A Case Study in Developing an Integrated Project Delivery (IPD) Course

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The following paper highlights the design and implementation of a 3 credit-hour, interdisciplinary technical elective in integrated project delivery including design-build (DB), construction manager at risk (CMAR) and construction manager/general contractor (CM/GC) delivery methods. In this course, architecture, engineering and construction management students were organized into teams of competing firms. Each team was issued a project request for qualifications (RFQ) and request-for-proposal (RFP) that culminated in the delivery of a statement of qualifications, written proposal and oral presentation for DB, CMAR and CM/GC services. Teams were provided commercial, institutional and heavy-highway construction documents (CDs) appropriate for each delivery method including conceptual-schematic CDs for design-build and design-development CDs for design-assist CMAR and CM/GC. Projects and industry mentors were provided by Kiewit Corporation and DLR Design Group. The goal of this effort was to introduce the concept of 'best value' contracting as an alternative to traditional design-bid-build delivery to prepare students to compete in the Associated Schools of Construction student competitions, and, to prepare students for successful careers in design and construction management.

Key Words: design-build, CM-at-risk, CM/GC, project delivery.

Introduction

The American Institute of Architects defines IPD as "a project delivery method that contractually requires collaboration among the primary parties; owner, designer, and builder; so that the risk, responsibility and liability for project delivery are collectively managed and appropriately shared" (CMAA, 2012). Key advantages of integrated delivery strategies such as design-build (DB), construction manager at-risk (CMAR) and construction manager/general contractor (CM/GC) include varying degrees of contractor involvement during the design phase, and, the ability to overlap or 'fast-track' design and construction activities (Figure 1).

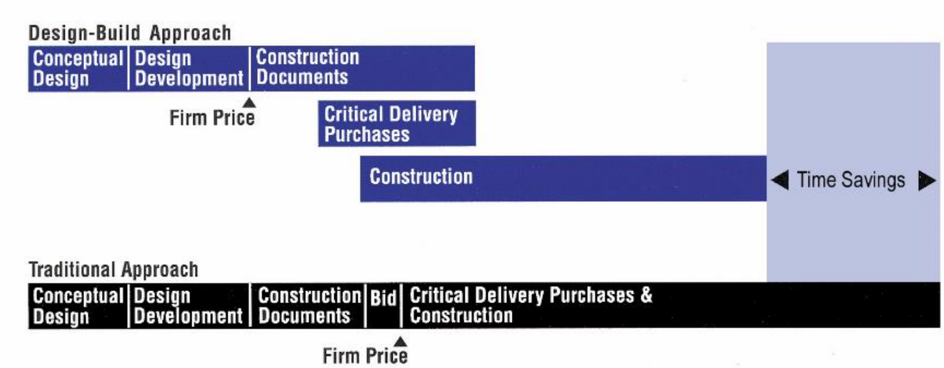

Figure 1. 'Fast-track' DB vs. traditional DBB.

As alternatives to traditional design-bid-build (DBB), integrated delivery methods have proven to improve project performance while reducing time and cost. As a result, sales from DB and CMAR projects alone are forecast to exceed $US180B by 2017, or roughly 40% of the U.S. vertical construction market (Tulacz, 2014). The objective of this paper is to present a pedagogical approach for developing an integrated project delivery course to supplement traditional design-bid-build instruction in ASC member programs.

Methodology

The focus of the integrated project delivery (IPD) course was alternative delivery methods during the preconstruction project award phase. Student teams were issued a project request for qualifications (RFQ) and request-for-proposal (RFP) that culminated in the delivery of a statement of qualifications, written proposal and oral presentation for DB, CMAR and CM/GC services. The goal of each project team was to demonstrate best-value to the Owner. Best-value was defined as a project approach that most cost effectively and time efficiently met the objectives of the Owner's program.

Each team was required to communicate its best-value approach in three (3) project award phases. The first phase was the **Statement of Qualifications (SOQ)** phase, where teams provided the Owner general company information in an effort to demonstrate the character, capital, and capacity to successfully complete the project. The second project award phase was the **Proposal** phase, where SOQ pre-qualified teams provided the Owner project specific information including design concepts, methods and materials and work-flow management techniques it will use to deliver best-value. The third and final project award phase was the **Presentation** phase where teams provided an oral overview of the written proposal to the Owner.

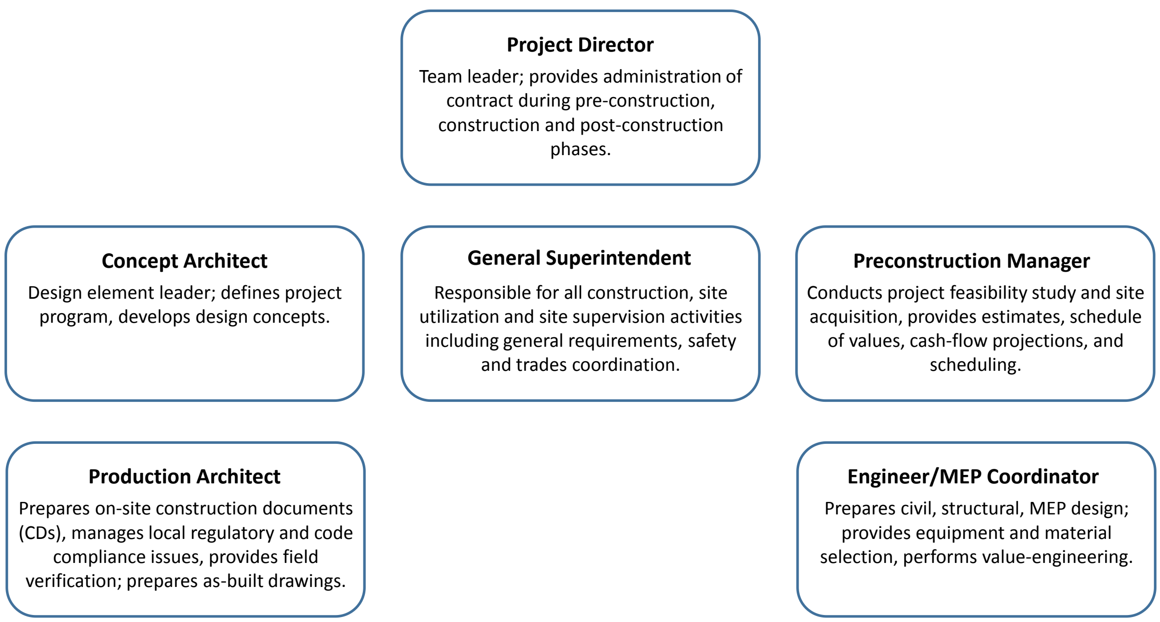

Figure 2. Student team roles and responsibilities.

Students were first organized into three (3) teams of six (6) students each based on project type, discipline and student career preferences. Students were assigned project team roles and responsibilities (Figure 2) throughout the qualifications, proposal and presentation process.

Team 1 – Creighton University Athletic Facility (DB)

This design-build (DB) project included full design and construction planning of a new 34,000sf athletic facility. Proposal requirements included site selection, programming, conceptual design (site plan, renditions, interior and exterior elevations, floor plans, and space use summary), preliminary cost estimates and proposed schedules for construction. This project team consisted of students from Architecture (2) and Construction Management (4) programs and included a commitment to Leadership in Energy and Environmental Design (LEED).

Team 2 – Peter Kiewit Institute Renovation

This construction manager at-risk (CMAR) project included design-assist and buildout of an existing 54,000sf institutional shell space. Proposal requirements included design completion (floor plans, interior elevations, materials and equipment selection, value-engineering and constructability analyses), detailed cost estimates and schedules for construction. This project team consisted of students from Construction Management (6) and included a commitment to safety, security and minimizing occupant disturbance during construction.

Team 3 – Tennessee DOT I-40 Rehabilitation

This construction manager/general contractor (CM/GC) project included design-assist and construction of a 3-span interstate bridge replacement. Proposal requirements included design assistance (value-engineering and constructability analyses), cost estimates and schedules for construction. Included in this project was demolition, temporary structures, and planning of detour routes. This team consisted of students from Civil Engineering (2), Construction Engineering (2) and Construction Management (2) programs and included a requirement for self-performing of 30% or more of the work. Additionally, this project included a commitment to traffic safety and disadvantaged business enterprises (DBEs).

Next, students were provided three (3) project assignments representing the three 'short-listing' and selection phases typical of alternative delivery including qualifications, proposal and presentation phases.

Assignment 1 - Request for Qualifications (RFQ)

In assignment 1, teams were responsible for design, preconstruction, and construction services required to complete the project in accordance with the RFP documents. Specifically, teams were required to submit a **Statement of Qualifications** according to the criteria below (Table 1). Prequalified teams would then be invited to submit proposals for design, preconstruction, and construction services.

Table 1. Request for qualifications (RFQ).

I. Company Information	II. Relevant Experience	III. Project Team
a. History	a. Specialized experience	a. Organizational chart
b. Business structure	b. Past Projects	b. Team members
c. Organizational chart	i. Name and description	i. Position
d. Description of services	ii. Contract value	ii. Role
e. Self-performed work	iii. Size ($) and scope	iii. Qualifications
f. Licensure	iv. Completion and duration	
g. Insurance	v. Photos or renderings	
h. Bonding capacity	vi. References	
i. Financial statements		
j. Quality program		
k. Safety programs and EMR		
l. Subcontractor selection		
m. Backlog		

Assignment 2 - Request for Proposal (RFP)

Next, prequalified teams were invited to submit a written **Proposal** for design, preconstruction, and construction services according to the criteria below (Table 2). Teams demonstrating best-value in terms of project performance, time and cost were invited to interview for design, preconstruction, and construction services.

Table 2. Request for proposal (RFP).

I. Design	II. Schedule	III. Budget	IV. Construction Plan
a. Program narrative b. Space use summary c. Site plan d. Exterior renderings e. Floor plan(s) f. Material and equipment selection g. Special considerations	a. Design schedule b. Construction schedule i. Critical path items ii. Long lead time items iii. Milestones c. Fast-tracking	a. Conceptual estimate i. $/GSF ii. Schedule of values b. Design fee i. Schematic design ii. DDs iii. CDs c. Preconstruction fee	a. Site utilization i. Site access ii. Staging & storage iii. Equipment iv. Temp utilities v. Traffic flow c. Safety and security d. Inspections e. Commissioning

Assignment 3 - Proposal Presentations

Teams invited to interview for design, preconstruction, and construction services provided an oral **Presentation** to a panel of Owners representatives (e.g. Kiewit & DLR industry panel) with selected team(s) awarded a contract for design and preconstruction services. Upon successful completion of design and preconstruction services, a contract amendment was negotiated with the selected team to include a Guaranteed Maximum Price (GMP) for construction services.

Course content was organized to follow the general order of project assignments beginning with the preparation of a qualifications statement (Table 3). In turn, the project was intended to provide a 'Capstone' case-study of key competencies learned in the course. Team breakout sessions with industry mentors were organized bi-weekly culminating in oral presentations to an industry panel.

Table 3. Course content and schedule (Jackson, 2011).

Week	Topic	Description
1	Project Delivery	Project delivery methods; DBB, DB, CMAR and CM/GC.
2	Introduction	Roles, responsibilities and organizational models; performance requirements, contractual relationships; integration of design, construction cost and schedule.
3	Procurement*	Qualifications and best-value selection; negotiated fees and competitive factors; *request for qualifications (RFQ)*; *request for proposals (RFP)*.
4	Team Assignment 1: Qualifications	Selecting the team; analyzing and responding to the RFQ, making the short list; *statement of qualifications (SOQ)*.
5-6	Team Assignment 2: Written Proposal*	Analyzing and responding to the RFP; managing and aligning proposal development tasks, *written proposal and oral presentation*.
7	Design and Construction Cost*	Developing the budget; designing to budget; programming, conceptual and schematic design, design development, and construction document stages.
8	Design and Construction Cost	Design fee; construction (management) fee; guaranteed maximum price (GMP), buyout, contingencies and shared savings.
9	Design and Construction Schedule*	Fast-track design and construction scheduling.
10-11	Special Topics	Building information modeling (BIM); Leadership in Energy and Environmental Design (LEED); lean design and construction.
12-14	Team Assignment 3: Oral Presentation*	Preparing and delivering the *oral presentation*. Scoring criteria, presentation strategies, contract negotiation, post-award phase.
15	Student Presentations	SOQ, proposals and oral presentations; design-build *summer internships*; ASC *student competitions*.

** Student team breakout session(s) with industry mentors.*

Results

Team 1 – Creighton University Athletic Facility (DB)

The design-build (DB) team provided site selection, conceptual design, preliminary cost estimates and proposed schedules for the construction of a new 34,000sf athletic facility. The team began with a rationale for site selection based on compatibility with adjacent athletic facilities, available utility connections and minimal disturbance with student and vehicular traffic. Included within the design was space allocation and orientation with 4D walk-thru animation (Figure 3).

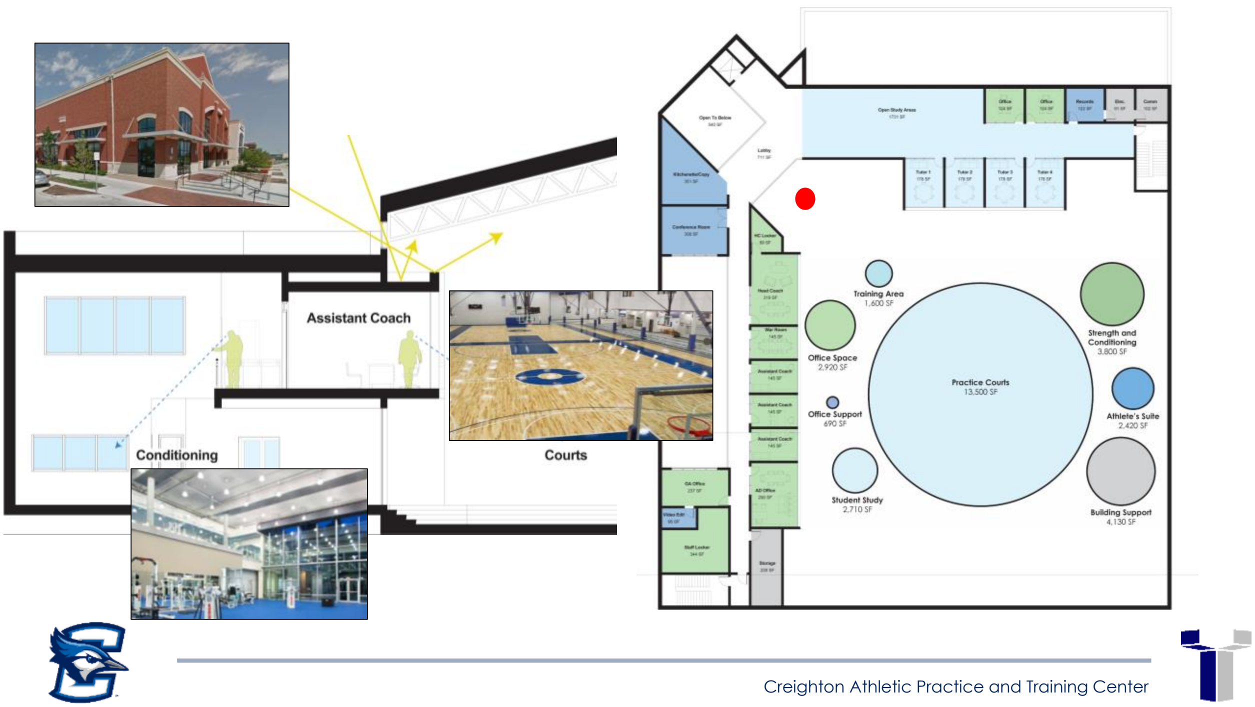

Figure 3. Team 1 – DB conceptual design.

Also included within the design-build approach was a focus on material durability and constructability. The team chose a steel structure with precast concrete-brick inset panels to reduce O&M requirements, increase productivity and utilize offsite prefabricated material assemblies. This approach reduced time, cost and site logistics while also reducing on-campus construction traffic and manpower. Additionally, the team incorporated energy high-efficiency equipment such as geothermal HVAC systems with variable air volume distribution and LED lighting. Also included were low-flow water fixtures and grey water recovery for on-site landscape irrigation, that collectively qualified the project for a LEED Gold certification. The total turnkey cost of the project was $8.4M with design and preconstruction fee of 6.5%. The team successfully negotiated a GMP for construction services with a 10% contingency. Project duration was 15 months, 3 months less than planned for traditional DBB delivery.

Team 2 – Peter Kiewit Institute Renovation

The CMAR team provided design-assist and buildout of an existing 54,000sf institutional shell space. Because the building was partially occupied, a phased construction plan was developed to minimize occupant disturbance during construction (Figure 4). Related, on-campus site access and staging areas were limited, requiring just-in-time delivery and installation of major equipment systems.

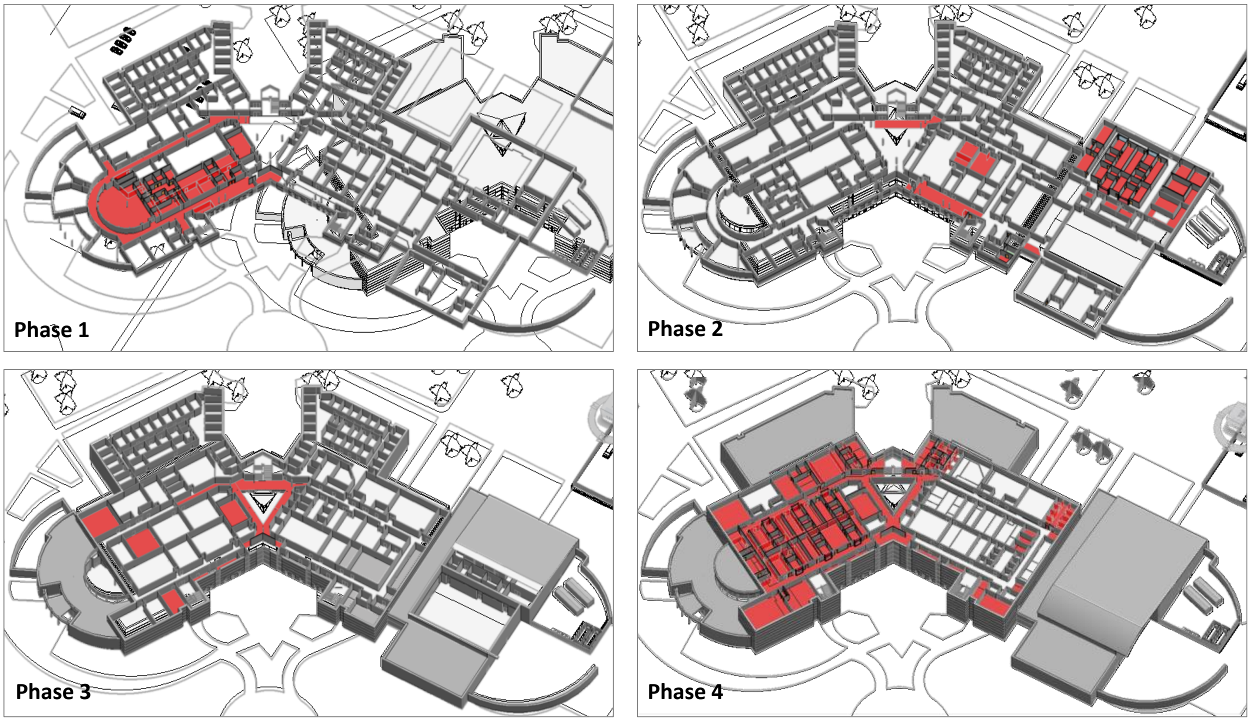

Figure 4. Team 2 – CMAR construction sequencing.

Included within the design-assist approach, the team provided several alternate material and equipment selection options intended to reduce initial and lifecycle cost as well as reduce construction time. Examples include use of modular wall systems that could be reconfigured to future space use changes. The team also used BIM 360 software for clash detection of MEP and structural systems and to avoid unnecessary demolition of interior partitions. Together, the team's design assist and construction plan resulted in a 13-month, $7.1M GMP for construction services. Additionally, the team's 0.68 EMR demonstrated a proven ability to maintain site safety for workers as well as building occupants.

Team 3 – Tennessee DOT I-40 Rehabilitation

The CM/GC team provided design-assist preconstruction services under a negotiated fee, and, a firm-fixed price bid for the demolition and replacement of a 3-span interstate bridge. Project restrictions limited bridge lane closures on weekends between 9:00PM Friday to 5:00AM. As a result, the CM/GC team proposed accelerated bridge construction (ABC) design modifications that would allow entire 3-segment bridge spans to be demolished and replaced with a 56-hour window. This required large pre-positioned pre-cast bridge spans to be assembled on site and placed utilizing specialized equipment and pick design as well as temporary support structures and false work. Additionally, CIP abutments were proposed in lieu of precast piles so that abutments could be completed prior to bridge demolition and to minimize lane closures. Additionally, the team was required to develop an I-40 detour plan and, provide continuous access to local businesses and residential areas during construction. The team successfully negotiated a preconstruction fee of $275,000 with a fixed price bid of $6.4M. Included were negotiated general requirements (4%), G&A (6%) and contingency (8%) as well as >30% self-perform and >5% DBE subcontractor and supplier contracts.

Throughout the 16-week semester, project teams met bi-weekly with industry mentors who were each former project managers on each of the student projects, culminating in oral presentations to an industry panel of Kiewit and DLR senior management and executive staff (Figure 5).

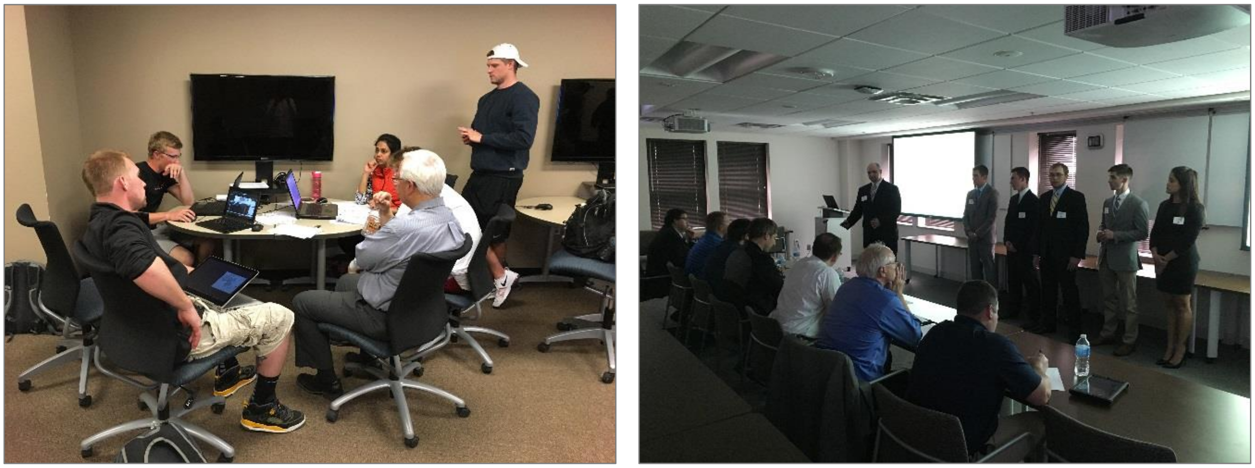

Figure 5. Kiewit and DLR industry mentors (left) and final project review panel (right).

Oral presentations for each team were evaluated by the Kiewit-DLR industry panel using a scoring rubric (Table 4) which was used in part to calculate student grades on the project, as were student peer evaluations. Together, the three project assignments comprised 85% of the students' grade (15% SOQ, 40% proposal, 25% presentation). The remaining 15% of students' grades were based on course assignments and quizzes.

Table 4. Oral presentation scoring rubric.

	Creighton Total Construction	% Points	Ken West Industry	UNK Industry	Eric Roumph Industry	Paul Eiting Industry	B.J. Kienit Industry	Mark Baxter Industry	Zac Vaiskunas Industry	Ralph Van Vliet Industry	Mousavi Faculty	**Average**
1	Overall presentation flow	10%	8	8	8	10	8	10	10	7	9	**8.67**
2	Design Solution	20%	14	18	15	20	14	20	18	20	20	**17.67**
3	Schedule	20%	16	16	19	18	16	15	17	20	20	**17.44**
4	Budget	20%	18	14	17	15	16	10	19	20	18	**16.33**
5	Site Utilization	20%	18	12	19	10	14	20	15	18	16	**15.78**
6	Risk and safety plan	10%	9	8	8	5	7	10	7	10	9	**8.11**
7	Bonus point (optional)	5%	4				1		5	5	0	**3.00**
	Total	100%	87	76	86	78	76	85	91	100	92	**85.67**
	PKI Durham Cornhuskers	% Points	Ken West Industry	UNK Industry	Eric Roumph Industry	Paul Eiting Industry	B.J. Kienit Industry	Mark Baxter Industry	Zac Vaiskunas Industry	Ralph Van Vliet Industry	Mousavi Faculty	**Average**
1	Overall presentation flow	10%	9	7	9	10	8	8	10	9	8	**8.67**
2	Design Solution	20%	13	16	20	20	18	18	19	20	19	**18.11**
3	Schedule	20%	18	14	20	18	15	15	19	20	20	**17.67**
4	Budget	20%	16	14	15	18	16	16	19	20	18	**16.89**
5	Site Utilization	20%	14	12	15	18	15	15	18	20	18	**16.11**
6	Risk and safety plan	10%	9	14	8	5	10	10	9	10	10	**9.44**
7	Bonus point (optional)	5%	4			5	3		5	5	0	**3.67**
	Total	100%	83	77	87	94	85	82	99	104	93	**89.33**
	DOT Vanderbuilt-Ranger, Inc.	% Points	Ken West Industry	UNK Industry	Eric Roumph Industry	Paul Eiting Industry	B.J. Kienit Industry	Mark Baxter Industry	Zac Vaiskunas Industry	Ralph Van Vliet Industry	Mousavi Faculty	**Average**
1	Overall presentation flow	10%	7	7	9	10	8	8	8	8	9	**8.22**
2	Design Solution	20%	12	16	20	20	18	20	18	18	20	**18.00**
3	Schedule	20%	14	18	19	10	18	15	17	20	20	**16.78**
4	Budget	20%	12	12	18	15	12	15	19	20	16	**15.44**
5	Site Utilization	20%	12	16	20	15	16	10	17	19	20	**16.11**
6	Risk and safety plan	10%	7	6	8	5	7	10	9	10	10	**8.00**
7	Bonus point (optional)	5%	3				2		5	5	0	**3.00**
	Total	100%	67	75	94	75	81	78	93	100	95	**84.22**

In addition to peer evaluations of team members, students were also asked to complete course and instructor evaluations. Overall, students rated the course 3.8 on a 5-point scale. Additionally, students were given the opportunity to elaborate on specific aspects of the course that helped (or hindered) learning and ways the course could be improved. The majority of students cited industry mentors as being a positive course attribute. Students also cited teamwork, presentations and the project as being a value-added experience for not only a better understanding of alternative delivery methods and the preconstruction process, but also in terms of personal and professional development.

Ironically, some of the same course attributes cited as being helpful by some students, were cited as being problematic by others. Specifically, having multiple faculty participate in instruction provided a wealth of perspective and experience for some, but created confusion for others. Similarly, while many viewed the project and teams as a more realistic alternative to traditional classroom and textbook delivery, some were uncomfortable with what they perceived as a lack of structure particularly with regard to subjective exam content and grading. Other issues cited as being problematic were the disparities in building information modeling (BIM) competencies between groups, and the complexity of project RFPs given that students were mostly 3rd year students.

Discussion

Design Build has experienced outstanding growth over other delivery methods, specifically the design-bid-build method (Songer et al.,1996; Beard et al., 2001)). Thus, an astute response to this shift in the market demand seems necessary. Present students are going to be future professionals, who are very likely to deal with the design-build delivery method and must obtain ample knowledge about this process. Serving as a team member will enable students to listen to each other's opinions. Although very challenging at the beginning, learning in a multi-disciplinary environment helped students stay involved with the course and their semester project.

> *"I had originally taken this course just to fill a requirement but ended up taking a ton out of it and it was by far my favorite class of the semester."*

Working in an environment where individuals with various expertise gather to solve a problem is the future of our collaborative industry. This course set-up was able to provide that environment for students to practice collaboration on real-world problems. An architecture student made the following comment:

> *"It was also helpful to hear about things that need to happen on the construction site to start construction. Architecture students could benefit from that. Things like staging and cranes and construction scheduling and budgeting could be extremely beneficial. Good course to pair CM (Construction Management) and ARCH (architecture) students together to understand a project fully from SOQ to Proposal phase and what exactly is involved in selling a project to a client."*

Existing construction curricula have mainly evolved around the low-bid mentality. The current transformation in delivery method from low-bid to best value, from prescriptive specifications to performance requirements, and from multiple contracts to the single source responsibility (Shrestha and Fernane, 2016) is not simply a slight 'tweak' of traditional delivery methods (Jackson, 2011). Thus, this course has been developed to not only teach those concepts, but also provide an environment where students can practice these new methods and experience the difference. In addition to preparing students for successful careers in construction, this course was also developed to provide a value-added technical elective, and, to prepare students to compete in the ASC student competitions.

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