

Instructional Design for an Integrated Project Delivery Studio

Gregory F. Starzyk, J.D., M.P.M., Margot McDonald, AIA, NCARB, LEED AP,
Brent Nuttall, SE, James Mwangi, Ph.D., SE, and Gary Clay, Ph.D.
College of Architecture and Environmental Design
California Polytechnic State University
San Luis Obispo, California

The Integrated Project Delivery Studio is an undergraduate level course, unique for its interdisciplinary faculty and students in architecture, landscape architecture, architectural engineering, and construction management. Each term it engages students in a challenging project that exposes students to, among other topics, interdisciplinary collaboration, integrated project delivery, design management, and the design-build process. Team-based learning strategies are used to help students to succeed at those challenges. To that end, instructors manage four processes: team formation, deliverables, assessments, and feedback. The later processes are invigorated when, in the team formation process, high-performance teams are formed. With the intent of using diversity to drive higher performance, the authors devised a novel method of leveraging differences in student' thinking styles to create heterogeneity among the teams. Measurements suggest that this method has efficacy to establish a better learning environment.

Key Words: Team-based learning, interdisciplinary collaboration, design management, design-build

Introduction

The Integrated Project Delivery Studio (IPD Studio) is a unique, interdisciplinary course for junior and senior level undergraduate students in architecture, landscape architecture, architectural engineering and construction management; taught by a team of four instructors who are professors in those disciplines. Its instructional design provides students with short lectures and informal desk critiques, augmented by site visits, analytical exercises, and case studies. Guest lecturers are engaged to provide topical information within their areas of specialization. Students present their work throughout the term, typically to a panel of external clients. The studio meets in five hour sessions, three times a week, over a 10 week term. Meetings are in two, large laboratory spaces, each featuring a common area suitable for lectures and presentations, and separate team work areas. The laboratory is open 24x7 for the duration of the term. New sections are taught each term (quarter) with three terms per academic year. Some 40 to 60 students enroll each term.

In the spring quarter of 2010, the IPD Studio undertook an infill project focused on the rebuilding of the Broadmoor neighborhood of the City of New Orleans. The project was a national design competition - the Natural Talent Design Competition - sponsored by the U.S. Green Building Council's Emerging Green Builders in partnership with Salvation Army's EnviRenew Initiative. For this competition, student teams from across the nation were invited to plan and design a compact, energy efficient, ADA-compliant, hurricane resistant, LEED platinum, low cost housing unit. Eight student teams of six members each entered the competition. The teams were tasked to arrive at an imaginative solution while maximizing the value of planning, design, engineering, and construction decisions. Potential solutions were measured by quantitative judging criteria, casting cost and schedule impacts against a wide spectrum of technical and social issues.

During the fall quarter of 2010, the IPD Studio undertook to implement portions of a master plan for the Sedgwick Reserve, located in the Santa Inez Valley in the central coastal region of California. The goals of this 5,896-acre reserve - owned by the Regents of the University of California and managed by the University of California Santa Barbara - are to provide world-class ecological research, university-level instruction, K-12 environmental education programs, habitat restoration, and a thriving place for the arts and humanities, while maintaining the 150-year ranching history of the reserve property. Students are tasked to tie in the plan's various elements into the historic structures and landscape in order to accomplish the plan's stated themes: preservation and restoration; environmental education; environmental research; and sustainability. Project deliverables consist of a dormitory for housing up to 24 researchers and a 4,000 square foot ecological field research laboratory including wet, dry and instrumentation labs, offices, meeting rooms, a workshop, and possibly incorporating a long-term seed storage

facility. The structures must be linked together and with all other elements in a village area; providing an integrated, user-friendly plan with ease of access and full-ADA compliance. The buildings must be sited and designed to conserve and supply energy in several ways, including passive and active solar, earth sheltering, earth-tube cooling, natural ventilation, evaporative cooling, with an emphasis on conserving and recycling water, conserving and using recycled construction materials, enhancing the human community, and healthy buildings. All of this must be responsive to a fixed capital budget.

Interdisciplinary classes require compatible instructors who value collaboration (Smith, J.C., 2009). The IPD Studio instructors proved compatible. Moreover, they all shared the common thread of collaborative know-how, founded upon extensive industry experience. For students to succeed, however, effective team-based learning must also be delivered. To that end the instructors managed four processes: team formation, deliverables, assessments, and feedback.

Hypothesis, Methodology and Objectives

Heterogeneous groups function more highly than groups selected at random (Porter et al, 1994). Yet diversity - other than the four academic disciplines of the students - from which heterogeneity arises, was found not to be in abundance. However, it is established that diversity in thinking styles exists as normally in the classroom as it does in the general population (Harrison & Bramson, 2002). Therefore, the authors hypothesized that measurable difference in students' thinking styles can be leveraged to create heterogeneity. Moreover, highly performing, heterogeneous groups would invigorate the deliverables, assessments, and feedback processes. Thus, the objective became to measure student progress therefrom, by focusing upon measures of successful student learning of the learning objectives of the course

The research methodology employs a survey instrument to assess student progress on the learning objectives. The survey provides an indicator of the instructor's ability to provide a learning environment that enables students to meet the objectives of the course through its format and content. Since the sample size by discipline was small (between 8 and 20 students per major) and would not account for variance between groups, the data is not analyzed statistically. Rather, cumulative totals are summarized as percentages for each question on the survey.

Team Formation

It is well established that self-selected teams are not as effective as teams that are selected by instructors (Porter et al, 1994) (Michaelson, 2002).

In the spring of 2010, the teams were formed in two stages. In the first stage the instructors formed eight teams composed of ARCH and LA students and eight teams composed of ARCE and CM students. They conducted breakout sessions where ARCH/LA and ARCE/CM teams were given different assignments to complete. Deliverables included a report out to the entire class. The ARCH/LA teams were encouraged to "shop" for an ARCE/CM partner while watching the ARCE/CM report. Likewise the ARCE/CM teams were encouraged to "shop" for an ARCH/LA partner. At the end, teams were asked to list up to three preferred partners, in the order of their preference. In the second stage the instructors matched ARCH/LA and ARCE/CM teams together to form final partnerships, accommodating their preferences wherever possible.

In the fall of 2010, ten teams with six members were formed in one stage, an instructor making all of the selections outside of class. All teams were heterogeneous by discipline. Research suggests that teams become higher functioning when they are heterogeneous by discipline but homogenous by interest (Porter et al, 1994). To make teams homogenous by interest, students who must take the class are placed on different teams than those who take the class as an elective (Porter et al, 1994). That cannot be done here because some disciplines are required to take the class while other disciplines take the class as an elective. Therefore, all teams were made heterogeneous by interest. Nevertheless, heterogeneous/heterogeneous groups are still more highly functioning than groups selected at random (Porter et al, 1994).

Heterogeneous Thinking Styles

Researchers Harrison and Bramson (2002) devised a testing method pursuant to their focus on getting people to work better together by helping them to understand the particular ways in which people think and how others think differently. That test method informed team selection in both the spring and fall terms. Five distinct styles of thinking are suggested: synthesist, idealist, pragmatist, analyst, and realist; viewed as equal but different preferences, each having a unique value in a group setting (Harrison & Bramson, 2002). Their test, called a *Preferences Self-Test* (PST), enables people to evaluate themselves, to determine which style (or styles) they prefer (Harrison & Bramson, 2002). Each Students took a PST. A lecture was provided to help them interpret the meaning of their scores but individual results were not shared with the class. All scores were known to the instructors, however, who used that knowledge to select the teams.

In the spring quarter of 2010, the PSTs were engaged to identify extreme opposites in thinking styles. That was done to avoid placing extreme opposites on the same team. It did not become apparent, however, that the teams that resulted were better or worse as a consequence of avoiding extreme opposites. One particular problem had not been anticipated. Problems surfaced within the teams that had similar thinking styles. No notable problems surfaced within teams that had a diversity of thinking styles. The fall, 2010 selection process responded to that problem.

In the fall quarter of 2010, the PSTs were engaged to select teams that were heterogeneous not just by discipline but also by thinking styles. For that purpose, thinking styles were segregated into three groups, which were given the labels: polytechnics, integrators, and nascent collaborators. The polytechnics consisted of students whom preferred realist or analyst thinking styles or combinations thereof. This group constituted over 1/2 of the class. The integrators consisted of students whom preferred synthesist, idealist, or pragmatist thinking style, combinations thereof, or had multiple preferences including realist or analyst thinking styles. That group constituted of about 1/3 of the class. The remaining students were all nascent collaborators. The term "nascent collaborators" deserves an explanation.

The concept of a nascent collaborator was motivated by an interview published about IDEO's CEO, Tim Brown (Hansen, 2010). IDEO is a global design consultancy with a reputation for innovative, collaborative design solutions. In his interview, Brown described particular types of employees that his company called "T-Shaped Stars". These employees had two kinds of characteristics: depth of skill, symbolized by the vertical stem of the "T"; and the disposition to collaborate across disciplines, symbolized by the horizontal crossbar of the "T". Employees possessing both characteristics are the backbone of a collaborative culture (Hansen, 2010). Each student – all juniors and seniors in their major – is presumed to have sufficient depth in their major; thus they possess the vertical stem of the "T". The PSTs identified 10 students who exhibited little or no preference for any one style of thinking. These students, comfortable with any of the five styles of thinking could come to possess the horizontal crossbar of the "T", it was reasoned, given time, opportunity, and perhaps some training. Thus; nascent collaborators are students with high potential to become T-Shaped Stars.

There was a good distribution of polytechnics, integrators and nascent collaborators across the disciplines. By moving a few students on the margins into other groups it was possible to put 3 polytechnics, 2 integrators and 1 nascent collaborator on each of the 10 teams. It was also possible to put 2 CM, 1 ARCE, and either 2 ARCH and 1 LA or 1 ARCH and 2 LA students on each of the 10 teams. In the end, the teams were heterogeneous by two criteria, discipline and thinking style, with each team of ten having CM/ARCE/(ARCH/LA) students in the ratio of 2:1:3 while also having Polytechnic/Integrator/Nascent Collaborator students in the ratio 3:2:1.

Deliverables

The IPD Studio is structured around short lectures and informal desk critiques augmented by site visits, analytical exercises, case studies, and presentations of students' work throughout the term. Deliverables are in two categories; one a series of small assignments and the other a series of major proposals. The proposals, typically a series of three in increasing level of complexity, consist of a conceptual design-build, schematic design-build, and a final design-build proposal.

Assignments typically consist of student research, analytical exercises, case studies, team-based learning exercises,

or some combination of those elements. They are created by the instructors while the term is in progress. By creating the assignments just-in-time, the instructors are able to respond to the needs of students, as those needs become unveiled during the course of the term. Students' needs are of two types: 1) between the disciplines there is uneven exposure to the studio environment, programming, budgeting, planning and design methods, construction sequencing, conceptual estimating, risk management, and value engineering; and 2) all students, regardless of their discipline, have had little or no prior exposure to interdisciplinary collaboration, integrated project delivery methods, design management, the design-build process, and preconstruction services. The assignments are designed to address either type of need.

On some occasions the instructors call breakout sessions for their disciplines only. These discipline breakout sessions are driven by the desire to address knowledge associated with their discipline that the students may not yet have adequately developed. Following the breakout sessions, students are expected to return to their teams where they can teach their teammates. Breakout sessions are also driven by the need for students to understand what is expected of professionals in their discipline when they are called on to work collaboratively. Combined breakout sessions of ARCE/CM students have been popular, as have combined breakout session of ARCH/LA students. Typically the breakout session will have either a report out to the entire class or written reports that are posted electronically and thereby made available to the class.

Some assignments, such as case studies, are designed for participation by the entire team as a unit. The deliverables for these assignments are also reported out to the entire class or posted electronically in written form. Whatever the assignment, the underlying need can be addressed by thoughtfully designed assignments.

Occasionally there are reasons to do a "pinup" presentation, where the teams may communicate their proposals to each other, instructors, or guests by pinning up graphic designs on the walls. But more commonly, their proposals are configured as a structured report accompanied by a brief, PowerPoint presentation. Their final presentations and often some of the intermediate presentations are attended by the client(s), whom provide immediate feedback to the teams. Interested faculty other than the instructors are invited and encouraged to participate as well.

Assessments

Highly effective learning groups are facilitated by performance assessment systems that include measures of and rewards for both individual team member contributions to the group and group performance (Birmingham & McCord, 2002). Grades for the IPD Studio are broken down into parts; one part arising from the assignments, and the remaining parts arising from the proposals; where 70% of the course grade is allocated to the proposals and 30% is allocated to the assignments. Proposals are generally graded to a rubric distributed with each assignment and shared by each team member. The assignment grade is generally split into two parts, one part an individual grade and the other part a grade shared by each member of a team, so that in the final analysis 85% of each student's grade is based on team performance while 15% is based on individual performance.

To mitigate the impact of the varying performance levels, instructors modify the letter grades of their students. The rationales for modification are: 1) different performance expectations of their department, and 2) a subjective modification based upon participation, attendance and other factors at the instructor's discretion.

A higher level of learning energy results whenever judging criteria are introduced. Judging criteria, to be effective, should be informed by the value judgment of the client. This was the case in the spring quarter of 2010, when the national competition provided uniform, national judging criteria. Those criteria enabled students to provide more balanced designs, informed by the value judgments imbedded in the criteria. Judging criteria need not be entirely expressive of the client's values, however. The instructors can and should add criteria that cause students to respond to any learning outcomes of the course that go beyond what is germane to the client.

Performance Feedback

Timely performance feedback is essential for the development of high student motivation and effective group functioning (Birmingham & McCord, 2002). Informal desk critiques provide invaluable and timely performance

feedback to the teams. Desk critiques are provided by the instructors, singly or in pairs, throughout the term during its many working sessions. These desk critiques are most effective when all team members are present. Feedback is also provided in the usual way, through posting the grades for each assignment and proposal.

Peer evaluation is an effective teaching tool, appropriate for team projects (Bray & Manry, 2010). At the end of each term, students are surveyed to solicit their evaluation of the performance of the other members of their team. Survey results flow to the instructors who use those results to inform their assessment of final grades. Peer evaluations might cause as much as a full letter grade adjustment to an individual student's grade.

Learning Objectives

The objectives of the IPD Studio are twofold: 1) to create an integrated design that includes a sound project approach including land-use, site development, architectural vision, space planning, and the integration/synthesis of systems; and 2) to function effectively on an interdisciplinary team. Objective 1 has the following sub-objectives: a) to apply and balance real world constraints in the development of the building concept; b) to select and configure appropriate systems based on the project constraints and interdisciplinary criteria; c) to use current industry standard tools and technologies in the creation and presentation of a team-generated design including verbal, graphic and digital presentations; and d) to estimate the consequences of design decisions on social, cultural and environmental systems. Objective 2 has the following sub-objectives: a) to communicate effectively by utilizing verbal, written and graphical methods; b) to integrate standards of professional and ethical responsibility into the working classroom relationships and the development of the integrated design; and c) to apply basic project management skills of team dynamics and decision-making strategies.

In the last week of the spring quarter of 2010, students were asked to evaluate their understanding of each objective and sub-objective prior to class and compare it with their understanding at the end of the class. Students were also asked to: "Rate your growth in knowledge of the requirements, basic procedures and design philosophies of the other departments as a result of this course." Rating criteria and the points associated with each were, as follows: 1) "Never thought about it or knew much about it;" 2) "I have somewhat of an understanding and respect for its relationship to a project;" 3) "I have a basic understanding and I am comfortable with its needs on a project;" 4) "I can't really do it but I understand the steps and main criteria;" and 5) "It is my major. I better understand it and be good at it." Student Evaluation Results are attached as Appendix A.

Objectives Evaluated

Students' understanding of both objective 1 and objective 2 improved during the class. At the beginning, students' understanding of objective 1 "create an integrated design" was lower than their understanding of objective 2 "function as an interdisciplinary team". At the end, their understandings of both objectives were similar. The standard deviation of objective 1 declined while that of objective 2 remained nearly the same. One can infer from this that students were less certain of what they knew in the beginning about creating integrated designs but more certain that their understanding of integrated design improved by the end.

Sub-objective 1.a. "Apply and balance real world constraints" was the highest scoring sub-objective at the end. Sub-objectives 1.c. "Use current industry tools" and 1.d. "Social, cultural and environmental consequences" were very close, both starting from a similar level of understanding and achieving similar improvements. Sub-objective 1.b. "Select and configure appropriate systems" started from the lowest level of understanding while improving more than any other sub-objective by the end. Sub-objectives 2.a. "Communicate effectively" and 2.b. "Integrate professional and ethical conduct" achieved the second and third highest levels of understanding while showing similar improvement. Sub-objective 2.b. "Apply project management and team skills" achieved a similar gain starting from a lower level understanding.

The survey asks the students at the end of the term to evaluate their change in learning. In future cases, the survey will be administered at the beginning and end of the term as a pre-test/post-test. This latter technique should provide a better measure of change.

Summary and Conclusion

The IPD Studio is unique for its interdisciplinary faculty and students. Each term it undertakes a challenging project that exposes the students to various design and delivery methods. Effective team-based learning helps students to succeed at these challenges. The instructors manage four processes: team formation, deliverables, assessments, and feedback.

A method for forming heterogeneous teams was successfully devised. The teams were heterogeneous by discipline and by styles of thinking. Students were categorized in one of three groups related to their particular thinking styles: Polytechnics, Integrators, or Nascent Collaborators. For fall quarter of 2010, ten, six-member teams were formed having CM/ACE/(ARCH/LA) students in the ratio of 2:1:3 while also having Polytechnic/Integrator/Nascent Collaborators in the ratio of 3:2:1.

Deliverables consisted of assignments and proposals. Assignments were usually created just-in-time to respond to gaps in students' knowledge. Multi-discipline breakout sessions were employed in conjunction with assignments that required either a report out to the entire class or written reports made available to the entire class. Proposals consisted of at least three exercises of increasing complexity, each requiring a structured, written report accompanied by a PowerPoint presentation. Clients were present at most presentations for immediate feedback to the teams.

As much as 85% of students' grades were based on team performance while 15% was based on individual performance. Judging criteria were employed as a grading rubric and instructors modified the grades of individual students. Performance feedback was provided through assignments, proposals, and informal desk critiques. Peer evaluations played a key role in assessing individual grades.

Student understanding of course objectives increased during the term. This suggests that teams made heterogeneous by discipline and by thinking styles invigorated the deliverables, assessment and feedback processes; thereby, establishing a better learning environment.

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Appendix A

Student Evaluation Results

		Start of Class			End of Class		
		Mean	**Mode**	**S.Dev**	**Mean**	**Mode**	**S.Dev**
	Criteria: 5 = Thorough understanding of objective 1 = Little or no understanding of objective						
1 Create an integrated design that includes a sound project approach (scope, budget, quality & constructability) including land-use, site development, architectural vision, space planning, and the integration / synthesis of systems.		2.81	3	1.18	4.34	4	0.65
1.a.	Apply and balance real world constraints in the development of the building concept.	3.30	3	1.07	4.44	5	0.64
1.b.	Select and configure appropriate systems based on the project constraints and interdisciplinary criteria (structural, mechanical, electrical, civil, exterior cladding)	2.70	2	1.26	3.97	4	0.82
1.c.	Use current industry standard tools and technologies in the creation and presentation of a team generated design including verbal, graphic and digital presentations.	3.32	3	0.95	4.32	4	0.68
1.d.	Estimate the consequences of design decisions on social, cultural and environmental systems.	3.45	4	0.90	4.30	4	0.68
2 Function effectively on an interdisciplinary team		3.52	4	1.15	4.16	5	1.22
2.a.	Communicate effectively by utilizing verbal, written and graphical methods.	3.76	4	0.75	4.41	5	0.81
2.b.	Integrate standards of professional and ethical responsibility into the working classroom relationships and the development of the integrated design.	3.71	4	0.74	4.40	5	0.87
2.c.	Apply basic project management skills of team dynamics (personal interactions and skill sets) and decision making strategies (communication types, negotiations)	3.45	3	0.71	4.17	4	0.87
	Criteria: 1. Never thought about it or knew much about it 2. I have somewhat of an understanding and respect for its relationship to a project 3. I have a basic understanding and I am comfortable with its needs on a project 4. I can't really do it but I understand the steps and main criteria 5. It is my major. I better understand it and be good at it.						
3 Rate your growth in knowledge of the requirements, basic procedures and design philosophies of the other departments as a result of this course.							
	ARCHITECTURE	3.39	3	1.25	4.15	4	0.67
	ARCHITECTURAL ENGINEERING	2.56	1	1.39	3.25	3	1.16
	CONSTRUCTION MANAGEMENT	2.79	2	1.39	3.70	4	0.92
	LANDSCAPE ARCHITECTURE	3.55	5	1.70	4.18	5	1.07