Questions	
Part C	Reflection on your progress: • What is going well? • What challenges have you confronted? • What are your next steps?

The third milestone focused on the delivery of the video itself, as well as the creation of a 90 second elevator pitch to share with their classmates. The aim of the elevator pitch was to advertise their topic so that their peers would be motivated to watch their "3 Levels" video. No reflection questions or written reports were required during this milestone, as the creation of the video entailed ample time and effort.

Lastly, instead of ending the project upon the completion of the students' videos, Milestone 4 asked students to watch three of their peers' videos. The aim of the final milestone was to expand students' knowledge about ocean engineering topics not covered in lecture. Further, the objective was to deepen communication skills through evaluating their peers' work, as well as their own. Part A of the milestone involved completing peer evaluations, followed by a self-reflection in Part B, with questions shown in Table 4.

Table 4. *Peer evaluation and self-reflection questions assigned in Milestone 4.*

Milestone 4 – Reflection Questions	
Part A	Watch three of your peers' videos. For each, respond to the following: • Describe their topic in your own words. • What was most effective about their video? • What could be improved? • What follow-up questions do you have?
Part B	Self-Reflection • What went well for you in this project? • What was challenging for you in this project? • What did you learn from this project – both in terms of content knowledge and skills?

The Delivered Project Results

Students were given free rein to select their project topics. The instructor intervened in a few instances to ensure each student had a unique project topic and to guide students away from selecting a topic covered in the course. There were a few instances where the scope of the topic needed adjustment as well. In the end, nearly every student had a unique topic to explore and explain for their "3 Levels" video. The topics, sorted thematically, are shown in Table 5.

Table 5. *Students' self-chosen project topics, sorted by theme.*

Theme Areas	Individual Project Topics
Hydrodynamic Phenomena	• Wave Interference Patterns • Whirlpools • Waterspouts • Tsunamis
Marine Vessels	• Submarines - Oxygen Generation • Submarines - Stability • Remotely Operated Vehicles (ROVs) • Chart Navigation for Boats
Measurement and Sensing	• Search And Rescue Algorithms • Lidar • Sonar • Underwater Acoustics • Bathymetry
Marine Energy	• Ocean Thermal Energy Conversion (x2) • Wave Attenuators • Tidal Turbines • Offshore Wind Farm Construction • Offshore Energy Storage and Transportation
Mining	• Metals Extraction • Vortex Induced Vibration on Mining Devices

Many of the students chose similar formats for presenting their work. The majority of students created slide presentations to explain their topics and provide supporting visuals. Two students used a drawing tool to create diagrams, write, and otherwise illustrate their points as they spoke. Examples of students work as shown in Figure 2. The Panopto video software allowed students to share a thumbnail video of their face while using the majority of the video screen for their visual aids. The average video length was 10 minutes 41 seconds, the shortest video was just over 6 minutes and the longest video was nearly 31 minutes.

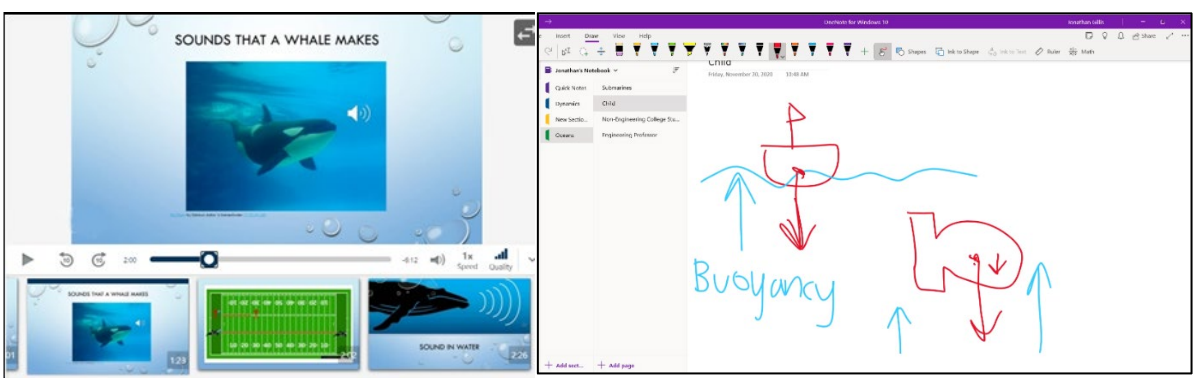

Figure 2. *Students used variable approaches for visual aids; PowerPoint slides with audio (left), and a synchronous drawing tool (right).*

Each student identified three audiences for their own project. Despite the open-endedness of this piece of the assignment, the majority of students selected very similar groups for their audiences. Most student identified elementary age students for their first audience, which is likely due to previous participation in a community engagement project with local fourth graders, which provided familiarity with that level [30]. A frequently identified audience for level 2 was high school students, though the specificity of the group varied; some specified students enrolled in physics, for instance. A college student audience was another common choice, again with variable levels of specificity – sometimes the student's major was stated, other times not. The level 3 audiences spanned the most difference – from parents to graduate students to engineering professionals and professors. Many students included transition slides in their PowerPoint presentations to signal changes between their audiences, as shown in Figure 3.

Figure 3. *Examples of transition slides from three students' presentations, identifying different audience levels.*

Methods

The efficacy of the course project, reinvented to be adaptable to a semester impacted by COVID-19, is assessed through two main methodologies. First, a direct assessment of student work is performed using "teacher research" [31], [32], [33]. That is, student created artifacts from the course project are analyzed to determine degree to which students learned skills and enhanced content knowledge. In particular, students' writing from various project milestones are examined, with a specific focus on reflection pieces. Throughout the milestones students were asked to evaluate the videos produced by Wired Magazine and their peers, as well as complete self-reflections at multiple time points. As discussed in the introduction, reflection work is critical to student learning. The assessment and inclusion of student work in this paper was reviewed and approved by the institution's Humans Subjects Review Board (HSRB).

Finally, an indirect assessment from student survey responses is presented. Upon completion of the course project, students completed an end-of-semester course survey which included eight

Likert-type questions. The numerical responses to the survey are used to indirectly assess various learning outcomes from the course project.

Results and Discussion

Direct Outcomes Assessment from Student Created Artifacts

Students responded to a variety of reflection prompts and evaluation questions throughout the four milestones of the course project. Pull quotes from the students' reflections and evaluations are sorted thematically in Tables 6-9, drawing from various milestones throughout their project work.

In Milestone 1, students watched two videos from Wired Magazine's "5 Levels" and evaluated what worked well and what didn't work well. In the final project milestone, students evaluated the efficacy and provided suggestions for improvements about three of their peers' videos. Recurring themes appeared in the students' comments about the Wired Magazine and their peers' videos, as shown in the first column of Table 6, alongside pull quotes.

The use of visual aids was a consistent theme throughout the students' evaluation. In the Wired Magazine series, students noted the effectiveness of props, and were later able to recognize the effectiveness of their peers' slides or other visual aids. Moreover, in evaluating their peers' work, students also acknowledged visual aids as an area where some of their peers could improve, often due to wordiness or appropriateness of content. More generally, students commonly noted positive traits from the Wired Magazine videos, which then appeared in their peer evaluations in both positive and more constructive ways. Other frequent themes included use of metaphors, catering information for different audience levels, use of questions, general structure of presentation, and finally vocabulary. A screenshot of a presentation that used PowerPoint slides and a thumbnail video of the student, is shown in Figure 4, exemplifying the ability for the student to ask rhetorical questions and simulate engagement with an audience.

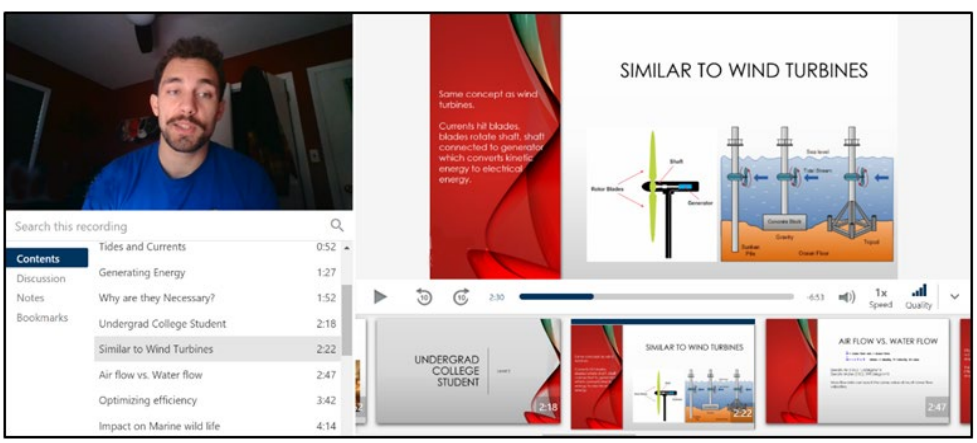

Figure 4. *An example of a presentation using PowerPoint slides and a thumbnail video of the student speaking.*

Table 6. *Thematic responses to students' evaluations of the "5 Levels" video series by Wired Magazine and their peers' videos, with pull quotes as examples, from Milestones 1 and 4.*

Theme	**Milestone 1: Reflections on Wired Magazine Videos** What worked well? What didn't work so well?	**Milestone 4: Peer Evaluation** What was most effective about their video?	**Milestone 4: Peer Evaluation** What could be improved?
Visual aids and props	"the use of props was good throughout his explanation"	"There was a very limited amount of words on his slides which meant that instead of reading the slides, I could just listen to his explanation of the topic." "The use of the whiteboard tool was very effective."	"The slides had mostly words and not too many pictures. Some of the pictures that were included were just graphs or tables that were hard to read and understand."
Metaphors, analogies, and examples	"When explaining this topic to a child, Samy Kamkar used the metaphor of breaking into a lock to help give a physical example that relates to hacking."	"Something she did well was making good comparisons for fourth graders to give context and help them understand concepts."	"If possible, I think more relatable connections could benefit this section. For instance, using analogies to something that a child may encounter in everyday life."
Different Audience Levels	"He strays more from explaining the basis of how it works, but rather focuses on a controversial aspect of the field."	"[The student] did a very good job using relatable examples for the 4th grade audience."	"I would have liked to see more of a difference between the levels."
Use of questions	"…starting off the conversations with assessing the other person's knowledge."	"He placed questions that could be asked in his slides, and the directly answered them. This […] mimicked a conversation as well as possible."	
General structure	"In the beginning, she asked what they know about, and at the end she asked what they learned from the discussion."		"The presentation needed more structure. There were times when elements were presented later than they should be, especially when they're apparently quite important."
Vocabulary and jargon	"For the lower levels, he does not use any fancy jargon or big words."	"Getting the visual reference and vocabulary ahead of time means there's much less risk of something being communicated improperly."	"I think the video could serve to be more careful about the words being used, as the vocabulary for the explanations was the same sort I would expect from an engineer talking to an engineer."

This thread of common themes perhaps suggests that it was a worthwhile exercise for the students to evaluate the experts in the "5 Levels" videos before creating their own videos and then reflecting on their peers' work. The evaluation of the Wired Magazine videos required students to recognize effective communication strategies and reinforce those ideas through reflection.

Table 7. *Thematic Responses from Students' Self-Reflections in Milestone 4.*

Theme	What went well for you?
Visual aids and props	"The use of PowerPoints also greatly helped me while performing my presentations because it gave me something to reference while performing the presentations."
Metaphors, analogies, and examples	"Picking out analogies to use for the first level (child) explanation. In my research for the first milestone, I found that the experts oftentimes used analogies to simplify things by contextualizing the concepts into something the child would understand. I chose to apply this to my concept."
Different Audience Levels	"I think one of the things that went well for my project was my slideshow, I feel that it does a good job in supporting the differences between my style for the audiences. For example, the slides for kids have a lot of animated and moving parts and pictures to keep them engaged, while the college students were more focused on text and diagrams."
Research	"I felt that my research effectively reflected the information required to discuss my topic with the 3 selected audiences. [...] It seemed to be there was a perfect resource available for exactly what I knew I was going to need." "In my research, I found that many of the equations used to model the vibrations were ones I was familiar with and could understand why scientists applied them as they did." "Watching a few of the WIRED Magazine videos proved to be beneficial to my presentation. I noticed in a few of the videos that the expert would dive deeper into a specific aspect of his/her topic for the more educated audience's vs trying to explain the basic concept again in more detail."
Creation of the Video	"I think the filming of the videos went well and by the end of it I only had to do one take for the final video."

When dissecting student self-reflections about what they thought went well for themselves, some of the same themes from their evaluations of others resurfaced, while some new ones were introduced. Common themes from students' self-reflections in the final milestone are presented in Table 7, alongside pull quotes.

The same refrains about visual aids, use of metaphors, and catering information for different audience levels were found in the self-reflections, just as they were in the evaluations. Additionally, many self-reflections included commentary about the research aspect of the project; that through finding resources, engaging in coursework, and watching the Wired videos, they felt well prepared to complete this project. The creation of the video was also mentioned as a self-identified success. Perhaps not surprisingly, the new theme areas represent factors that students would not be able to comment on about others.

Table 8. Student-identified challenges confronted during Milestones 2 and 4.

Challenges Confronted		
Theme	**Milestone 2**	**Milestone 4**
Research	"I think it might be best for me to look up YouTube videos explaining them, perhaps on Khan Academy, and then turn back to scholarly journals once I establish a foundation. The articles are a little bit over my head at the moment." "One of the challenges that I have faced in my research is that the theory for the equations presented in the first article were complicated and confusing."	"The most challenging part of this project was performing the research. I found it very hard to find relevant articles to pull from and most of the time I only came away with a couple of pieces of information from each article." "I found a majority of the articles involving [my topic] were not available online through the [university's] library resources. This made understanding my topic harder, as information was hard to find without some clever keyword searching"
Lack of a real audience	"Another challenge I've encountered is just trying to think about how to have a conversation with someone who's not there." "I kind of wish we could record ourselves talking with another person because I would honestly be interested to see how much my 9-year-old cousin knows about the way whales communicate and the speed of sound in the ocean."	"I was upset the project was not laid out like the actual '5 Levels' videos where we could have a conversation with a person from each level we chose. Obviously, this was not a reality given the circumstances of this semester, but I hit an unexpected roadblock when it came time to record my video." "I wish I brought a friend to act as the audience for the various levels of expertise. This would have allowed my videos to be more similar to the three levels, without finding a child, high school student and PhD student."
Selecting a topic	"I got off to a bit of a rough start with my initial topic choice, as it was much too broad." "I initially struggled with deciding on a topic. I could not think of something that would be appropriate for 3 different audiences."	"The first challenge I had was picking a topic, which I know doesn't seem to be very difficult, but was something I had trouble with. My issue was that ocean engineering encompasses such a broad spectrum of topics that it made it difficult to hone in one just one."
Creating the videos	"As far as the recording with Panopto, I had some difficulty in the beginning."	"One of the main things that I struggled with during this project, was first of all, working with Panopto. I found this software very confusing to work with and somehow, I ended up with 50 videos in my files which were all mistakes since you are not able to delete them."
Audience above their level		"What I found most challenging was creating the explanation for the graduate student. I wanted to pick an upper level audience to add more variety to the project, but found it difficult trying to explain the topic to someone who had more background knowledge than I did going into the project."

Beyond self-identified success areas, students were asked thinking more critically about what challenges they confronted while working on the project. The prompt was given in both Milestones 2 and 4. Commons themes, alongside pull quotes, are presented in Table 8. New themes arose when students reflected on the challenges they confronted, but these themes remained consistent between the early stages of the project and upon completion of the work.

Students pointed to the challenge of speaking to audiences above their own, for instance graduate students and engineering professionals. Slides from a student's presentation to three audiences, including a level above their own – engineering graduate students – are shown in Figure 5. The slides demonstrate jumps in complexity when explaining search and rescue algorithms, which at the graduate level required learning advanced fluids topics (Lagrangian vs. Eulerian flow descriptions). Many students also reported that the research, lack of a physical audience, topic selection, and video creation level as challenges.

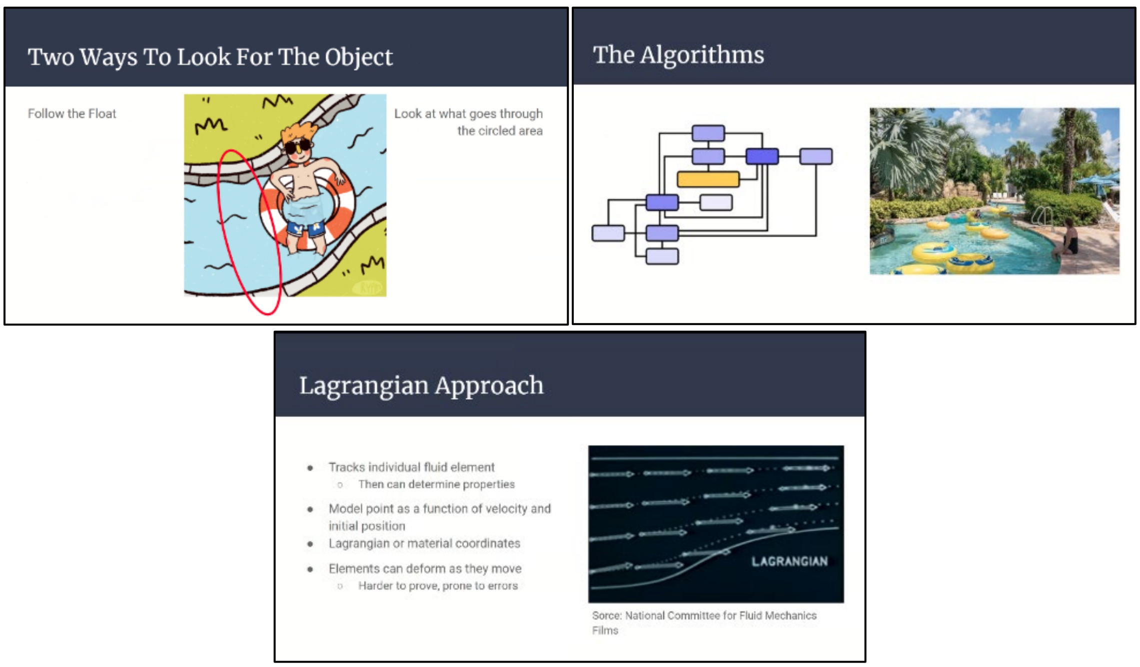

Figure 5. *PowerPoint slides created by a student to explain search and rescue algorithms at three levels; to a fourth-grader, a high school physics student, and an engineering graduate student (clockwise from top left).*

Finally, in Milestone 4 students identified skills that they gained from working on the course project. Representative pull quotes, sorted thematically, are provided in Table 9. Students pointed to gains in communication skills, most notably in catering information to different audiences. Additionally, students recognized growth in their ability to perform research from scholarly sources, confidence in presenting, and newly gained technical skills in creating videos. Responses from students also recognized the inherent difficulty of communicating complex topics to a range of audiences. Finally, students shared that they gained new content knowledge in ocean engineering upon completing this project.

Table 9. *Thematic responses to student-identified gained skills from course project, as reported in Milestone 4.*

Skills Gained	
Theme	**Milestone 4**
Catering information for different audiences	"This project has provided me with various types of tools: understanding the needs of your audience, methods of catering to your audience, and general presentation skills. As mentioned in the beginning of this reflection, I believe catering to your audience is a vital part of presentations that can often times be overlooked." "I developed a better understanding of what methods are most effect for talking to different audiences. I solidified that younger audiences glean more from a presentation that includes visual examples and relatable anecdotes. As for the higher level audiences, I learned that there is more freedom to discuss the mathematical relation of some topics, but that it is still smart to avoid getting too specific, because even with a well versed professional extensive talk of strictly mathematical concepts can be confusing."
Research Skills	"I learned a good amount about annotated bibliographies and how to do effective research. It is a necessary skill, but not one that I practice very often." "I believe it has also helped me improve my ability to research and extract important information from lengthy articles, as well as gauge my audience and their ability to comprehend the topic at hand."
Presentation skills	"In terms of presenting, I hate it. I do not like presenting whatsoever and feel my presentation is poor. I get very nervous when I have to do it. [...] I looked at this as an opportunity to practice presenting in order to fix these issues I have when I enter the work field and ultimately have to present."
Creating videos	"I learned new skills with Panopto and how to create a lecture with visual aids that enhanced the presentation."
Appreciation of Challenges	"I also learned that it is one thing to understand a topic enough to complete an assignment, and another to understand it enough to be able to teach it." "I learned how hard it is to make quality learning material for audiences of all ages."
New topic in ocean engineering	"I learned a lot both in terms of a new ocean engineering topic and in terms of putting myself in an "instructor" role." "[The project] was beneficial to me as a student because I got to learn and master in something new that I found interest in and I also had the opportunity to share the knowledge learned with my peers and family."

The insights provided by analyzing student-identified challenges in conjunctions with their recognition of gained skills are two-fold. First, their comments shed light on potential improvements to the assignment itself. Moreover, the challenges and successes highlight places where students may have grown most while completing the work, consistent with Piaget's theory of experiential learning [21].

Student comments indicate that catering information to different audiences provided a challenge, which deepened communication skills. However, the assignment would benefit from clearer guidance in selecting appropriate audiences. Students were most successful when speaking to audiences that were at their level or below, but struggled when the identified audience had more advanced training. Further, more specifically identified audiences led to stronger outcomes – for example discerning between high school students versus juniors taking a physics class.

Conducting the research was another area in which students pointed to struggles, which if overcome, led to enriched learning outcomes. On the contrary, if students confronted a challenge and were not able to surmount it, then the learning outcomes were not achieved. To maximize outcome attainment, the assignment would benefit from enhanced guidance and support in conducting background research – for example, by inviting a university librarian to guest lecture on best practices in using scholarly research databases.

Students also identified gains in skills such as presenting and creating videos, as well as expanded content knowledge in ocean engineering.

Indirect Outcomes Assessment from Student Responses to End-of-Course Survey

Students completed a course survey, alongside the university-wide course evaluation, at the end of the semester. The survey included prompts specifically tied to the project learning outcomes. The survey was administered online following a brief introduction by the professor on Zoom. Students were then released to fill out the survey, using however much time they needed. Completion of the survey was not incentivized, which is perhaps why only 12 of 23 students provided responses about the course project.

Table 10. *Responses to End-of-Course Survey Question(s)*

Survey Prompt (1 = Strongly Disagree, 5 = Strongly Agree)	**Average Score** (n = 12)
1. I enjoyed the Three Levels course project this semester.	4.58
2. Whether I liked the project or not, it was valuable for my learning.	4.83
3. Whether I liked the project or not, it was academically rigorous.	4.33
4. I believe that I gained skills from this project that I can apply later in my life and career.	4.75
5. The project strengthened my communication skills.	4.58
6. I gained new skills in audiovisual technology through the process of creating my video presentation.	4.83
7. I learned something new about ocean engineering through the process of creating my video presentation.	4.83
8. I learned something new about ocean engineering by watching my peers' videos.	4.92

The average scores in response to eight Likert-type survey questions are provided in Table 10. For all prompts, the average student response was well above four, indicating strong agreement across the board. In general, the responses suggest that students gained skills they believe they can apply later in life, in areas that including audiovisual technology and communication. The prompt "Whether I liked the project or not, it was academically rigorous" received the lowest average score (4.33). The highest average score (4.92) was given to the prompt "I learned something new about ocean engineering by watching my peers' videos". Interestingly, students' responses suggest that they felt they learned more from watching their peers' videos than they did by creating their own videos. Overall, the scores indicate the project's success in meeting learning outcomes.

Conclusions and Suggestions for the Future

The Fall 2020 semester presented many unprecedented challenges to instructors and universities due to the global pandemic. Safety guidelines necessitated by COVID-19 meant that many universities offered only remote learning opportunities, and the schools that opened for in-person instruction could not guarantee how long students would remain on campus. The variety of modalities – remote, hybrid and in-person – were sometimes offered simultaneously in a single course, making the use of lab equipment and machine shops difficult. Additionally, social distancing requirements challenged the ability for students to work collaboratively. In turn, instructors needed to be creative and adaptable in altering, or even recreating, their methods of course delivery.

The course project in an upper-level ocean engineering elective course for mechanical and electrical engineering students was reinvented for delivery in a semester impacted by COVID-19. In lieu of requiring students to work collaboratively on a design/build project, a new project was inspired by Wired Magazine's "5 Levels" video series [27]. Students worked independently to create a video explaining a self-chosen, advanced topic in ocean engineering to three different audiences. Analysis of students' self-reflection, evaluations of others, and responses to an end-of-course survey indicate achievement and enrichment of multiple learning outcomes. Students enhanced communication, presentation, and scholarly research skills. Further, they gained new content knowledge in various areas of ocean engineering.

This project can be adapted for any course. Future implementations of the project would benefit from a few adjustments. First, students would benefit from additional guidance and support in completing the background research component of this project. A lesson dedicated to using scholarly research databases, perhaps with a guest-lecture from a university librarian, would strengthen student work and achievement of learning outcomes. Additionally, clearer guidelines in selecting the audience levels would support student learning by not overburdening them with the challenge of explain a topic to someone with more advanced training.

Logistically, ample time was spent by the instructor to ensure each student had a uniquely chosen topic. A class spreadsheet or online forum could be used for students to share their topics with their peers early in the project, to avoid overlaps. Students shared that they struggled with the Panopto platform for creating videos, largely due to file management issues. Alternative video platforms should be considered for future offerings of this project.

Finally, students shared disappointment in not being able to speak to their audiences directly and felt that the one-sided conversations were awkward. This issue could be ameliorated by having students record conversations with audience members via Zoom. When social-distancing and other safety measures are no longer necessitated by the presence of COVID-19, these conversations could take place face-to-face, further strengthening this course project if it were to be reused in future years.

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