

Identification of Long-Term Learning Outcomes and Opportunities for Improvement from an Interdisciplinary Course between Architecture and Construction Science

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This longitudinal study reports on lessons learned from interdisciplinary courses between architecture and construction science with a mix of former graduate and undergraduate students taught at Texas A&M University at College Station. The study compares lessons learned from past research in interdisciplinary studies in the architecture and construction curriculum with former student perceptions 11-16 years after graduation. Previous research on learning outcomes from interdisciplinary architecture and construction science curriculum have identified teamwork, mutual respect for other disciplines, real world understanding, collaboration, coordination, and time management as the most important skills learned. This study analyzes the impact of learning outcomes on the former students during their years of practice and experience in the building industry. For this study 19 survey responses were collected from former students who are currently working in practices or industries related to the built environment. A quantitative and qualitative analysis of the data reveals that the former students highly value teamwork, collaboration, and interdisciplinary understanding. Although the number of responses was statistically limited, they nevertheless suggest there is value to such interdisciplinary courses within architecture and construction science curricula for those who practice afterward in the building industry, and that this topic warrants further study.

Key Words: Undergraduate education, AEC curriculum, longitudinal study, interdisciplinary curriculum

Introduction

According to the US. Bureau of Economic Analysis (BEA, 2014), the construction industry in the US added 652.7 billions of dollars value towards the nation's Gross Domestic Product (GDP). By nature the construction industry requires collaboration among professionals from Architecture, Engineering and Construction (AEC) sectors for the success of a project. Majid (2006) stated that a successful construction project is one that is completed on time, within budget, in accordance with specifications, and to the stakeholders' satisfaction. Nguyen et al. (2004) identified a "competent and multidisciplinary project team" as one of the important components of the five critical factors that affects a construction project's success. Although the industry is expected to function as a harmonious

mixture of different disciplines, researchers Zollinger and Leary (2005) stated there is more litigation in the construction industry than ever before. Also, the industry is plagued with problems due to lack of trust and collaboration, ineffective communication, and lack of planned thinking, which in turn affect stakeholders' relationships (Elmarsafi 2008). Interactions between Owner, Architect, Engineer and Contractor (OEAC) impact a project's success.

Problem Statement

Over the past 100 years, the design profession and the construction industry have become among the most fragmented sectors with various stakeholders involved in a project. Today, various project delivery methods such as Design-Build (DB), Integrated Project Delivery (IPD), Construction Manager at Risk (CM at Risk) and other IPD-like delivery methods are attempting to introduce a more collaborative approach between different stakeholders of a project, in order to improve construction project performance with respect to cost, quality, time, and safety. However, Lichtig, (2006), states that the stakeholders work in isolation with no actual sharing of collective wisdom. Implementation of IPD methods has also not completely helped resolve issues because of lack of trust and collaboration among stakeholders in the construction industry. To meet the demand and challenges of the AEC sector, an interdisciplinary approach to curricula for the built environment becomes vital (Irizarry et al. 2010).

Past research identifies the need for a curriculum that replicates industry-level collaboration with other disciplines (O' Brien 2003). Outcomes from particular interdisciplinary courses have been identified. However few studies have been carried out to see if learning outcomes are retained by students over years of practice in the industry or how they affect their careers. For this reason, it was imperative to identify the learning outcomes that former students value the most in order to incorporate changes to future interdisciplinary courses in a way that will most benefit professional practice and industrial experience.

Research Objectives

This research is an exploratory study to identify long-term learning outcomes from an interdisciplinary course between the departments of architecture and construction science taught at Texas A&M University. The objective is to help inform and introduce improvements to similar interdisciplinary courses offered in the future.

Significance of the Study

Time and again researchers such as Edwards (2012) have highlighed the fact that, today due to privatization, and involvement of international firms, professionals from different countries have introduced new challenges for AEC education. O' Brien (2003) and Boyer and Mitgang (1996) in their writings have mentioned that the construction industry is ill-equipped with the skills needed to integrate knowledge across disciplines. According to Chan and Sher (2014), many employers feel that most college graduates do not possess generic employability skills identified by researchers. Edwards (2012) argued that graduates need skills such as communication, negotiation, planning, problem-solving, and ability to work effectively within an interdisciplinary team. Chan and Sher (2014) argued that students participating in collaborative learning environments can enhance their academic knowledge and can learn professional skills. By identifying the outcomes retained by former students from these interdisciplinary courses in the AEC curriculum, such courses in the future can be modified in a way that adapts them to the current needs of the industry.

Literature review

Newell & Green (1982) defined *interdisciplinary* as inquiries that critically draw upon two or more disciplines and which lead to an integration of disciplinary insights. There is often a misunderstanding between "multidisciplinary" collaboration and "interdisciplinary" collaboration. Borrego and Newswander (2008) highlighted that during multidisciplinary collaboration the knowledge gained remains unchanged at the end of the collaboration, whereas during an interdisciplinary collaboration, participants work hand-in-hand to repeatedly integrate knowledge. Apart from adding new content from different fields, interdisciplinary learning has the ability to promote understanding and create new values and approaches to define and solve problems (Richter & Paretti 2009).

Interdisciplinary Studies: A Timeline

Since its founding in 1979, the Association for Interdisciplinary Studies (AIS) at Oakland University has encouraged interdisciplinary studies across all academic fields and subjects (Klein, 2006). The book *The Interdisciplinary Curriculum: Design and implementation* by Jacobs (1989), illustrated a step-by-step approach to integration, beginning with selection of an organizing center to frame a matrix of activities, for developing integrated units of study. Newell (1990) conducted a longitudinal study with former students from Wayne State University (WSU) and concluded that students were able to see all sides of the story, appreciate other perspectives, understand that each person's decisions were not final, and also feel confident about a wide range of subjects apart from their major. Findings by Orillion (2009) suggested that learning outcomes and their relationship with an interdisciplinary curriculum are impacted by an institution's culture. Students within an interdisciplinary program experience integrated viewpoints and strategies that are solution-focused.

Interdisciplinary Curriculum in AEC

In comparison to the AEC sector in Asia and Europe, the equivalent sector in the US is highly fragmented (Howard et al. 1989). Howard et al. (1989) also noted that fragmentation occurs throughout different stages of construction and affects the overall productivity of the industry. With current advances in the construction industry it is imperative that curricula embrace new methods to improve productivity, mitigate litigation, and deliver satisfaction to clients (Shelbourn et al. 2007). Similarly, Boyer and Mitgang (1996) in their report, stated the need to fully exploit interdisciplinary potential for architectural education and practice. Especially relevant literature to this study are mapped along a timeline shown in Figure 1. A few studies in interdisciplinary curricula design—such as Jacobs (1989)—and in AEC research—such as Boyer and Mitgang (1996) and work by Fruchter (1999)—serve as well-cited milestones. Others studies are less well-known but again, include information relevant to this research. Perceived learning outcomes were identified and tabulated from a review of the 13 papers and one initiative (AIS), as shown in Table 1.

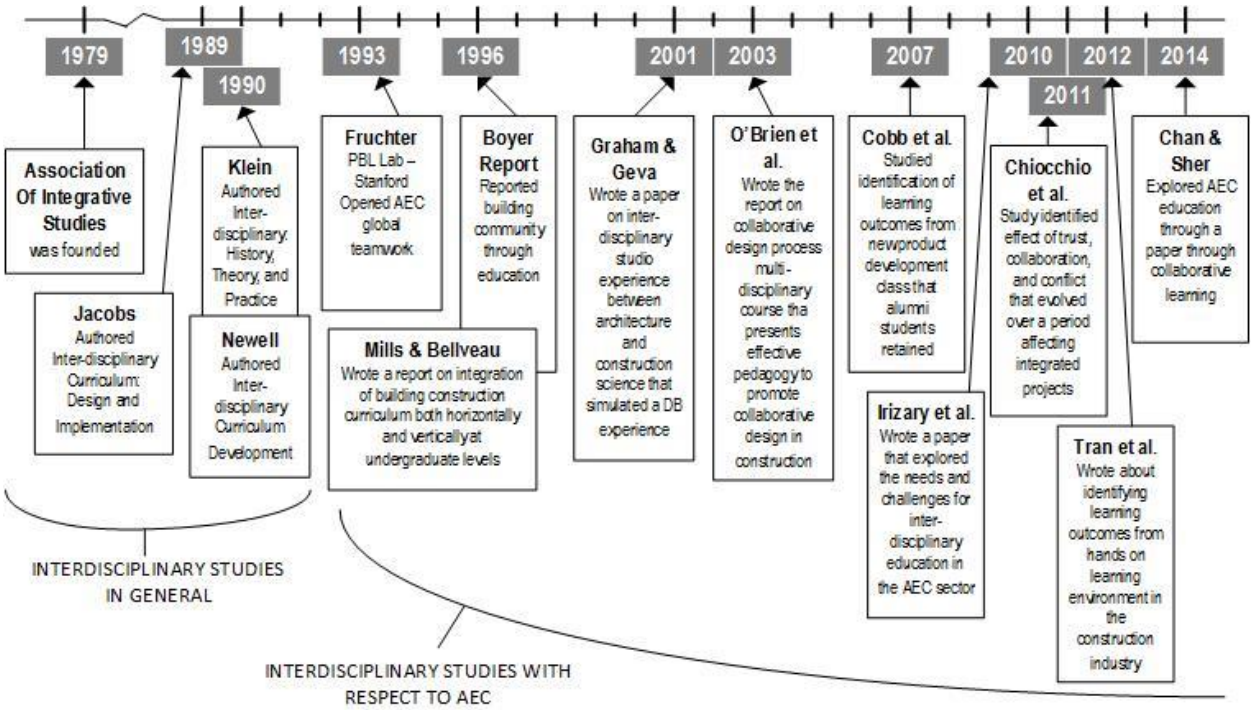

Figure 1: Timeline of relevant sources in the field of interdisciplinary studies in general and interdisciplinary studies in AEC curriculum, in particular.

Table 1: Factors identified as "perceived learning outcomes" from review of 14 sources shown in Figure 1.

Factor	No. of papers/sources* citing this factor
Teamwork	4
Mutual respect for other disciplines/ understanding values of other disciplines/ Trust	4
Practical scenario " real constraints"/ problem solving	3
Collaboration	3
Communication	2
Creativity	1
People management	1
Leadership skills	1

* Number of papers/sources considered for literature review= 14

Method

The study aims to identify the learning objectives retained by students over years from an interdisciplinary course in an AEC environment and to assess the impact of these learning outcomes on their careers. This study also identifies suggestions to improve these courses in order to benefit the AEC industry. In order to accomplish these research objectives, two interdisciplinary courses taught at Texas A&M University during the fall of 1999 and the fall of 2003 respectively were chosen for the study.

Interdisciplinary Course Description

Two studio courses offered during the fall semesters of 1999 and 2003 were structured as interdisciplinary studios between graduate and undergraduate students from Architecture and Construction Science at Texas A&M University. The courses were structured in such a way that the architecture students delivered the design, site planning and other architectural details while construction science students delivered the estimates, schedule, and MEP package for the project.

Data Collection

The data collection process for this research was initiated by gathering a list of students who took an interdisciplinary architecture and construction science studio course from Professors George Mann and Anat Geva, who were the respective faculty members for the fall semesters of 1999 & 2003. The fall 1999 class under consideration comprised a total of 73 graduate and undergraduate students. The class consisted of 30 undergraduate students from Environmental Design (ENDS), 8 from Landscape Architecture (LA) and 15 from Construction Science (COSC), as well as 7 graduate students from Architecture (ARCH) and 7 from Construction Science (COSC). The fall 2003 class under consideration, comprised a total of 35 graduate and undergraduate students. This class consisted of 12 Environmental Design (ENDS) and 11 Construction Science (COSC) undergraduate students and 5 Architecture (ARCH) and 8 Construction Science (COSC) graduate students.

The survey was divided into five sections: educational background; professional background; interdisciplinary course(s); career implication; and retrospection. The participants were asked to suggest areas of potential improvement for future courses. The survey was kept active for a period of 21 days, during which 23 responses were recorded, representing a response rate of 24.73% (23 out of 93 surveys). 19 complete responses were recorded (completion rate >80%), and conclusions were drawn based on these responses.

Data Analysis

Data collected from survey responses were systematically categorized in alignment with their section in the survey. The demographics section classified the responses based on respondents' major and year when they took the course, as well as their maximum level of education, and years of experience working in the industry. The interdisciplinary course(s) section elaborated on the course structure, course challenges, and learning outcomes from the course that the former students regarded as positive. The career implication section based on the ranking given by the alumni

prioritized "perceived learning outcomes" from the interdisciplinary course that impacted their career. The retrospection section gave respondents an opportunity to record personal reflections about course outcomes.
The organized data were then analyzed using both quantitative and qualitative methods. The demographics section elaborated on the survey participant's background and how his or her career role affected personal perceptions of the interdisciplinary course. Responses from the interdisciplinary course section were analyzed in relation to responses from the career implications section and identified the actual learning outcomes that former students retained from the course. Data from retrospection were analyzed to suggest improvements for future interdisciplinary courses.

Assumptions

For successful completion of this project it was assumed that respondents from the departments of architecture and construction science from the fall semesters of 1999 and 2003, who took these interdisciplinary studio courses, remember and retain the knowledge gained from their course work.

Limitations

The authors acknowledge that the following factors represent limitations to the conclusions that can be made about this research:

- The population size considered for research was 108 former students (total number of students from the two classes). The final sample size was only 19, which is not a statistically significant sample size to conclude with any confidence level.
- There were only eight landscape architecture students in the fall 1999 and no responses from this discipline were recorded. Results may have varied if at least one response was recorded from this major.
- The research does not consider participant's grades in the particular coursework as a factor that affected respondent perception about course outcomes.
- There was no *control group* (i.e. longitudinal survey of a non-interdisciplinary course) for comparison.

Delimitations

This case study research is bounded within the scope of interdisciplinary studio courses only and is further restricted to finding the long-term outcomes only from two interdisciplinary courses taught at Texas A&M University during the fall semesters of 1999 and 2003.

Results

Demographics

Fourteen former students from fall 1999 and five former students from fall 2003 took the online survey; nine respondents (22%) were from construction science major and 10 (19%) were from environmental design/ architecture major. Of those who responded, 7 were currently pursuing careers as contractor/ sub-contractors, 5 were designers/ architects, 2 were owners, 2 were project managers, and 3 represented other professions or roles. It was also noted that while 31% of the respondents (6 out of 19) had more than 16 years of experience, 47% of them (9 out of 19) had 11-15 years of experience in the fields of construction, and the remaining 22% had less than 10 years of experience. It was also observed that 14 of 19 respondents had a master's degree. The survey responses included 9 master's students and 10 undergraduate students who took part in these interdisciplinary course(s).

Interdisciplinary course(s)

This section focused on former students' experiences of the course that they took. It was found that most often students from one discipline formed a group based on their compatibility and professors teamed them into one complete design group at random. This scenario is analogous to that of the industry where a group of architects, contractors, and sub-contractors unfamiliar with one another, is assembled based on business needs. Eleven of these former students stated they were either comfortable or very comfortable during the initial phase of the project. This comfort could be attributed to the frequency with which the teams met, the strategies they used, and the challenges they faced to work as a team. Twelve out of 19 respondents (63% of respondents) said they did face challenges working as a team. Six out of those 12 respondents claimed that schedule clashes for meeting times created their biggest challenge. Other challenges included personality conflicts, communication difficulties, lack of authority or leadership, and lack of mutual respect among disciplines. Table 2 depicts terms that describe the five most important learning outcomes students felt they obtained from the interdisciplinary studio course.

Table 2: Tabulation of learning outcomes terms explicitly noted by survey respondents.

No.	Skill/ Learning outcome	No. of Responses	Percentage of Response
1	Teamwork	9	11.8
2	Collaboration	8	10.5
3	Communication	6	7.9
4	Interdisciplinary understanding	6	7.9
5	Coordination	4	5.3
6	Client interaction- Delivering the need	4	5.3
7	Time management	3	3.9
8	Leadership Skills	3	3.9
9	Creativity	3	3.9
10	Accountability	2	2.6
11	Early communication / integration as team	2	2.6

Career implications

In the survey, alumni students were asked to rank "perceived learning outcomes" based on impacts on their career, where on a Likert scale 5 represented "highly beneficial" and 1 represented "not so beneficial." They were also asked to explain the rank they gave. Table 3 represents a tally of the rankings respondents assigned, as well as examples of responses to open-ended questions.

Table 3: Former student's ranking of perceived learning outcomes

No.	**Learning Outcome**	**Mean (1-5 scale)**	**Standard Deviation**	**Example Response**
1	Teamwork	4.68	0.67	*"As a consultant, I have to encourage teamwork to ensure the loudest voice doesn't always win."*
2	Creative Thinking	4.32	1	*"I consistently have to be creative in how I communicate a problem or solution to my client."*
3	Trust Building	4.16	1.17	*"Reliant upon each other's performances in order to win. Deadlines, completion of responsibilities."*
4	Decision Making	4.21	1.03	Decisions are to be made about, *"impacts of (an) individual's performance(s) and how it played into the overall result."*
5	Negotiating Skills	4.05	0.97	-
6	Leadership Skills	4.33	1.08	*"Keeping the team focused and on task. Making commitments."*
7	Communication Skills	4.53	0.96	*"Communication failure is number one project killer."*
8	Time management	4.47	1.02	*"I work on very complex tasks, and when no clear deadline exists I have to work very hard to manage my own time and progress."*
9	People management	4.37	1.01	*"I need to use all resources available to me including people to get the job done";* *"Interacting with others who may be initially shy, see things from a different perspective and not realize your point of view and what it takes to do your job."*

Retrospection

It appears from the responses of former students that the interdisciplinary course(s) strengthened skills needed to work with all kinds of people from various backgrounds by building trust. Former students emphasized that the course promoted a holistic understanding of the larger realm of construction and provided a platform to experience a real world situation.

Recommendations from Former Students

Former students were asked to undertake a plus-delta analysis to suggest opportunities for improvement to future interdisciplinary courses in the AEC sector. 94% respondents felt coordination was indispensable in the construction industry and therefore it is necessary to have more interdisciplinary courses. The respondents also emphasized the need to work on real projects, including the involvement of mentors from firms and industry. About 50% of respondents mentioned schedule clashes as the main challenge they faced as a team. In order to adjust the interdisciplinary course so it is more aligned with industry needs, participants recommended introducing leadership skills to the course design. Adding scope for more creativity, risk management, conflict management and making such interdisciplinary courses mandatory were several other suggestions from respondents.

Discussion

It was observed that the number of respondents who graduated 16 years ago from the group of fall 1999 was 22% (14 out of 61 former students contacted) while those who graduated 12 years ago from the batch of fall 2003 was only 15% (5 respondents out of 32 contacted former students). It was also observed that 11 out of 19 respondents were able to recollect details about the project they worked on during the studio courses. It is possible that the greater response from the 1999 students may be partly due to inclusion of industry mentors and volunteers. If including industry mentors represents a prime ingredient for achieving desired outcomes, this should be considered when designing future interdisciplinary courses.

Further observations indicate that apart from common perceived learning outcomes such as "teamwork," "collaboration," and "coordination," former students also suggested "valuing another's opinion," "value of early integration between designers and constructors," and "accountability" as course outcomes. The values retained by former students and their suggestions to improve curricula for future interdisciplinary courses in AEC fields implies there is a demand to introduce coursework that better satisfy the needs of the industry.

For future research in this field, it would be interesting to identify and analyze the course outcomes of interdisciplinary courses taught in the AEC sector that include architecture, construction science, and business majors. For future studies it would also be valuable to include a longitudinal study of a control group (i.e. non-interdisciplinary studio), as well as a comparative study of interdisciplinary courses from several universities.

Conclusions

The survey analysis reported in this research concluded that the former students now practicing in AEC fields who took interdisciplinary studio courses at Texas A&M University in the fall 1999 and fall 2003 valued perceived learning outcomes such as teamwork, communication skills, creative thinking, trust building, etc., as the most important aspects of the interdisciplinary studio courses. The former students further analyzed the interdisciplinary courses in the context of their career experiences and identified additional factors such as "valuing other's opinion equally," "early integration as a team," "accountability," "work prioritization" and "delegation of work" as important learning outcomes which emerged from the courses. However, they also identified working together in a team, communication with team members and scheduling a meeting time as the challenges they faced. Suggestions to improve similar courses included working with real projects and engaging mentors from the industry.

63% percent of former students responded that the coursework had a positive effect on strategies they adopted during their careers. Three of them stated they enjoyed the course and felt it offered a different experience. Two respondents quoted that it was their first experience to work with people outside their discipline, which taught them values about collaboration and cooperation. These responses suggested that the course(s) might have had a generally positive impact. However, one of the respondents expressed dissatisfaction with the course structure. The respondent felt architecture and construction science students cannot work hand-in-hand, as there was no mutual respect between the disciplines. This respondent further added that aesthetics of design aspects were valued less and also felt an interdisciplinary course with architecture and business majors would have been better.

Perhaps of greatest interest is that there was a general sense that integration needs to be included as part of a school curriculum and that simply integrating after completing formal education may be too late to develop the skills needed as professionals.

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