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Improving Capstone Outcomes: Changes to Deliverables and Accommodating Remote Learning

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Abstract

It has become evident in the past years that capstone design project course in the Electrical and Computer Engineering Department (ECE) does not provide adequate guidance to students. The fall semester of this two-semester course was spent largely on project proposal deliverables, delaying project implementation. There was a disconnect between course instructors, administrators, and students about project expectations and scope. Also, the COVID-19 pandemic forced all courses to take place online and restricted student access to most university facilities. This work evaluates changes to the course structure based on student surveys and observations from teaching staff.

To address concerns with project execution and expectations, the timing and format of course deliverables were changed. A September proposal meeting was introduced to allow all stakeholders to clearly define project expectations and scope. As a result, misinterpretations of the project were resolved at early stages. The "Implementation Plan" deliverable was delayed from September to late November, giving students adequate time to consider implementation strategies before following with documentation. An Interim Demonstration was introduced during the first week of December to encourage students to kick-off the implementation phase during fall semester. After the Interim Demonstration, requirements and methods were clear to most students, allowing them to complete the projects with minimal supervision. Deliverable expectations must be better communicated in future years however, as student feedback identified how deliverables were not well-suited to software projects and were not always clear.

In addition to changes in deliverables, significant changes had to be made to accommodate remote learning. Online networking sessions were held during summer to help form teams and build community within the class. The sessions were well-attended and resulted in formation of several student teams at early stages of the course. Course lectures were held online with minimal difficulty, following an identical format to other online ECE courses. Team meetings with administrators and supervisors were held online, and students' feedback were positive. The end-of-course design fair was moved online, with pre-recorded videos replacing in-person presentations. Some students expressed disappointment that they were not able to present their projects to a wider community.

Despite pandemic challenges and changes to deliverables, a detailed end-of-semester student survey showed that students perceived the course workload to be similar to other courses. Despite accommodations for remote learning, student surveys revealed that the pandemic affected their choice of project, and negatively affected the quality of their projects. The survey also showed, however, that the changes to deliverables and the early all stakeholders' meeting

were effective and improved overall project quality. 71% of students indicated they would take the course even if it was not a program requirement. The structure of deliverables for the 2022-2023 will be similar, and remote learning tools will still be used when appropriate.

Introduction

Capstone project courses are an essential part of undergraduate engineering curricula, valued by students, faculty, and industry as an opportunity to apply learning to practical problems. The effectiveness of these courses must be monitored to maintain desired course outcomes, however. This study makes use of survey data from the ECE capstone course which typically has an enrollment of over 300 students. The study examines how this course adapted and coped with COVID-19 pandemic. And how the pandemic provided an opportunity to explore online tools in improving the course organization and quality.

An important aspect of capstone courses is how the project is communicated. In addition to assessing and reinforcing communication skills, presentations, meetings, and reporting deliverables are tools to provide feedback, help address issues and strengthen the quality of final projects. They can be perceived by students to take away time from project implementation, however. Changes implemented to clarify project scope and support project implementation will be examined and compared to previous course iterations.

While these changes were being considered, the structure of the capstone course had to change for the 2020-2021 school year, as all classes were mandated to take place remotely. Apart from transitioning to video-conferencing tools as a replacement for in-person meetings, other changes had to be implemented to accommodate team-forming and design fair activities. The projects themselves changed as well, with most groups losing access to lab space and equipment. While the changes were forced upon the course with few alternatives, some of these changes will remain in place, as they afford students increased flexibility.

These changes, and changes to deliverables, were evaluated with extensive survey data. Past years surveys, as well as a survey from the first cohort to take place entirely during the pandemic, offer insight into student sentiment. This sentiment can be used with qualitative observations from course staff to decide which changes are beneficial and which challenges remain to be addressed in the future.

This work benefits from nearly two full years of pandemic response, from the last weeks of the winter 2020 term to the first weeks of the winter 2022 term. This course can now be effectively delivered remotely or in person and can easily and quickly transition between the two. Some changes made for remote delivery were found to be beneficial and are kept for in-person delivery.

Background

The ECE496 capstone course is taken by over 300 students each year, in the final fall and winter terms of the 4-year program. Groups of 3-4 students complete a project, supervised by a professor and course administrator. Teams would meet regularly with administrators and course instructors, and work over fall and winter terms to complete projects. Project topics could be proposed by student teams or professors. Industry partners occasionally collaborate on projects, but only at the initiative of student groups.

The course is conducted during fall and winter semesters (September to April), nevertheless, planning and team-forming activities are carried out in summer (May-August). Students are expected to form teams and select faculty supervisors and project topics on their own. To accommodate the logistical challenges in pairing about 100 teams with supervisors, team-forming resources are made available in the summer term preceding the official course start. Some students take initiative and find complete teams and supervisors even earlier, however. Faculty supervisors are encouraged to post project topics in a shared spreadsheet, students without complete teams are encouraged to post and share their interests. Several networking sessions are also held to "pitch" project ideas and share interests. To incentivise early team-forming, a 1% "bonus mark" is typically offered to teams who are fully registered by August. The goal is to have all students placed in teams, with faculty supervisors, by the official start of the course in September. An additional challenge specific to this engineering program is a year-long work placement known as Professional Experience Year (PEY). PEY typically takes place between third and fourth years of the program. Outgoing internship students may be located outside the city or country during the last months of their PEYs' placements, and all are working full-time leading to challenges in registering teams. Some 3rd year students will be unsuccessful in securing placements, proceeding directly to 4th year. These students may continue looking for placements very late into the summer semester, meaning they start looking for capstone projects late in the semester when fewer options are available.

Once teams are formed in early September at the latest, the course begins in earnest. Each team is assigned a course administrator, who offers feedback and grades the communications aspects of the course. Weekly course activities for students include meeting with faculty supervisors periodically for technical guidance, attending a few lectures, and meeting with course administrators. The first few months would focus on a project proposal document that describes the project to be completed. Implementation would then take place for the remaining months, before a final report and design fair in later March and early April, respectively. Throughout the two terms various deliverables would evaluate project progress and communication aspects. These course deliverables were structured as shown in Table 1.

Table 1: Previous course deliverables.

Deliverable	Description	Deadline
Team forming	Students form teams, find supervisors, and select a project topic	September
Project Proposal Draft A	Describe project functionality, scope, etc.	Late September
Project Proposal Draft B	Revise Draft A	Mid-October
Project Proposal	Revise Draft B	Early December
Progress Report	Report/present progress to date	Mid-January
Oral Presentation	Present progress	February
Final Report	Summary report of project	Late March

The first term, in the prior pandemic offerings of the course, was largely spent focusing on the project proposal – completing background research and reporting the design process. This delayed project implementation, limiting the completeness of projects. While the final proposals were of high-quality, improvements could be made in "onboarding" student teams.

While these changes were being considered, the COVID-19 pandemic required public-health measures to take effect. In-person classes were suspended in late March 2020 and remote learning was quickly implemented. Almost all classes continued remotely throughout the 2020-2021 academic year. This forced lectures and meetings to take place using video meeting platforms, and limited student access to on-campus resources like equipment or labs. While some groups did have limited access to research labs through faculty supervisors, no widely available makerspace or lab was available. Several students completed the school year from different countries, leading to time-zone difficulties.

Previous work

Adjusting course delivery to accommodate pandemic restrictions is a challenge at universities worldwide, and as such many initial works describe the initial responses taken by teaching teams. Changes have been justified using frameworks such as "Resilience Theory" [1] or "Emergency Remote Teaching" [2] and others. Most of these approaches can be summarized as, given the changes forced by the pandemic, taking actions with available resources to optimize some outcomes, often some combination of accreditation outcomes, student experience, instructor workload, etc. Then the changes are monitored and evaluated over some period of time and iterated upon based on those evaluations.

Published works on COVID-era capstones, for the most part, are based on the last few weeks of the Spring 2020 term and part of 2020/2021 school year. They obtain best-practices by interviewing capstone instructors [3], university faculty [4], and making use of student surveys [5]. A common focus is the end-of-term "design fair", which is more affected by pandemic restrictions than most course activities. This work will consider the full 2020-2021 academic year of pandemic course delivery, as well as some qualitative observations from the first part of the 2021-2022 academic year.

Methods

This work evaluates changes made to a capstone design project course over the course of the 2020-2021 school year. Additionally, changes made to accommodate pandemic difficulties are evaluated. Student satisfaction and qualitative feedback from course staff were used as outcomes to evaluate the effectiveness of the changes.

An extensive survey was circulated to the 2020-2021 class, with several questions repeated from previous surveys which can be used to directly compare student satisfaction. The six years of evaluation data offer a baseline for overall student satisfaction, and some qualitative responses outlining student sentiment. Additional questions asking about the pandemic and remote work were also asked. Questions were posed as a six or seven level Likert scale, or as a short-answer response. While the six-level version is not "balanced", with two negative responses, one neutral response and three positive responses, it was retained to maintain consistency between survey years. The 2020-2021 survey had 52 total responses. 289 students were enrolled, for a response rate of 18%.

Changes

To address the challenges outlined above, several changes were trialed in the 2020-2021 course. The new deliverable structure, shown in **boldface**, is provided in Table 2.

Table 2: New deliverables employed for 2020-2021 offering.

Deliverable	Description	Deadline
Team forming	Students form teams, find supervisors and select a project topic	September
Project Proposal Draft	Describe project functionality, scope, etc.	Late September
Project Proposal	Revise draft	**Late October**
Implementation Plan	**Plan for implementation**	**Late November**
Demo Meeting	**Demonstrate early implementation progress**	**Early December**
Progress Report/Meeting	Report/present progress to date	Mid-January
Oral Presentation	Present progress	February
Final Report	Summary report of project	Late March

The changes are mainly in the first term, where fewer project proposal drafts are submitted, and replaced with a project implementation report and demo meeting. The ultimate goal was to start implementation earlier and balance the workload evenly between fall and winter semesters.

COVID also necessitated changes in course delivery. In March 2020, in-person classes were cancelled a few weeks before the final design fair. To replace the in-person fair, each team

recorded a demo and submitted a digital poster. Nonetheless, time constraints prevented each team's materials from being shared in a public forum. Then, planning began for the fall 2020 term. Pandemic restrictions were unknown at this point, but it was assumed that delivering at least part of the course remotely was required.

Over the summer, remote meetings were held roughly every month during weekday evenings. These meetings served as an opportunity to aid in team-forming. Through a video chat application, students were given the opportunity to pitch project ideas to other attendees, with the goal of recruiting team members. Project topics recently posted by faculty supervisors were highlighted by the course staff, and breakout rooms were created for specific areas of interest (machine learning, mobile app development, hardware design, etc.). These meetings were supplemented with detailed spreadsheets students could fill out to indicate their interests. Later in the summer it became clear that many students who were planning to take a year-long internship would not find a placement and would therefore proceed directly to their fourth-year program and enroll in the capstone course. Course administrators and supervisors therefore had to manage more teams than they typically would.

At the start of term, lectures were held through a video chat platform. Team meetings with supervisors and administrators were held at the discretion of attendees, and no specific meeting platform was prescribed.

Finally, the end-of-term design fair was, again, held virtually. As more time was available, a page was created on the internal course site. Links to each team's virtual "poster" and video demo were available. Because the page was hosted on the course webpage, it could only be viewed by other students and course personnel.

Evaluation

One method of evaluating changes to the course, and the course in general, is through student surveys. The authors have access to several extensive surveys from previous years, which offer feedback on specific aspects of the course – much more detailed than a standardized end-of-course evaluation. Similar questions are asked each year, allowing direct comparisons to be made. Those same questions, as well as some new ones, were asked from students at the end of the 2020-2021 course iteration and can be used to directly evaluate changes to the course. The evaluation also measured the effectiveness of online learning. In addition to questions asking how the pandemic affected projects, unstructured comments offer additional insights.

While course evaluations offer insight into student sentiment, positive evaluations are not equivalent to positive course outcomes. It does, however, provide some objective measure of student satisfaction, which is one aspect of effective course delivery. Other aspects, such as project quality and completeness can be evaluated qualitatively based on observations from the authors involved in the course. Table 3 presents common questions that were asked from students in surveys conducted every year.

Table 3: Common questions asked in yearly surveys.

Question	Format
Your initial level of enthusiasm for taking this course	Likert 7
Your level of enthusiasm now that you have completed this course	Likert 7
Your supervisor's apparent knowledge of the technical aspects of the project was	Likert 6
Your supervisor's overall involvement with the project and team was	Likert 6
Your supervisor's availability for consultation was	Likert 6
Your supervisor's commitment to ensure that student work was graded fairly with appropriate feedback	Likert 6
Compared to other courses, the workload in the fall was	Likert 7
Compared to other courses, the workload in the spring was "	Likert 7
Considering the calendar weighting, the overall workload was	Likert 7
The value of the feedback you received from the Engineering Communication Program for the Project	Likert 7
The value of interacting with your administrator throughout the course of the project was	Likert 7
Your administrator's commitment to ensure that student work was graded fairly was	Likert 6
The value of the comments and suggestions you received on your Oral Presentation was	Likert 7
The value of your experience at the Design Fair (including Friday's Final Showcase) was	Likert 7
The relevance of this course to your professional development is	Likert 7
The relevance of previous design courses in preparing me for capstone	Likert 7
Considering your experience with the course, and disregarding your need for it to meet program or degree requirements, would you still have taken this course?	Yes/No

Some additional pandemic-specific and deliverable specific questions are shown in Table 4. These questions were added to further evaluate the changes made during 2020-2021 offering of the course.

Table 4: Supplementary questions for surveys to evaluate the effectiveness of the changes made in 2020-2021 course offering.

Question	Format
What was your overall satisfaction with finding a team	Likert 7
What was your overall satisfaction with finding a supervisor?	Likert 7
What was your overall satisfaction with finding a topic?	Likert 7
What worked well in finding a team/supervisor/project topic and what resources/tools did you use? Please explain and provide any suggestions you may have.	Short answer
Did the pandemic affect your choice of project? Please explain.	Short answer
How did working remotely impact your interaction with your supervisor?	Likert 7

Table 4: Supplementary questions for surveys to evaluate the effectiveness of the changes made in 2020-2021 course offering (continued).

Your supervisor's availability for consultation was:	Likert 7
How did working remotely impact your interaction with your administrator?	Likert 7
How effective, in terms of clarifying the project, were the two meetings with your supervisor and administrator during fall semester? [answer]	Likert 7
General guidelines posted were useful in getting my team started with the deliverable.	Likert 7
Considering the restrictions imposed by working online: The effectiveness of the final video for showcasing your final project was [answer].	Likert 7
Which deliverable(s) worked well? And how could the course deliverables be made better? Please make your suggestions.	Short answer
How did working remotely affect the quality of your final project?	Likert 7
What tools or resources could have helped your team work better together? Please provide any suggestions you may have.	Short answer
Anything else you want to add?	Short answer

Responses from previous offerings of the course are summarized in Table 5.

Table 5: Responses from previous years providing the number of students participating.

Year	Responses (N)
2009-2010	86
2011-2012	100
2012-2013	50
2014-2015	41
2016-2017	41
2020-2021	52

To evaluate the responses, distributions can be compared from year to year. Comparisons can also be made by assigning point values (0-5 or 0-6) to each response and taking an average. A median value could also be taken, but the majority of questions have identical median responses from year to year, despite differences in distributions of responses.

While the response rates in most years are not particularly high, the mixed methods of the survey capture a useful amount of detail from each response. The 18% response rate in the 2020-2021 survey is marginally higher than the 14% response rate in 2016-2017. In future years more emphasis could be placed on the survey during various course meetings, or incentives could be offered for survey completion. The authors found the number of responses to be sufficient to gain insight on student sentiment, however.

Team forming

Most students who completed the survey found teams by May 2021 and were fully registered with topics and supervisors by July 2021. This was as good as or better than previous years, and

the median survey responses were all “Above Average” when asked about satisfaction finding a team, supervisor, and topic (Figure 1). The average point values for each are 4.5, 4.1 and 4.0, respectively. A score of 4 corresponds to “Above average” while 5 corresponds to “High”.

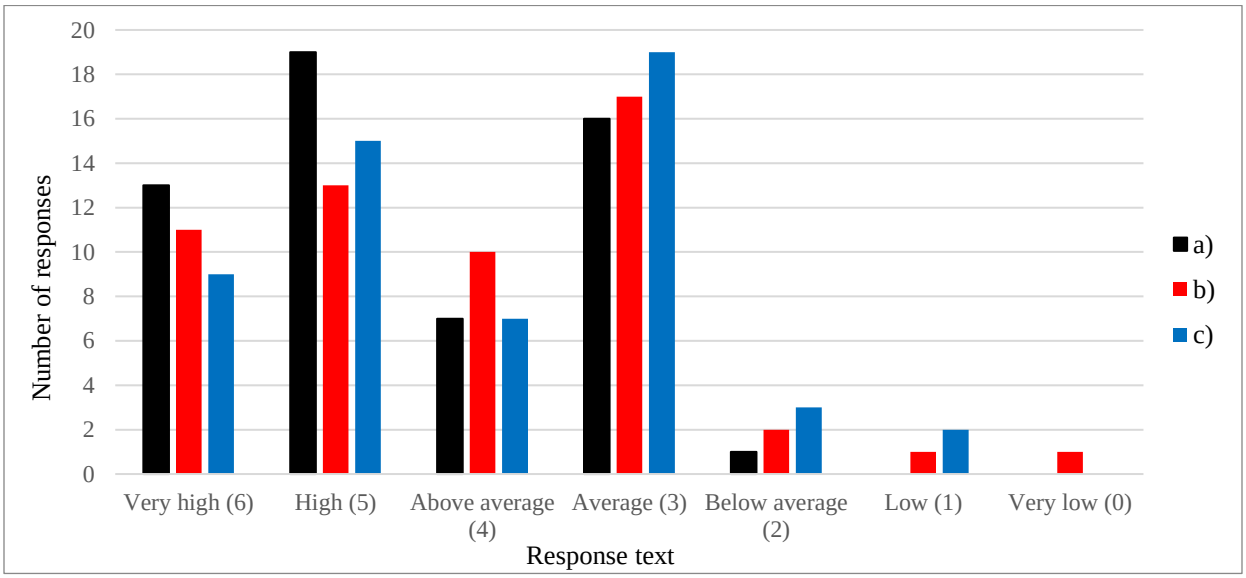

Figure 1: Satisfaction in a) Finding team, b) Finding a supervisor, and c) Finding a project topic

While detailed survey data is not available for the 2021/2022 school year, similar tools were used for team-forming. Students formed teams at a similar rate and were all on teams by the start of term. Of note was the decrease in attendance at each networking meeting. This could be due to several factors. Changes from the previous year include the meetings being held bi-weekly, different tools used to host the meetings, and the students having just gone through two consecutive semesters of remote learning.

Online meetings

Student responses to the working relationships with supervisors were largely positive. Figure 2a shows how 67% of students indicated that the pandemic had a positive or neutral effect on their relationship with their supervisor. Figure 2b and 2c also show how most students were positive on their supervisor’s availability and grading. Despite the increased workload from remote learning, student perception of supervisor availability was positive.

Deliverable changes

An important aspect of the deliverable changes is the change in perceived workload. A common perception with capstone courses is that too much time is spent on deliverables, and not working on the project itself. Some student comments suggested this in their short-answer responses, while others were generally content. There was positive and negative feedback for specific deliverables, but only a few clear trends. Table 6 summarizes some common responses regarding the effectiveness of deliverables, and all responses concerning deliverables are compiled in Appendix A.

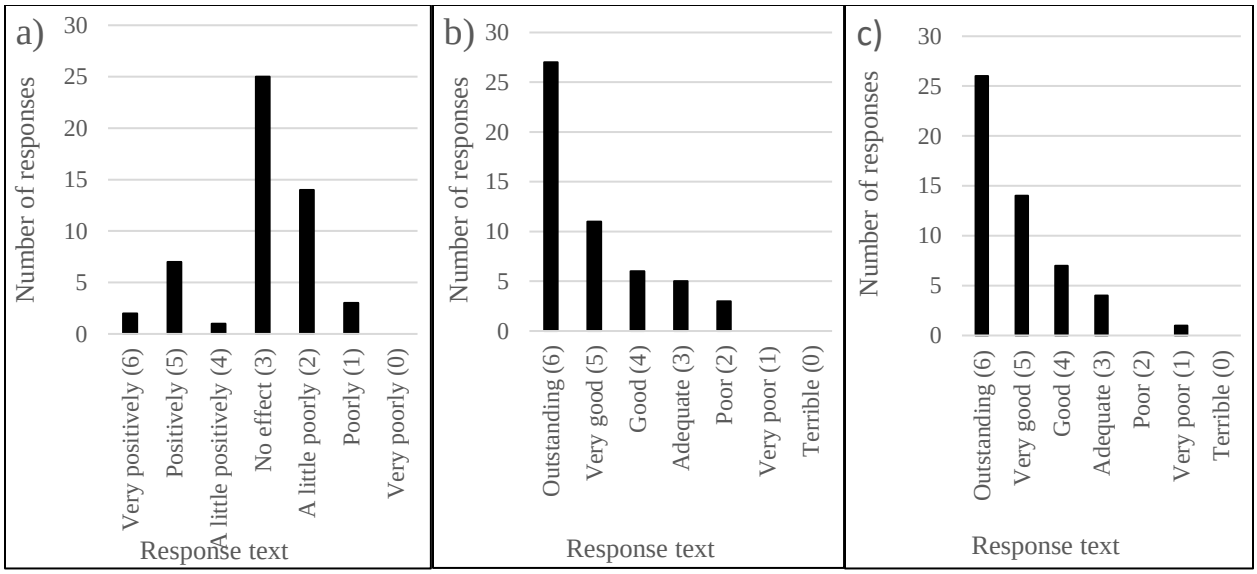

Figure 2: a) "How did the pandemic affect working with your supervisor" b) "Your supervisor's availability for consultation was" c) "Your supervisor's commitment to ensure that student work was graded fairly with appropriate feedback was"

Table 6: Survey results regarding effectiveness of deliverables.

Response number	Response	Sentiment
15	*"The oral presentation worked well, provided students flexibility"*	Positive
18	*"Project proposal worked well."*	Positive
33	*"I believe the only deliverable really needed should be the final proposal, interim demo document and final report (+ poster)… Deliverables where too focused on only planning and cut in significantly into the time one could spend actually implementing the project."*	Negative
41	*"Implementation Plan was good and helpful"*	Positive
45	*"I feel like there was too many reports like the progress summary. The proposal and final report were good. I didn't find the mid project demo to very useful"*	Negative
48	*"The Progress Report is absolutely useless. Useless and a waste of time."*	Negative
50	*"The proposal and implementation plan had very well-defined and useful purposes. The interim demo did not make much sense, since it occurred only a week after the implementation plan was due…The progress report also did not make much sense, since it occurred only about three weeks after the interim demo….I saw some value in the oral presentation as preparation for the final presentation and design fair"*	Mixed
58	*"In general I have no complaints about the deliverables except one. I think the progress report was a disaster"*	Mixed

Reactions to the new implementation plan were positive, with a few students praising it specifically in their survey responses. Reactions to the interim demo were mixed, with a few students noting that it was scheduled too close to other deliverables. The progress report was criticized more often than other deliverables, usually because of its timing relative to other deliverables or the required content of the report itself.

A common sentiment was that the structures of the report did not accommodate software projects well. One student suggested "*the guidelines are very much hardware/electrical engineering based*", one said that some required documentation was "*strange for a software project*", another said that "*the structure needs to be more flexible for software projects*" This is outside the scope of this work but would be a worthwhile area of examination.

The added deliverables are meant to encourage earlier project implementation, which should balance the workload over the two semesters. Student-perceived workload, as measured by the survey, decreased relative to previous years. The averages of 3.4 and 3.7 for the fall and Spring semesters, and 3.4 overall, are all between "Average" and "Above Average". This corresponds to a lower perceived workload. It is also notable that the spring workload decreased more, relative to the previous average, than the fall or total workload, suggesting a more-balanced distribution of work.

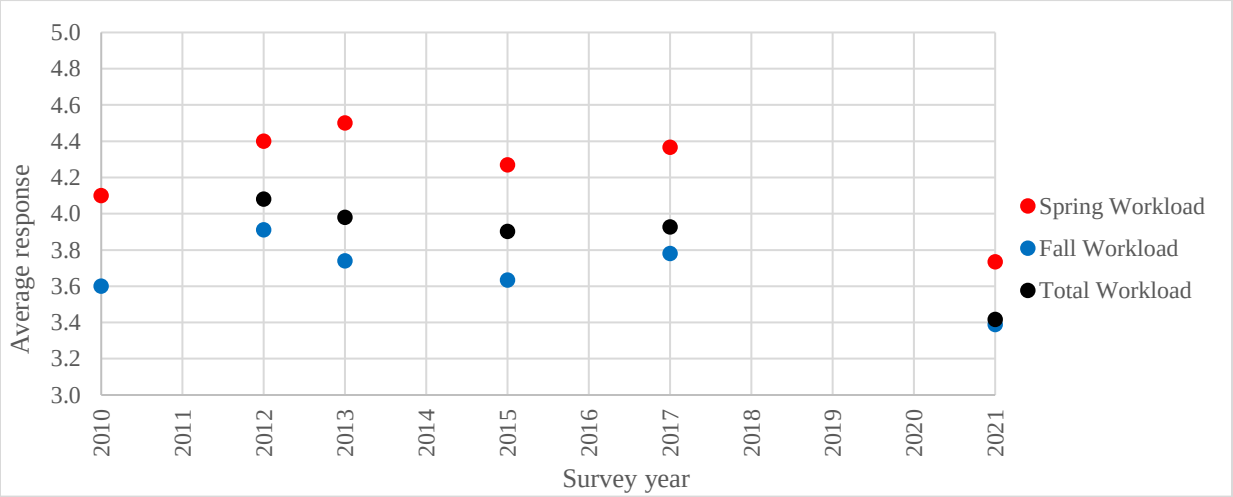

Figure 3: Course workload over time, as perceived by students. Higher scores indicate more work. 3.0 is equivalent to an "average" course, 5.0 is a "high" workload.

Design Fair

Perhaps the biggest loss to capstone necessitated by remote learning was the in-person design fair. Comparing the rated effectiveness of the in-person design fair to the pre-recorded project videos used as a replacement (Figure 4) shows a lower rating (3.8) than the average in previous years (4.3). Regret over missing what is seen as a culmination of their degree was a common sentiment in short-answer question responses also. Table 7 presents students' comments regarding the online Design Fair that was imposed by the pandemic.

Table 7: Students' comments about the online Design Fair.

Response no.	Response	Sentiment
15	*"Even though the students were promised a live online design fair which is usually the highlight of the capstone, this was not delivered."*	Negative
22	*"I wish to have more interactions with others teams. For example, having an online showcase which other teams can comment on our projects."*	Negative
24	*"For the design fair aspect of the course, I think there were many other ways to make this more similar to previous years in person that were not explored. This was a little of a disappointment."*	Negative
25	*For one, the design fair felt like it was basically non-existent and tons more effort could have been made to make it seem closer to the real thing. ... I feel like we completely missed out on this crucial professional development aspect of the course. ... I would have liked to present my work to others and get something as close to possible as the in-person design fair*	Negative
32	*"I was unsure of the value of presenting a poster virtually for the design fair. However, I found that this was adequate considering the current circumstances."*	Positive
34	*"the design fair was quite underwhelming, with all the hard work everyone put in, I expected more effort on the Capstone staff side to actually make a sort of live virtual event to showcase our projects to not only the Capstone students but to all of those in ECE as well as highlight the top Capstone projects. Quite a disappointment ..."*	Negative
44	*"The final poster video presentation was also weird because it's annoying to present a poster online...."*	Negative

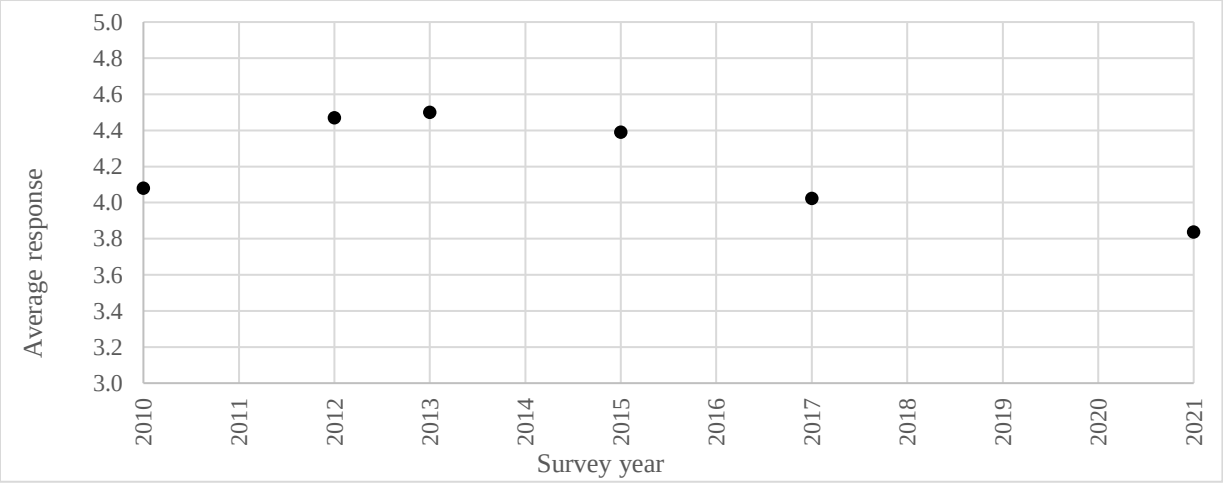

Figure 4: "The value of your experience at the Design Fair (including Friday's Final Showcase) was"

As for the “remote fair” itself, some students expressed (outside the survey) concerns about their videos being publicly available. While this would most closely approximate the public in-person design fair, the potentially permanent availability of project presentations on public platforms such as YouTube was a source of concern among some students. Other students expressed disappointment that the fair was not publicly accessible, as they looked forward to demonstrating their achievements to a wider community.

Overall

In general, student sentiment on the course declined compared to previous years. Figure 6 shows the percentage of students saying they would take the course even if it were not a requirement. This percentage declined to 71% in 2020/2021, lower than the previous average of 83%. While the initial average enthusiasm, shown in Figure 5, of 4.0 (“above average”) was close to the recent average of 4.1, mean enthusiasm declined to 3.2, smaller than the recent average of 3.8. A decline in enthusiasm took place in most years, except for 2011/2012, but the 2020/2021 decline of 0.82 average points is larger than any other year.

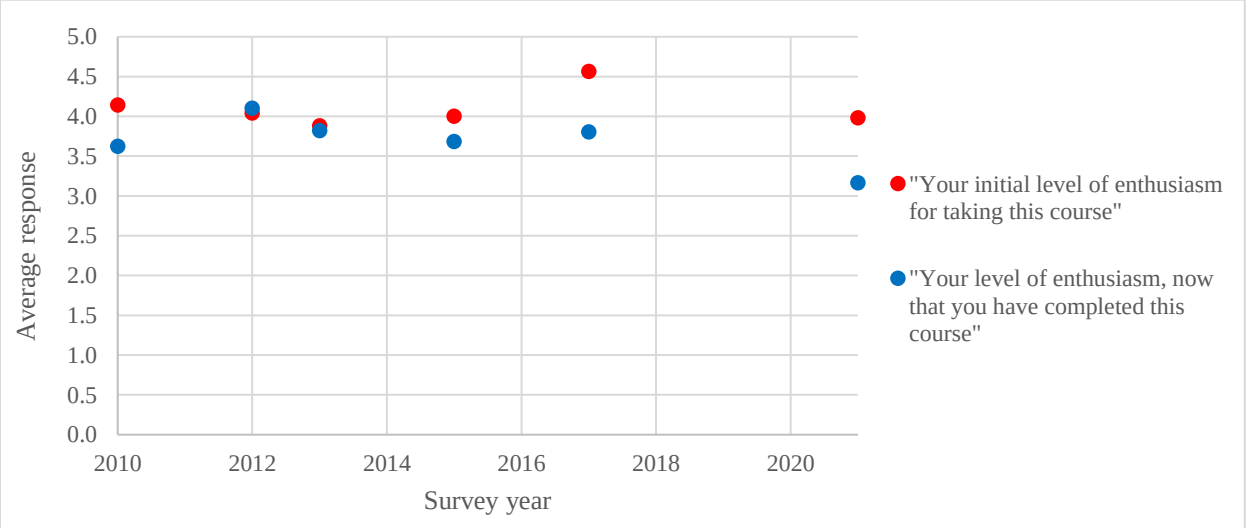

Figure 5: Student enthusiasm

Conclusions, Discussion and Future Work

Team forming

While in-person networking sessions offer richer interactions, virtual tools continue to be employed prior to official opening of the course in September. Many students are not in proximity of the university during summer holidays, and those who may not wish to attend on-campus events. Nevertheless, in-person events can offer a richer networking experience. In

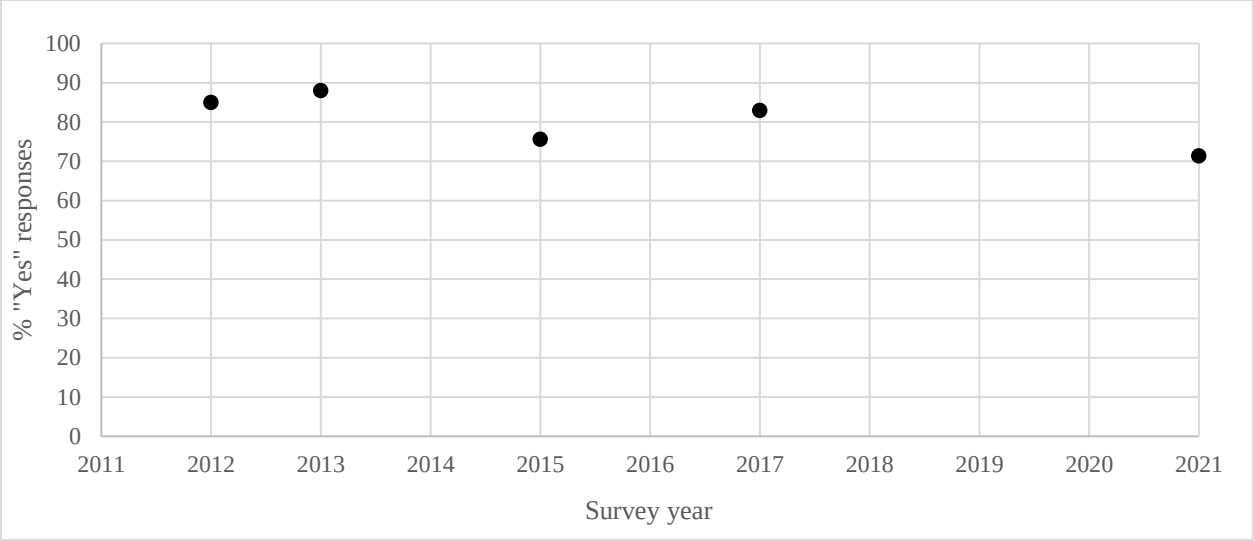

Figure 6: "Considering your experience with the course, and disregarding your need for it to meet program or degree requirements, would you still have taken this course?"

future years, perhaps a mix of in-person and virtual events can be held to meet the needs of a particular cohort. To combat "Zoom fatigue", sessions should be limited in their time requirements and specific in their goals. Unstructured networking time was found to be less effective than sessions with specific activities, such as instructor Q&A, pitching project ideas and explicit team-matching.

When finding topics, it is fully logical to choose software-heavy projects when the projects are implemented virtually. However, to allow students to pursue their true interests, this course would benefit from more readily available "makerspace" labs even with strict pandemic measures. Such facilities are available on-campus, but work may need to be done to make these facilities available to capstone students.

Classes

Though in-person classes were permitted for the 2021 fall term, limits on class size prevented the whole class from gathering at a single time. It was therefore more practical to continue holding lecture sessions virtually. Posting lecture recordings allows for easy access later, and has been a standard practice in the course, but also allows for students to skip the lecture itself. These remote lectures had some advantages, such as the ability to easily post lecture recordings. Students were free to meet in-person with their teams, supervisors, and administrators.

Deliverables

Survey results, and qualitative observation, suggests that the changes to deliverables were effective. Perceived workload decreased, though a mix of positive and negative comments suggest improvements can still be made. The same structure will be used going forward. In

future years, changes may need to be made to accommodate software projects, or address perceptions that those projects are not well-accommodated by current deliverable guidelines. The Progress Report was the most consistently criticized course deliverable, suggesting it could perhaps be reconsidered or modified in future terms.

Design fair

It is clear from student feedback that a publicly accessible design fair is preferable. Virtual design fairs pose a challenge as there is a balance that must be struck between student desire for privacy and demonstrating work to a larger community. Perhaps a public demonstration, available virtually for a limited time offers the best compromise. Tools like Gather can offer a virtual space with an Avatar [6], seamless small-group conversations, and semi-public access. Pre-recorded video can also be made available for grading purposes, students who do not wish to participate in a design fair.

Overall

Overall course evaluations for this year are more negative than in previous years. This could be expected, given the general stresses associated with the COVID pandemic and remote learning. Despite the poorer student experience, the changes necessitated by COVID forced instructors to revaluate how capstone is delivered, and to experiment with new tools.

While in-person instruction offers many advantages, remote has some advantages as well. Moving forward, flexibility will be required to maintain a strong capstone experience. Though the survey responses and discussion in this work focuses on the 2020-2021 school year, the 2021-2022 capstone class has made some of the same changes. Remote meetings took place over the summer 2021 term, and course lectures are continuing to take place online. The first few weeks of the winter 2022 term are taking place online, showing that some of the same strategies must continue to be employed.

Finally, this work examines the changes made to accommodate remote learning into the ECE capstone course. While not all the changes were effective, they all offer insight into how capstone courses can be made more resilient and flexible. Emphasizing implementation in project deliverables can balance workloads, even when the circumstances surrounding a course are particularly challenging. Digital tools can be useful in offering flexibility to students, especially, outside of normal course dates. When challenges and disruptions arise, efforts should be made to maintain essential aspects or experiences of a course as much as possible, such as the design fair. Generally, students and course staff, whether faculty or administrative, can be counted on to show resilience and adapt when urgency arises.

References

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Appendix A

This appendix provides the complete list of responses provided by students in Table A.1.

Table A.1: Survey results regarding effectiveness of deliverables.

Response number	Response	Sentiment
3	*"All deliverables were fine, content-wise"*	Positive
12	*"the guidelines are very much hardware/electrical engineering based. This needs to change and accommodate for software projects"*	Negative
14	*"For the most part, the deliverables made sense for developing our project management and communication skills."*	Positive
15	*"The oral presentation worked well, provided students flexibility"*	Positive
18	*"Project proposal worked well."*	Positive
27	*"I am not sure if the docs fits as well for software projects."*	Negative
28	*"there were so many reports that felt like the same thing repeated again and again. I think that the structure needs to be more flexible for software projects!"*	Negative
33	*"I believe the only deliverable really needed should be the final proposal, interim demo document and final report (+ poster)… Deliverables where too focused on only planning and cut in significantly into the time one could spend actually implementing the project."*	Negative
35	*"Deliverables that worked well were documents."*	Positive
37	*"The report deliverables worked well and make sense for a capstone project."*	Positive
38	*"Deliverables are designed perfectly."*	Positive
41	*"Implementation Plan was good and helpful"*	Positive
43	*"There were a lot of written documents. We spent more time writing about what we did than actually doing things."*	Negative
44	*"I think there were some repetitive deliverables…"*	Negative
45	*"I feel like there was too many reports like the progress summary. The proposal and final report were good. I didn't find the mid project demo to very useful"*	Negative
46	*"The deliverables constantly asked for repeated work from past reports and asked for barely any new content…The documents are also very old fashioned and are not reflective of many workplaces particularly in the software industry."*	Negative
48	*"The Progress Report is absolutely useless. Useless and a waste of time."*	Negative
49	*"The written documents were absurdly long and not as relevant to certain classes of projects."*	Negative

Table A.1: Survey results regarding effectiveness of deliverables (continued).

Response number	Response	Sentiment
50	*"The proposal and implementation plan had very well-defined and useful purposes. The interim demo did not make much sense, since it occurred only a week after the implementation plan was due…The progress report also did not make much sense, since it occurred only about three weeks after the interim demo….I saw some value in the oral presentation as preparation for the final presentation and design fair"*	Mixed
51	*"Deliverables felt long and often outdated to what is expected in industry."*	Negative
52	*"They were all generally fine…."*	Positive
55	*"For the Progress Report, providing proof of EVERY task was quite superfluous. But besides that, I found all course deliverables were reasonable and straightforward."*	Mixed
57	*"The project proposal and implementation plan were useful for figuring out specifics of the project and designing it. For my team, the practice oral presentation was way too early … so the practice presentation wasn't that helpful for preparing."*	Negative
58	*"In general I have no complaints about the deliverables except one. I think the progress report was a disaster"*	Mixed
59	*"all good"*	Positive