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# Interdisciplinary Design Project Teams: Structuring an Impactful Experience

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# Interdisciplinary Design Project Teams: Structuring an Impactful Experience

Abstract

Providing opportunities for students to interact on teams is increasingly being incorporated into engineering and architectural education, in part due to industry feedback that graduates should gain experience working on collaborative teams, particularly with students of other disciplines. Educators might incorporate industry collaborative organizational structures, but while there are some aspects of collaboration used in industry that faculty can incorporate, often those models are complicated by the need to achieve academic goals. The potential benefits of interdisciplinary teamwork include development of communication skills and the incorporation of and exploration of a multi-layered, more creative solution from different viewpoints, which need to be balanced with students' acquiring and incorporating new material and carving time for assignments that demonstrate student outcomes for accreditation. As the College of Engineering, Architecture, and Technology at Oklahoma State University has strategically planned a shift toward an interdisciplinary senior design focus and dedicated extensive resources to achieve it, they are having to adjust previous course models. The paper will discuss the structure of one long-standing interdisciplinary architectural engineering senior design class within the college in the architecture department, called the Comprehensive Design Studio (AE-CDS), and compare it to developments of the last three semester of the newly developing engineering Interdisciplinary Senior Design projects (ISD) from the perspective of an architecture faculty member who has taught both courses. In examining these courses, some important characteristics regarding interdisciplinary team projects emerge. Structuring an environment to allow students ample time in a consistent meeting space for iteration and equal communication among all members is a difficult but impactful shift for any team project. Particular to interdisciplinary design work, regular commitment to mentorship by faculty with specialized expertise directly affects student learning and the quality of the solution, as does students' previous experience with skills and teamwork. All of these factors impact departments, not only during senior design, but throughout its curriculum. ISD has made some relevant shifts toward AE-CDS, and interest in ISD in the college has dramatically increased over the past year.

## Introduction

Problems engineers and architects solve are inherently complex with an interrelated nature of layered systems that can be examined at any scale. Solutions to complex problems must be designed, tested, and redesigned from a variety of viewpoints, and as the professions face new challenges, the breadth of interdisciplinary collaboration grows. Industry as a result is shifting away from an "individualist approach toward a cooperative teamwork paradigm [1]" and searching for employees with competency in collaboration [2]. In fact, in 2018, the college built a 72,000 square foot, $35 million first-of-its-kind facility, the Endeavor Lab, using significant industry donations to intentionally shift the paradigm of education to encourage "interdisciplinary, hands-on, and industry-aligned learning. [3]" See Figure 1. In conjunction with the new facilities, the college's strategic plan stipulated that, by 2022, 40% of graduates would have an interdisciplinary design experience.

As the overarching conceptual platform and physical space in the college are established for interdisciplinary collaboration, departments and faculty are developing ideas for more collaborative interactive learning. The faculty in the ISD course needs to determine the most effective framework to realize this pedagogical shift. A director was hired from industry who has experience mentoring student design-build projects, and the ISD structure was initially based on the existing team structure used in the Mechanical and Aerospace Engineering Senior Design Team Projects, which were rarely interdisciplinary. The existing MAE senior design course was densely packed with team-based deadlines and student team assessments and a requirement for each team to design and fabricate a functional prototypical object, a requirement encouraged by industry partners. In addition to the object fabrication, not only is the complication of collaborating with different departments layered into the framework of this full course, but the call by industry to move toward an open-ended design process that asks students to solve problems broader in concept and scope is also incorporated. The first semester of the ISD was Spring 2019. Faculty and administrators have been refining the course with adjustments over the last three semesters, although it is difficult to find appropriate team structures in industry that address all educational objectives. They do exist, however, in other academic disciplines like architecture. Studios, or labs, in architecture have long-standing models that create opportunity for an iterative design process of a wide variety of project scopes and scales. In particular, this college has the AE-CDS model that has over five decades of development to reference.

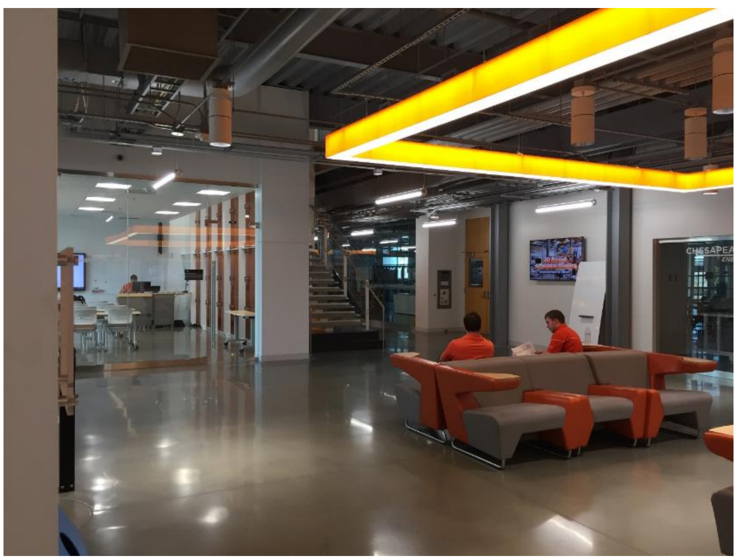

Figure 1. Endeavor Lab showing informal “sticky” spaces with adjacent classrooms and labs

Courses’ goals, outcomes, opportunities, and challenges related to teamwork

For the complex tasks of building and equipment design and construction, industry often structures its tasks within a traditional cooperative team framework in which employees and consultants perform within their areas of expertise in a “mutual engagement of participation [4]”. Benefits of collaboration in academia include improved creativity, development of analytical and communication skills, and development of a respect for others’ ideas [5]. Layering teamwork into any academic course is challenging, however, and must be carefully structured and activities crafted, especially since some research shows that typical cooperative collaboration can result in as much as a 50% decrease in “covered ground” for learned material [5]. In engineering and architectural education, the goals of cooperative learning should include not only the development of social skills like verbal and nonverbal communication and the understanding of social rules [2], but also the development of design skills that produce solutions that are conceived and tested from different viewpoints and a respect for a variety of approaches. In engineering and architecture undergraduate curricula, the time to adequately ensure that fundamental skills and knowledge are mastered by graduation is limited, so faculty must structure the incorporation of learning collaborative skills to balance multi-faceted goals and outcomes.

Where the courses’ parameters differ primarily is related to the scale of a proposed problem to solve and what semester deliverables are. ISD projects tend to be smaller in scale, and they are expected to produce a functioning prototype. AE-CDS projects are at the scale of an entire building, but its deliverables are structural systems, mechanical system design calculations and loaded models. The student outcomes discussed in this paper are defined by those common to both the ISD and AE-CDS courses. The first outcome, driven by industry and the realization that the designs of objects and buildings are integrated complex layers of different systems, focuses on the development of social collaborative skills and communication. Another outcome is student learning of some new knowledge that must quickly progress from a basic understanding to the ability to incorporate the knowledge within a design. This requires repetition and detailed input from a faculty member of a particular discipline. The goal for both courses is for students to design a project using an open-ended design process for a real client, test it using a range of parameters, and redesign it to improve performance. The differences have an impact on the structure of the courses, but it is in the logistics established to meet the common goals where ISD faculty can learn from AE-CDS.

## Architectural Engineering Senior Design Project/Comprehensive Design Studio (AE-CDS) Course Description

The School of Architecture at our university is one of the few schools in the country to house both architecture and architectural engineering. Its curricula are integrated, offering both 5-year Architectural Engineering and Architecture degrees. Students work together throughout the curricula, but the Architectural Engineering senior design course, the Comprehensive Design Studio (AE-CDS), in particular has most directly emphasized the development of students’ long-term collaborative skills. The structure of this required studio has been tweaked over the years and the type of collaborative structure incorporated has varied. Underlying most of the course’s activities is the need for students of both majors to understand that building design and development process is a holistic integration of spatial, structural, lighting, and environmental systems. The studio is a six credit-hour course with an integrated three credit-hour technology seminar. In addition, in a three credit-hour co-requisite management course, students explore issues such as contracts, budgeting issues, and specifications. Essentially, these three courses form a comprehensive semester organized into schematic design, design development, and design documentation, based on the three project phases used in most practices. In the technology and management courses, the seminars and assignments correlate directly to activities happening in studio [6].

The assigned semester project is a building design typically between 20,000 and 30,000 SF. The faculty adopts a variety of project programs including homeless community centers, small theaters, and community libraries, so the scope is large. The programs are Stillwater community-based with actual “clients” who might either be working toward a proposal or construction of a new facility or have a particular expertise valuable to the project program. Throughout the semester, students interact with professionals in a variety of settings. At the end of each phase of the semester, the faculty invites professional architects, architectural engineers, and mechanical engineers as well as client representatives to engage students. Students present to several professionals at the end of schematic design, and they face the same professionals at the end of design development. Professionals are also invited into the studio at different times to discuss and critique issues related to code, lighting design, and wall section assembly [6].

During the first five weeks in Schematic Design, Architects and AEs work as a team of one AE student and between two and four architecture students based on a typical cooperative team structure. The teams are expected to research the project, explore conceptual directions, and settle on a schematic design with structural and mechanical systems design. Roles are not determined by faculty, but typically the AE student works on the systems design and the architects develop the building and site design. Every student team member interacts at least weekly with faculty of all disciplines, including architects, a faculty member specializing in environmental systems, and an architectural engineer.

Any teamwork done in the studio is structured through daily scrums, short meetings between faculty and a team that determine what has been completed since the last meeting, what needs to be completed, and what obstacles might be hindering progress. The idea of scrums originated in software design to help streamline the creation of a product that involves a multi-layered approach of interrelated expertise. Like designing a building with different systems, it involves a

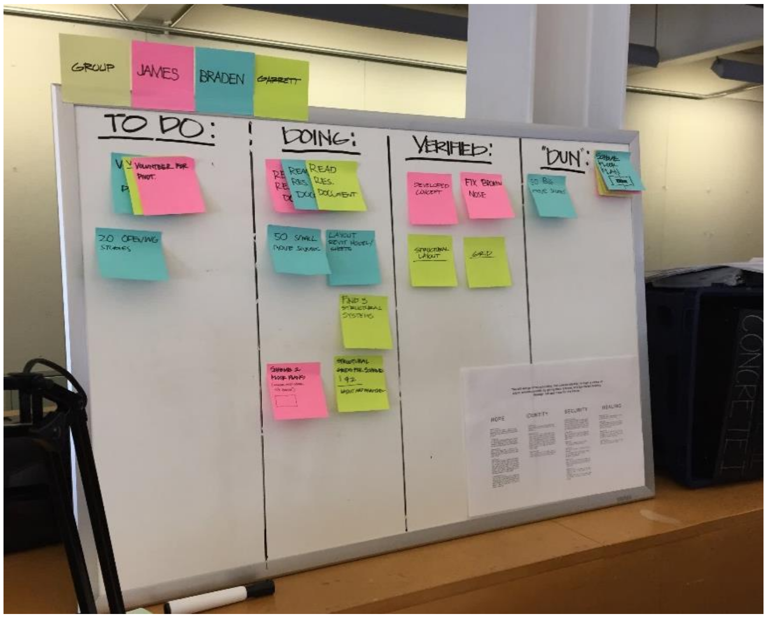

Figure 2. Student scrum board.

variety of designers establishing and testing different aspects of a program. Daily scrums are parts of a sprint that last from one to four weeks, and their foundation is based on team values of courage, focus, commitment, respect, and openness [7]. Teams use publicly visible boards with simple post-it notes listing a particular task, color-coded to the person responsible for that task. It is a transparent way to identify progress. Within each sprint, tasks are done, then tested, then reworked, and there is a column for each of these phases of a task on the board, and the post-it moves accordingly. See Figure 2. This semester, in a survey from every student, 100% of students in the course saw benefit in the scrum method to help the team stay focused on tasks and to identify impediments to progress [8]. An important aspect of the success of the scrum process is having a common work space like the studio paired with significant common meeting time.

After Schematic design, students work individually for the remaining 11 weeks of the semester to complete Design Development and Design Documentation. AE students focus on the structure of the building, but they also size mechanical equipment, verify code compliance, and integrate an architectural wall section. This is the part of the semester in which an atypical collaborative paradigm is used that focuses on long-term appreciation and understanding of the design with an immersive experience. The phrase used to describe the paradigm is "conversant immersion" which emphasizes depth and breadth of the building design process [9]. The term conversant addresses the goal of each student's becoming familiar with a variety of systems and their interrelated impact on the performance of the overall building, and immersion is essentially how that happens. Immersion is an effective method of learning in other areas like language studies. In an intensive environment like language immersion, students might learn fundamental aspects of the language more quickly and independently, and with more breadth and depth than if they had focused on only one aspect of it. Each student again regularly has access to all faculty members of all disciplines.

| | **Professional Engineers Assessment of AE-CDS Students per ABET criteria** |
|---|---|
| Year | Criterion 1 Ability to solve engineering problems (Score 1 lowest, 5 highest) |
| 2019 | 4.4 |
| 2018 | 4.0 |
| 2017 | 4.09 |
| 2016 | 4.5 |
| 2015 | 4.0 |
| | Criterion 2 Ability to communicate effectively (Score 1 lowest, 5 highest) |
| 2019 | 4.78 |
| 2018 | 4.3 |
| 2017 | 4.13 |
| 2016 | 4.4 |
| 2015 | 3.94 |

Figure 3. Exterior Professional Assessment of AE_CDS Course

Arguably, this experience is intense for students and faculty and requires a substantial commitment from the faculty team and department, but the course has been assessed very positively by professionals and national award programs. See Figure 3. The studio course has also been nationally recognized throughout its recent history. In 2004, the course won a $25,000 National Council of Architectural Registration Boards award for “Creative Integration of Practice and Education in the Academy”, and in 2004 and 2010 it was recognized as meeting the National Accreditation of Architectural Education criteria with distinction, and in 2016, the combined studio and seminar courses met 53% of the curriculum’s criteria, and including the parallel management course, they combined met 65% of the curriculum’s criteria. In Spring 2020, the course has been awarded the Columbia University’s Temple Hoyne Buell Center for the Study of American Architecture and the Association of Collegiate Schools of Architecture (ACSA) as one of five winners of the 2020 Course Development Prize in Architecture, Climate Change and Society. The objective of this paper is to identify crucial factors that emerge regarding interdisciplinary design team course planning by comparing the structure of the long-standing AE-CDS design course and that of the emerging ISD course.

Interdisciplinary Senior Design Projects Course Description in the Spring 2019

Although teamwork in the Engineering Senior Design course is not new, its interdisciplinary nature is. The origin of its current structure is one which is based on the Mechanical and Aerospace Engineering senior design team projects. Unlike the AE-CDS, cooperative teamwork in the ISD stretches over the entire semester. The ISD has begun to incorporate changes to reflect some characteristics of the AE-CDS, but the brief ISD course description to follow will reflect projects involving architecture and architectural engineering students during Spring 2019. See Figure 6 for comparisons of the two courses.

Of the fifteen ISD projects developed in the Spring semester of 2019, four of them involved one or more teams that involved both engineers and architects. Their projects were larger in scope and scale than the intradisciplinary projects and included designing an accessible entry for the Stillwater Community Center, and performance pavilion for a future community park, a 3-D printed concrete affordable house, and a shading structure for a west-facing glass wall on an office building in Tulsa. All projects addressed real-world situations and engaged with clients. Two teams produced separate solutions for the shading project, so there were five teams total with architecture students. In addition to architecture students, the teams had a combination of various engineering disciplines representing three departments: Architecture, Mechanical and Aerospace Engineering, and Civil Engineering. Figure 4 lists the disciplines of each team. Larger teams were subdivided into smaller teams for logistical reasons. Although the overall ISD course was based on the MAE Senior Design project model, it was an elective for the architecture students, and the civil engineering students enrolled in a separate Civil Engineering Senior Design course with a separate syllabus. The faculty leader had to navigate the varying requirements, values, and deliverables of each course. It was intended that each discipline within the team would have a faculty mentor within their department to answer more detailed questions and to receive critiques, but for many teams that did not happen. To further complicate the process, due to students’ varying schedules, meeting times were set by the students just once a week for one hour. Larger teams were not able to establish an overlapping hour within the week, so they were divided into sub-teams that focused on a particular aspect of the project. Those sub-teams had leaders that attended the larger team meeting.

**Interdisciplinary Senior Design Project Teams**

| Team | Subteam | Student Major | Course | Meeting | Location |
|---|---|---|---|---|---|
| | | | | | |
| **3D Concrete Printing Affordable Housing** | Overall Team- led by Homer and Ley | | | Tuesdays 12:30 - 1:30p | FSB Conference Room,BCEL |
| | Concrete Printing SubTeam- led by Dr. Ley | | | Wednesdays 2:30 - 3:30p | FSB Conference Room,BCEL |
| | | ME/EE double | MAE 4344 | | |
| | | Mech E | MAE 4344 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| | Design SubTeam- led by Homer | | | Wednesdays 6:00-7:00p | 3rd Floor Architecture Bldg |
| | | Arch | ENGR 4010 | | |
| | | Mech E | MAE 4344 | | |
| | | ArchE | ENGR 4010 | | |
| | Resilience SubTeam- led by Homer | Civil | CIVE 4043 | Fridays 4:30-5:30p | Ag 202 |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| **Stillwater Community Center** | Led by Homer | | | Fridays 11:30-12:30p | Student Center ATRC |
| | | Mech E | MAE 4344 | | |
| | | Mech E | MAE 4344 | | |
| | | Mech E | MAE 4344 | | |
| | | Arch | ENGR 4010 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| **Outdoor Stage** | Led by Homer | | | Thursdays 12:00-1:00p | Student Center ATRC |
| | | Arch | ENGR 4010 | | |
| | | Civil | ENGR 4010 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| **Building Envelope Design of Wallace Engineering** | Led by Homer | | | | |
| | Team A | | | Tuesdays 3:30-4:30p | *X 170*, Exxon Mobil Room |
| | | Arch | ARCH 5100 | | |
| | | Mech E | MAE 4344 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| | Team B | | | Fridays 1:00-2:00p | Student Center ATRC |
| | | Arch | ARCH 5100 | | |
| | | Mech E | MAE4344 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |
| | | Civil | CIVE 4043 | | |

Figure 4. List of student projects with teams, sub-teams, majors and mentors

Figure 5. Students working with industry professional on the 3-D concrete printer (left)
Students presenting their Outdoor Stage Pavilion to member of City Council (right)

The semester was divided into design, testing, and final production of a product. Multiple interim deadlines that involved regular meeting minutes and a report and presentation to clients and/or faculty helped focus students on task. With an architecture faculty in the lead, however, a more open-ended approach to design and deliverables was introduced and initially difficult to embrace by the engineers. Many adapted, and design became iterative and occurred throughout the entire project, and all students were expected to contribute to design versus a more familiar model in which architects design and engineers calculate. Engineers were expected to strategize, conceptualize, and analyze each iteration. It may be more comfortable for students to isolate themselves within their particular task and viewpoint, but experiencing some discomfort is an important step in learning [10]. Although deliverables in the course are typically a built operational prototype object, since the scope of the problems was larger and options for solutions broader than a typical engineering senior design project, the deliverables were a report with drawn representation and calculations of the design, with the exception of some pieces built by several of the sub-teams. See Figure 5.

In the end, after an intense semester, projects were presented that were considered from a variety of viewpoints. Despite some grumpy meetings and even tears, the overall student perception of their experience was positive. Noted were their wider understanding of different perspectives and the perceived future value of this experience. Informal feedback from students, faculty, and professionals suggested that Spring 2019 was a solid beginning, but adjustments could be made to better facilitate communication development and student learning.

## Analysis and Conclusions

Looking at the comparison of the two courses in Figure 6, one can see some characteristics in ISD that are shifting toward the AE-CDS model; these factors emerge as important for anyone structuring an open-ended interdisciplinary senior design course. Two obvious characteristics that have changed to facilitate team communication are the numbers 4 and 5, the addition of required in-class common meeting times for all members and a common classroom meeting location. This is no small feat when working with different departments, curricula, and schedules, but in Spring 2020 there is agreement among many disciplines to set aside six hours per week to meet. Discussion can happen with all members present, and communicative activities could be occasionally inserted to ensure learning outcomes related to communication or individual performance, and each student can demonstrate knowledge and contributions. An issue related to this is number 6. The college has worked to provide some permanent space for teams, but there are a couple of issues hindering progress in this area. Currently there may not be enough space for all teams, but even when they have assigned spaces, they choose to not work there until later during fabrication. In AE-CDS, working in the studio throughout the semester is required. There are security issues to consider regarding personal property, and student studio spaces are notoriously messy; engineers are not open to that in a new expensive facility. Assuming students from different disciplines, especially in large teams of ten students, can commit to a number of hours per week in a consistent space that is conducive to work and communication is a mistake that can have a devastating impact on team performance and learning. If the intention is to promote a more open-ended design process, a significant portion of that time must be dedicated to productive communication in which all members can equally participate. In written student feedback provided after Fall 2019, frustration with these characteristics was a primary concern, so shifts in these characteristics are promising.

## ISD AND AE-CDS COURSE COMPARISONS

| Characteristic | | | Interdisciplinary Senior Design | | | AE-CDS |
|---|---|---|---|---|---|---|
| | **Characteristic Connected to Benefit of Inter-disciplinary teamwork** | **Characteristic Connected to Challenge of Inter-disciplinary teamwork** | **Spring 2019** | **Fall 2019** | **Spring 2020** | **As of Spring 2020** |
| 1. Number of credit hours | | | 4 | 4 | 4 | 12 total for 3 interrelated courses |
| 2. Course teamwork structure | | Student learning | cooperative | cooperative | cooperative | Cooperative, then conversant immersive |
| 3. Same course syllabus for all student team members? | | | no | no | No, but planned for Fall 2020 | yes |
| 4. Required common in-class meeting times for all team members | Communication skills | | 0 hrs | 0 hrs | 6 hrs | 19 hrs |
| 5. Common classroom meeting location? | Communication skills | | no | no | yes | yes |
| 6. Set space for the team to work off hours together? | Communication skills | | Varies, but all at end of the semester have space for fabrication | Varies, but all at end of the semester have space for fabrication | Varies, but all at end of the semester have space for fabrication | yes |
| 7. Time for schematic design | Open-ended design process | | 6 weeks | 6 weeks | 6 weeks | 5 weeks |
| 8. At least once per week of access to technical help within each discipline? | | Student learning | Not always- varied | Not always- varied | Improved in some depts, but varies | yes |
| 9. Expected deliverable at semester end | | Student learning | Operable prototype and/or design with technical calculations in a team report | Operable prototype and/or design with technical calculations in a team report | Operable prototype and/or design with technical calculations in a team report | Design of entire building structure with technical calculations and modeling and integration with other systems |
| 10. Involvement of industry professionals | Communication skills | | At end- varies | At end- varies | At end- varies | Extensive throughout semester |
| 11. Involvement of real clients during process | Communication skills | Student learning | yes | yes | yes | yes |

| ISD AND AE-CDS COURSE COMPARISONS | | | | | | |
|---|---|---|---|---|---|---|
| 12. When projects and team disciplines are established | | | Latest was during the first week | Sometime prior to first semester | Four months prior to semester | Two months prior to semester |
| 13. Team versus individual performance ratio | | Student learning | 55% team 45% individual | 55% team 45% individual | 55% team 45% individual | 30% team 70% individual |
| 14. Documentation of meetings/management of team communication | Communication skills | | Meeting minutes | Meeting minutes | Meeting minutes | Scrum meetings |
| 15. Is interdisciplinary teamwork optional or required? | | | Optional | Optional | Optional, but number of students signing up is increasing | Required |
| 16. Structured interim deadlines? | | Student learning | yes | yes | yes | yes |
| 17. How many open-ended design projects prior to senior design? Any hands-on skills? | Open-ended design process/Improved creativity | Student learning | 0-2 | 0-2 | 0-2, but changes beginning for lower level students | 9-12 |
| 18. Regular assessment of interdisciplinary coursework? | | | Assessment of student work within their separate depts | Assessment of student work within their separate depts | Assessment of student work within their separate depts, but overall ISD in progress. | yes |
| 19. Number of projects faculty manage in the class | | Student learning | One different project per team typically | One different project per team typically | One different project per team typically | One project for all teams |

Figure 6. Course Comparisons

In process of changing     Should consider changing

A change regarding characteristic number 3, the course syllabus, that will be happening is worth noting. Students in different departments were to some degree trying to follow two syllabi, the one for ISD and one for their department senior design. This is another obvious problem, but not surprisingly, it is a difficult one to solve. It requires departments to change the course that they rely most heavily on for ABET accreditation, but having one umbrella syllabus marks a shift toward sharing common values and goals for each team. Next semester, in Fall 2020, the departments have agreed to one syllabus, or at least one in which grading and deadlines correspond.

Other significant areas in which IDS is shifting toward the AE-CDS model include number 12, the time frame in which interdisciplinary teams and projects are determined. Deadlines for project proposals have been established well before the semester starts, giving all participating departments time to collaborate. It also provides the students opportunities to carefully consider which project they are interested in, given the option. The fact that students have the option to do the ISD versus an intradisciplinary design project has not changed, but the participation in it has increased as changes are made. The college had in 2018 articulated a goal of 40% graduates participating in an interdisciplinary senior design experience by 2022 in its Strategic Plan. They are vey close to meeting that goal early. See Figure 7.

| Semester or year | Percentage of participating students in college | | | Percentage of participating undergraduate programs |
|---|---|---|---|---|
| | Engineering/ Engineering Tech | Architecture/AE | Total for all students in college | |
| 2018 | 0-2% | 100% | 10% | |
| Spring 2019 | 22.8% | 100% | 28% | 54.5% |
| Fall 2019 | 28.6% | 100% | 35.6% | 54.5% |
| Spring 2020 | 34.7% | 100% | 39% | 63.6% |

Figure 7. Participation in interdisciplinary senior design of students and departments in the college is increasing.

Another emerging shift is related to characteristic 17 regarding previous open-ended design experience which is going to occur within the next few years, as changes to the early curricula begin to occur next semester. Although it does not yet show on the chart, the college has introduced a series of one-hour early curriculum module lab courses that develop skills for lower level students. Some are attached to fundamental engineering science courses. One is a class called Engineering Toolbox, which consists of short three-week exercises covering such topics as data acquisition, additive manufacturing, electronic component design, material properties testing, and flow systems; these modules occur in the new Endeavor Lab. Departments are building in more design experiences into their curricula prior to senior design. Assessment regarding this change can be performed in a few years to study the difference these new experiences have on ISD, but a program interested in ISD should anticipate the incorporation of broader changes.

Finally, the characteristics number 8 and 19, student access to regular faculty help for technical guidance and how many projects faculty must manage, are two of the biggest advantages of AE-CDS and factors that ISD should improve and/or consider. Currently, faculty mentor involvement varies per team and per department. This was noted as a major frustration for students and project leaders teaching the course. Without this mentorship, the accuracy of the testing and assessment during the process is unreliable. Understandably, faculty are limited in their time to mentor teams. Some departments have hired faculty whose only role is to mentor their departments' students, but depending on the number of projects, that task is still daunting. In AE-CDS, all the teams design the same project. ISD's projects have smaller scopes, so doing this across the board may not work, but reducing the number of projects and potentially having several teams work on the same project while proposing different solutions would not only lighten faculty load, but it will also promote the idea that there are a wide variety of viewpoints, a goal of teamwork in academia.

The process of developing a course with extensive teamwork and open-ended design iteration should continually evolve, but some basic values must be established. Any department involved in ISD must commit to the interdisciplinary concept in terms of faculty resources and a willingness to adjust its own curriculum. It is difficult to integrate effective teamwork into a course, but the added layer of interdisciplinary viewpoints and increased scope and design freedom involves a deeper department commitment. In fact, this was recognized and commended by eight designers in industry who were invited to evaluate senior design projects in the fall of 2019. They appreciated the addition of large interdisciplinary teams with increased complexity and scope, but noted that those projects were in a completely different category from those produced by smaller single-discipline teams. They added that they were only interested in reviewing the interdisciplinary projects.

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