

Convergence in Collaborative Course Design while Remaining Virtual

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Abstract—This Innovative Practice Full Paper presents a collaborative course design and delivery model that supports teamwork among faculty, tracks course alignment throughout the development process, and fosters a greater variety and distribution of student engagement opportunities, even when the collaborative relationship must be virtual. Multiple perspectives, when used effectively, enhance course design and delivery, but collaboration among faculty can be challenging without a structured process. In addition, establishing alignment between learning outcomes and course activities is increasingly difficult. We show the benefits of this approach through deployment in a collaboratively redesigned engineering course. The resulting course has improved alignment of learning objectives and activities across all modules, provides a wider set of student engagement opportunities, and gives a more consistent instructional voice among the different delivering faculty.

I. INTRODUCTION

Collaborative course design and delivery promotes student learning, engagement, and inclusion by bringing together a diversity of perspectives, techniques, and activities to reach students. The COVID-19 pandemic forced faculty into solitary environments, isolated from the natural collaborations they previously enjoyed when on campus. It also placed faculty, and their students, into new instructional modes that require greater attention to engagement, the classroom community, and the learning experience. It is essential that faculty have an effective means of collaborating as they navigate the challenges and opportunities of the current teaching climate.

We present a collaborative course design and delivery model that supports faculty teamwork, even if they must remain virtual during the collaboration. This past year we worked closely together on a large project-based learning course in engineering. The collaboration significantly improved the course's design and delivery, increased student engagement, and provided greater consistency among offerings.

Once we converged on the overall course design and learning outcomes, we used a set of collaborative course maps for organizing the schedule of topics, assignments, and projects. The course maps list the course learning outcomes, relate course topics to these learning outcomes, the reading materials, lecture topics, learning activities, homework, and larger projects students will engage in, and describe the order in which they do so. They facilitate multiple levels of perspective: from the big picture to ensure the timeline supports

the students' progression through the course and acquisition of learning outcomes to a detailed view that guarantees a variety of engagement and inclusion activities. This resulted in a much more organized course with better alignment and pacing.

The course maps are also valuable for managing the creation of a wide array of course materials, outlining how faculty would partition the work. Alternating who developed and who reviewed different topics promoted a diversity of perspectives with a wider range of course activities than would have been produced by a single faculty member.

With this structure, faculty can easily see what types of activities are planned and where to inject additional engagement opportunities. This perspective on the activity distribution exposes where adjustments can be made to promote greater inclusion and encourages faculty to broaden the types of activities offered by providing space to plan for them. This variety also exercises multiple levels of learning, from recalling course concepts to applying them to new situations to designing and evaluating new work based on them.

We present qualitative data describing the demonstrated benefits to aligning learning outcomes, course materials, and learning activities, to a richer delivery that engages students in multiple ways, and to a more consistent instructional voice. We share our experiences and lessons learned so this type of collaboration is easier for others to replicate.

II. RELATED WORK

The nature of learning and its implications for effective teaching has been long studied. Course alignment and student engagement are repeated themes that promote student success, and collaborating faculty are more effective in building these in their courses.

A. Collaborative Course Design and Delivery

Collaborative teaching is often used to bring in material from different disciplines where faculty from different areas work together on a single course or a set of clustered courses [1], [2]. Usually faculty develop a common syllabus and decide on major course topics [3]. Course delivery is shared in a *rotational model* where only a single faculty member is present in given class session, in a *participant-observer model* where all faculty are present in a class session but only one takes

an active role, or in an *interactive model* where all faculty are present and active, dialoging and interacting with each other and the students [4]. The *dispersed team model* is a hybrid model where one class session a week has all faculty present and then individually hold cohort class sessions the rest of the week [5].

With multiple faculty, students are exposed to different viewpoints [6] and blending viewpoints together helps students develop critical thinking skills [3], [7]. Students often have improved relationships with their instructors [8] and feel they are better prepared for future courses and their career [9]. They also achieve learning outcomes at a higher rate [10], even developing more mature communication skills [4]. Collaboratively taught classes can promote diversity by assembling a diverse team of faculty to develop and deliver it [8].

Students respond positively to collaborative taught classes and often prefer them over traditionally taught courses [10]. Interestingly, students slightly prefer the interactive model for collaborative teaching, but do not prefer more than two faculty in the set of instructors [11]. Students note that communication among faculty is essential and express concerns when this or course organization appears to break down.

Collaborative course development and delivery also benefits the faculty and teaching assistants involved, creating mentoring opportunities for newer instructors to work with more experienced instructors [12], [13]. It also spreads out the development workload.

Despite the numerous benefits, collaborative teaching can strain resources, particularly as multiple faculty are now responsible for the same number of students. In response, often courses have a *team-coordination model* where faculty agree on major course components but have little continued collaboration [5]. While this maintains greater autonomy and requires fewer resources, it often does not yield the same types and levels of benefits of more tightly coupled collaborations.

B. Course Alignment

Course alignment occurs when all content and activities support the course's learning outcomes. Learning outcomes provide the foundation for choosing appropriate content and activities [14]–[16], focusing on concrete actions and behaviors [17], [18] that assess student learning.

Course alignment underpins competency-based curriculum and facilitates the shift from a teacher-centered approach to a student-centered approach [19]. Student-centered approaches have great pedagogical support [20], [21], help students engage in deeper learning [16], [22]–[24], and better prepare students for their future [25]. Alignment has been heavily promoted in education to improve learning in general [16], [26], [27].

Motivation is a crucial component of learning as students must balance both greater autonomy and a larger number of competing goals for their time [28]. Motivation impacts how a student values the course's goals and their own expectations for success [29]–[31]. Clearly defining the course's learning outcomes and aligning activities to these outcomes

shows students how the course supports them, increasing their confidence in their ability and thereby their motivation [32].

Many faculty still find it difficult to implement these alignments in practice [33]. Without an explicit plan to link activities to outcomes, faculty often inadvertently wander from their outcomes due to the time delay between developing outcomes before a course starts and planning activities for a class session later in the semester. In other cases, faculty are not given sufficient guidance and practice to effectively align their classes [34]. Sometimes faculty are resistant to aligning courses that they have already taught [35]. Our development model provides community support and course maps to assist faculty with course alignment and reduce the strain of an unstructured approach.

C. Student Engagement

Student engagement is the participation in activities, both inside and outside the class, that are linked with learning outcomes [36]–[38]. Many consider student engagement a predictor for learning [39], [40] and one of the fundamental purposes of teaching [41], [42]. The more students become involved in their learning, the more engaged they are with the course material, the deeper their learning [38], and the greater their commitment [43].

There are many different types of engagement activities including discussions, anonymous polls, comprehension quizzes, group work, practice problems, and reflections. These can be categorized along both social (independent to collaborative) and academic axes (passive to intense) [44]. Each serves different purposes and supports learning in differently. Discussions help students process course content [45], [46] while surveys and polls help students feel part of the classroom community [38]. Quizzes and homework provide multiple practice opportunities, and deliberate practice correlates with student learning [47], [48]. Reflection activities promote a growth mindset and give students insight into their own learning [49]–[52].

Providing a variety of engagement opportunities reaches more students as they often resonate differently [53]–[55]. This improves student motivation, especially activities that help students understand how their own learning works [32], [42], [49]–[52]. A varied approach also hits hitting multiple levels of thinking [17], [18] and provides varying levels of challenge [23], [48], essential for student learning [32]. It also honors diverse ways of learning [41], supporting more students.

Faculty have a profound role on student engagement. Their behaviors, attitudes, and the activities they supply can greatly encourage students to become active participants in their learning [56]. Faculty that provide multiple types of interaction have more engaged students that better connect with course material. Providing this variety is challenging as faculty tend to select types of activities they are more familiar with or have had greater success with. Our development model addresses this challenge by exposing and tracking activity distributions.

III. METHOD

We present our approach to collaborative course design. Our collaborative model blends the benefits of co-teaching models

and team-coordination models. Faculty tightly collaborate in the course development phase to reap the benefits of multiple perspectives and areas of expertise as well as the synergy that occurs when creating in community. During course delivery, however, each faculty member is responsible for only their section of students. Students may see prerecorded videos from other faculty, but the live class sessions and all course logistics are handled by a single faculty member. This eliminates the resource strain that co-teaching models have on their faculty to student ratios. It also guards against student concerns on miscommunication between faculty since they have a single point of contact and voice for course logistics and grading as in traditionally taught courses. (Note that this is different than the dispersed team model which still has sessions with multiple faculty present requiring greater faculty hours.)

Our approach also uses a set of shared course maps to help manage the collaborative development and refinement of course materials, both for in person collaborations and virtual/remote collaborations. These shared course maps improve alignment between learning outcomes, and promote richer student engagement by providing planning space and metrics that expose any gaps in these areas whereby faculty can make more informed decisions about course adjustments. They also help faculty make sure they satisfy any requirements passed on to them from their department's curriculum committee. We detail the different phases of collaborative development and discuss how to facilitate them with the shared course maps.

A. Collaboration Phases and Modality

There are several phases of development, each with different types of collaboration:

- 1) *Curriculum planning* (tighter/synchronous collaboration): identifying learning outcomes, identifying and mapping modules to those outcomes, deciding on what types of activities/elements to include in the course
- 2) *Development planning* (tighter/synchronous collaboration) deciding on the granularity to partition the development work (at module level, at activity level), assigning roles (creator/reviewer) for each task
- 3) *Content development* (independent/asynchronous collaboration): iteratively creating and revising modules and/or activities
- 4) *Publishing* (independent/asynchronous collaboration): final review of all content and alignment, publishing to learning management system.

Figure 1 provides the over all flow through the development phases, colored by type of collaboration needed. We based this process after the principles and flow of the ADDIE instructional design model [57] which contains five phases: analyze, design, develop, implement, and evaluate. Our phases have the following ADDIE mappings: curriculum planning aligns with analyze and design, development planning completes design, content development maps to develop and implement, and publishing completes implement. Faculty then monitor student performance and perception, aligning with evaluate. This supports backward design by starting with the course

learning outcomes and working backward to the content [58].

Initial curriculum planning requires a greater degree of synchronous collaboration. Faculty must identify the course's major learning outcomes and select modules/topic areas that will support them. These are the foundation for the course, so it is critical that they are set and refined collaboratively. This typically involves multiple meetings as they discuss and refine. Once learning outcomes and modules/topic areas are solidified, faculty plan the overall flow of the course, the mode of delivery, the types and timing of learning activities used, and a module template describing a consistent rhythm and pattern across modules. Meetings may be conducted in person or virtually depending on the faculty needs.

Development planning follows where faculty make decisions on the overall scheme for partitioning the content creation. Content creation may be logically partitioned by module or by learning activity type. This will depend on the preference and experience of the faculty. In some cases, faculty may want to develop the initial course content at the module level until they are all comfortable with module flow, and then switch to partitioning by activity to leverage their individual strengths and expertise. After deciding on the partitioning, faculty then assign the Creator and Reviewer roles for each task, recording these roles in one of the shared course maps by adding additional columns for the role assignment and status. It is best if all contributing faculty have tasks under each role. This balance gives greater consistency and richness and provides growth opportunities for less experienced contributors. As with initial curriculum planning, development planning requires some synchronous collaboration, although role assignment may be done asynchronously. This phase typically requires fewer meetings which may be in person or virtual.

During content development, faculty members create and review each content element. They update each element's status in the appropriate map. Status may include not started, started, ready for review, feedback provided, completed, and published. By using a shared map, all contributing faculty have eyes on the status of content creation as a whole. This helps with setting and monitoring deadlines. This phase is largely done asynchronously.

In the final development phase, all faculty complete a final review of the course content. They check for consistency, alignment, and flow. They then publish the content in their learning management system. This may be asynchronous.

After the course is developed collaboratively, the faculty shift into course delivery. Delivery is also done collaboratively, but with a different model than typical team teaching approaches [4], [5]. Faculty are responsible for their own sections of students. Students may see prerecorded videos from the other faculty developers to give them a broader perspective, but class sessions are facilitated by individual faculty members. This reduces the resource burden that other team teaching models carry. During course delivery, faculty meet weekly with the teaching assistants across all sections. These joint meetings ensure a single instructional voice. In addition to

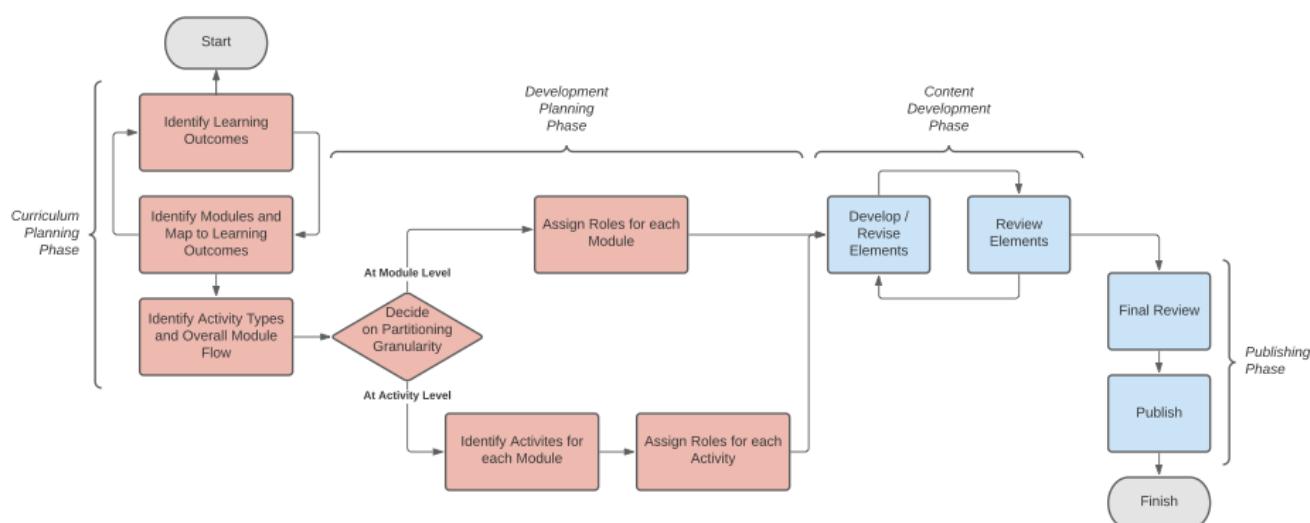


Fig. 1. Collaborative development flow. Steps in red typically require tighter collaboration while steps in blue can often be completed more independently.

these more formal meetings, faculty often also meet informally between class sessions to share updates and make micro-adjustments. These meetings are essential to encourage and support faculty and teaching assistants during course delivery.

B. Course Maps for Alignment and Engagement

Student learning is enhanced when the course's learning outcomes, readings, assignments, and activities are aligned. Creating and monitoring this alignment can become difficult, especially when the number of these items increase and/or when multiple people are involved in the course design. One way to handle this complexity is to document and track different alignment and engagement metrics.

The course maps contain two main shared spreadsheets: the *learning outcome-to-module map* that relates course learning outcomes to course modules (e.g., units or topics) and the *module-to-activity map* that organizes course materials, activities, and assignments into these modules to track alignment and engagement metrics. This also facilitates multiple levels of perspective: high-level to ensure the timeline supports progression through the course and low-level that guarantees a variety of engagement activities.

The *learning outcome-to-module map*, see Figure 2, lists the course modules and their descriptions and provides a matrix identifying supported learning outcomes. From this view, it is much easier to see how learning outcomes are covered and identify areas needing adjustment. This can happen if some learning outcomes are not sufficiently supported or if some modules are too broad.

The *module-to-activity map*, see Figure 3, lists the set of activities for the module along with supported outcomes, notes when they are delivered (pre-class, during class, or post-class), and gives metrics on the time and work required.

By explicitly identifying learning outcomes for each activity, faculty are better equipped to ensure that every activity

supports the module's stated outcomes. This brings clarity to activity choices and faculty can make informed choices about removing or adjusting activities.

Engagement type grouping allows faculty to easily see their distribution. Providing this space to see and plan activities encourages faculty to broaden the types of activities offered. Now faculty are empowered to provide a diverse set of engagement opportunities that are consistently distributed throughout the course. This diversity exercises multiple levels of learning and increases student engagement by appealing to different students.

C. Supporting Collaboration with the Course Maps

The course maps are also valuable for managing the creation of a wide array of course materials. By adding three additional columns to either type of map (Creator, Reviewer, Status), faculty can track the work partitioning and development status. Development status cycles through not started, started, ready for review, feedback provided, completed, and published.

We recommend that one faculty member creates the content for a module/activity and another faculty member reviews it. Alternating roles promotes a diversity of perspectives with a wider range of course activities than would be produced by any single faculty member.

Faculty can partition the work at a course-grained level (the module level) or at a fine-grained level (the activity level). Often, collaborators prefer to partition at the module level *learning outcome-to-module map* where each faculty member leads in the creation of all the content for a given module. However, some faculty may prefer to focus on developing a particular type of engagement activity, especially if they have more experience with it. In this case, faculty can partition work with the *module-to-activity map*. Granularity may also be adjusted on a module-basis, which can be particularly helpful for longer or more challenging modules.

Module Mapping						TOTALS
Module/Project	Description/Subtopics	Outcome 1	Outcome 2	Outcome 3	...	
Module 1		x		x		
Module 2			x			
Module 3			x	x		
Module ...						
TOTALS						
PERCENTAGES						

Fig. 2. Mapping between course learning outcomes and course modules. The *learning outcome-to-module map* provides metrics for ensuring coverage of all learning outcomes and examining their distribution.

Activity Mapping													
Module:													
Activity	Outcome	Outcome	Outcome		Delivery Timing			Reading	Video	Poll	Quiz	Discussion	Reflection
Sequence	1	2	3	...	Pre-	During	Post-	(Pages)	(Minutes)	(Questions)	(Questions)	(Questions)	(Questions)
Activity 1													
Activity 2													
Activity 3													
Activity ...													
TOTALS													
PERCENTAGES													
WORKLOAD													

Fig. 3. Organization of course activities and assignments for a module and its mapping to learning outcomes and engagement activities. The *module-to-activity map* provides metrics for learning outcome coverage, the distribution of when activities are delivered (either pre-class, during class, or post-class), and the distribution and workload of different activity types.

IV. FINDINGS AND DISCUSSION

Prior to the 2020–2021 academic year, we collaboratively redesigned a junior-level Computer Science course, Programming Studio. It is required for all Computer Science and Computer Engineering students, serving over 250 students each semester. Individual faculty are responsible for individual sections, each containing 90 students. These are further divided into labs with 30 students each. Students see content and videos from all collaborating faculty, but class sessions, communications, and grading are conducted by individual faculty. This addresses students’ concerns with communication and grading in collaboratively taught courses [11].

The course integrates several core concepts and familiarizes students with a variety of development tools and techniques. During the course, students also grow their teamwork and written communication skills. The course uses project-based learning (PBL) [59] as its main pedagogical approach, but the collaborative design process is not limited to PBL and can be applied to a other of approaches. Table I lists the course’s learning outcomes and corresponding assessments. Outcomes were not changed in the redesign.

We compare both the course alignment and the engagement offerings that the collaboratively redesigned course has over the previous version. For both, we see a positive impact in the redesigned course and attribute this to the collaborative development process using the course map structure.

A. Impact of Collaboration on Course Alignment

We first computed the mapping between the course learning outcomes and the two sets of modules and projects, the original set and the redesigned set. Table II compares the percentage of modules and major projects that address each of the six course outcomes for each version. Note that both versions of the course contain four major projects, but the number of modules varied slightly as content was reorganized. The final row in the table reports the percentage change from before to after the redesign.

Prior to the collaborative redesign, topics were introduced and discussed in a compartmental slide deck format as a self-contained unit. Thus, modules focused more on topics covered than on particular learning outcomes. This resulted in low coverage across all outcomes (less than 50% of modules covered any given outcome) and some outcomes having significantly low coverage (less than 15%). For example, Outcome 6: Technical Writing had less than 8% coverage and Outcome 1: Understanding the Need had less than 14% coverage in the original version. Technical writing had been recently added to the course’s learning outcomes when it became a designated writing-intensive course. The lack of coverage prior to the redesign is likely due to the shorter time span for this outcome to be adopted verses the established course momentum.

In the collaborative redesign process, the mapping structure exposed areas where outcomes were less supported. With the course map structure, we could better see where to introduce, repeat, and expand on course concepts. This resulted in better learning outcome support with all outcomes having over 40% coverage (the prior maximum).

Compared to the original course, all outcomes showed improved coverage with some outcomes having six or seven times more coverage than before. The lowest covered outcomes originally had the greatest gains. We discuss specific outcome impacts below:

- *Outcome 1: Understanding the Need.* In the redesign, we discovered how rarely the course specifically addressed the need for software development beyond the introductory modules. We made a focused effort to explicitly motivate each software development concept to ground students in the need. Correspondingly, we saw that 93% of the redesigned modules addressed this learning outcome.
- *Outcome 6: Technical Writing.* We worked to more fully integrate the newest learning outcome into the course. Instead of having a single, stand-alone writing-focused project, we now have many modules and all projects with a writing emphasis giving 43% coverage.

TABLE I

COURSE OUTCOMES AND ASSESSMENTS FOR A JUNIOR-LEVEL COMPUTER SCIENCE COURSE. OUTCOMES WERE UNCHANGED DURING THE REDESIGN.

Label	Short Name	Description	Assessment
O1	Understanding Need	Explain the need for software engineering through industry examples and experience	Individual low-stakes quizzes, individual weekly reflections
O2	Software Development Concepts	Exercise the fundamental concepts of software development	Multi-week team projects with different development methodologies, development phase reports, project retrospectives, in-class group activities
O3	Software Development Skills	Design and develop software that is clearer, more maintainable, and solves complex problems	Multi-week team projects providing real-world solutions, in-class group activities
O4	Software Development Tools	Integrate a variety of current software technologies to build new software products	Multi-week team projects requiring use of multiple technologies, GUI prototyping, project management tools, and APIs
O5	Teamwork	Collaborate and communicate effectively in teams	Multi-week team projects with peer review, in-class group activities
O6	Technical Writing	Recognize and apply characteristics of effective technical writing (writing-intensive course)	Individual written technical report on a software development issue, group project proposals, design documents, and reports

TABLE II

OUTCOME COVERAGE AND DISTRIBUTION ACROSS COURSE MODULES AND PROJECTS BEFORE AND AFTER COLLABORATIVE REDESIGN.

Version	Outcome					
	O1	O2	O3	O4	O5	O6
Before	13%	28%	40%	28%	28%	7%
After	93%	79%	43%	57%	43%	43%
Increase	7.0X	2.9X	1.1X	2.1X	1.6X	6.0X

TABLE III

AVERAGE AMOUNT OF DIFFERENT TYPES OF ENGAGEMENT ACTIVITIES ACROSS COURSE WEEKS BEFORE AND AFTER REDESIGN USING COURSE MAPS. READING ACTIVITIES NOT SHOWN AS NO CHANGE WAS MADE.

Version	Engagement Activity Type					
	Mini-Lecture (min.)	Poll (#)	Quiz (#)	Discuss (#)	Reflect (#)	Group Apply (min.)
Before	110	1	0	0	0	30
After	60	4	2	2	2	90

- *Outcome 5: Teamwork.* This outcome had mild improvement due to the project-based design of the original course which was maintained. While the projects stayed largely the same, we were better able to articulate how each project supported the learning outcomes and how they related to each other in the redesign.
- *Outcome 3: SW Development Skills.* This had the least improvement as the previous topic-focused module approach naturally has greater alignment with this outcome.

B. Impact of Collaboration on Engagement Opportunities

Previously, the course was delivered face-to-face and contained the following types of engagement activities: reading materials, live mini-lectures, class discussions, and group in-class activities. The redesigned version was delivered both synchronous online and hybrid face-to-face/remote in response to COVID-19 safety protocols. In addition to the original activity types, the redesigned course also included recorded mini-lectures, polls, comprehension check quizzes, discussion boards, and reflections.

Table III shows the average amount of each activity type per course week, both before and after the collaborative redesign. Note that course weeks are shown instead of modules because originally, modules spanned the full week while two modules were covered each week in the redesign.

The most significant change is the shift in the mini-lecture and group application balance. In the original version, one and a half class sessions were typically devoted to lecturing while half a class session involved a group activity each week.

Lectures introduced and discussed course material, but students largely remained passive except during group-work. In the redesign, this lecture time was reduced by nearly 50% to provide more time for active discussions and group activities.

Lecture content was also split into shorter segments and interleaved with polls, comprehension checks, and discussion boards. Each class session now has time to discuss the topics the students had been introduced to in the reading material and pre-recorded mini-lectures.

In the redesign, group activities are offered every class session and take more of the session time with students spending three times as much time working in groups, applying course concepts, and developing teaming skills with the faculty present to coach and guide. This required development of nearly twice as many group activities. We used the course map to track this development and balance the work.

The redesigned course offers more types of engagement activities than before. The course map directed development by exposing the existing distribution. It was easy to see what type of activity to interleave between mini-lectures, reading materials, or in class sessions by noting what types of activities are already offered. The course map also aided the planning of polls, low-stake quizzes, and discussion board posts to use as a springboard for live discussions.

The course map showed that students did not have reflection activities to deepen their learning. In the redesign, students now reflect on all the content and activities from the week. Low-stakes quizzes were also added to give students yet another opportunity to reflect on the reading or lectures.

As a result of offering multiple types of engagement opportunities, students felt highly-supported in their learning. In course evaluations for all sections, students frequently commented on the engaging learning environment and how it helped them in the course. For example, one student noted “She goes out of her way to foster a great learning environment

and truly cares about the students.”

C. Impact of Collaboration on Course Development

During development, we were able to see new ways of ordering and timing content to better support the learning process. This was needed as the course content does not imply an obvious ordering. The schedule went through several revisions to make sure students acquired the needed skills in time to complete in class activities and projects. This became especially important during delivery when we had to make unexpected changes due to losing an entire week of instruction from an unprecedented winter storm. Students frequently reported in course evaluations that the course was highly organized, regardless of the instructor. One student said “this was probably the most organized and fairest class I took this semester” and another commented that faculty “handled the shift to online better than any of my teachers.”

Collaboration also brought greater breadth and depth to group activities. Recall that group activities received the largest change in class time spent. Previously, students had half as many activities as in the redesign. Activities also were able to take larger amounts of class time, so they could now become more in-depth and engaging. For instance, students went from reading and hearing about inspection processes to actually taking on the roles of moderator, author, and reviewer to find defects. Participating in the actual inspection provided a deeper learning experience than before.

D. Impact of Collaboration on Course Delivery

Given the structure and multiple perspectives, we also saw a positive impact on course delivery. Because of the collaboration, students experienced greater consistency across sections and between semesters. Students saw no variation in course activities and assessments between instructors. This was especially helpful as one faculty member was new to the course entirely while the other had taught the course for many semesters. It is important to note, though, that both faculty contributed equally to course development giving them both ownership and confidence in delivering the redesigned course.

Regular formal meetings among faculty and teaching assistants provided a consistent instructional voice and fostered a team/community mindset. This is essential in supporting multiple teaching assistants that are each responsible for separate labs, especially when some were new to the course or to the teaching assistant role. Teaching assistants also felt that they were part of a larger team and had many people they could reach out to. Students also enjoyed the team dynamic and took advantage of having a larger group of people to access.

This collaborative mindset spilled over into frequent, but informal, meetings between faculty after class sessions. We often shared what went well and what did not, sparking new ideas off each other. This fueled excitement for the class throughout the entire semester, and students felt this difference. They often reported in course evaluations that the faculty are “very enthusiastic during lectures,” that faculty “really care” and “want us to learn and grow.”

This model can be scaled through more contributing faculty or serving more students. Including more faculty will bring richer materials and perspectives. Because students only interface with the faculty member responsible for their section, the model maintains a single source for communication as it scales. More sections can be added to serve more students.

E. Impact of Collaboration on Student Learning

The nature of the projects and assessments were not significantly changed, but they now have more structure. We saw a 50% increase in teams achieving full mastery of development process from the Spring 2019 semester to the Spring 2021 semester. We also observed a 30% decrease in “average” mastery, and the failure/drop rate went from 1% to 0%. In the future, we would like to compare how these students perform in subsequent courses to those who did not have the redesign.

V. CONCLUSION

We presented a collaborative course design and delivery model that supports student learning through improved course alignment, greater engagement opportunities, and multiple perspectives. It can be applied to any course and any modality; faculty can effectively collaborate through this model either in-person or virtually. This model does not require the resource overhead that many collaborative teaching models need. We demonstrated the positive impact of this approach on a collaboratively redesigned engineering course. The redesigned course has greater coverage and alignment of activities to learning objectives, provides a larger variety of student engagement options, and facilitates a more consistent instructional voice.

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