Long-distance multidisciplinary collaboration: Some lessons learned

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This paper documents some lessons learned from an experimental long-distance multidisciplinary collaborative 'capstone' course conducted in Fall 2008. The course was intended to prepare students for industry by simulating a professional architectural collaboration, where architects, engineers and construction managers collaborate over long distances via Building Information Modeling (BIM).

The course included over one hundred architecture and engineering students from the University of Nebraska-Lincoln, Montana State University, and the University of Wyoming. Working in small groups across hundreds of miles, the students collaborated using filesharing and a variety of communications tools to complete a comprehensive architectural design problem.

The results were mixed, and the experiment has not been repeated for a variety of reasons. Although many of the students reported a positive experience, the instructors encountered a variety of unintended consequences which were deemed to be detrimental to the larger educational objectives. Some of the negative unintended consequences should have been easily anticipated and could be corrected; others may represent more fundamental obstacles to long-distance multidisciplinary collaboration.

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Introduction

In 2008, the University of Wyoming initiated a pilot project to test distance collaboration among Architecture, Engineering, and Construction (AEC) students, along with partners at the University of Nebraska-Lincoln and Montana State University. The intention was to allow students to mimic a growing trend in professional practice, where AEC practitioners increasingly use new technologies to collaborate 'virtually' (rather than face-to-face). The proposal was awarded an American Institute of Architects (AIA) Research for Practice (RFP) grant of $7,000.

The project, which included four faculty and 109 students working in 23 teams, was implemented in Fall 2008. Faculty collected quantitative and qualitative data throughout the semester-long experiment. Results were reported in an AIA White Paper[1], and the project won an AIA Technology in Architectural Practice (TAP) honorable mention award in 2009.

Background

The need for more collaborative experience among AEC students has been discussed for years. In 1996, Boyer and Mitgang argued: "Making the connections, both within the architecture curriculum and between architecture and other disciplines on campus, is, we believe, the single most important challenge confronting architectural programs."[2] Similarly, Scheer (2006) contended: "While architecture has always been collaborative, current architectural education downplays this fact."[3]

The need is further supported by recent industry developments, particularly the advent of Integrated Project Delivery (IPD). The IPD model alters professional responsibilities to involve engineers and contractors at a much earlier stage in the design process. Additionally, the maturity of Building Information Modeling (BIM) tools permit 'virtual' IPD to occur more easily, because team members of different disciplines can work in the same model (computer file) simultaneously. As a result, architect Norman Strong believes, "Our profession will be utterly different, transformed, within the next 5-10 years."[4]

Perhaps the most significant impulse towards collaboration is that accreditation boards are moving to require it. The Accrediting Board for Engineering and Technology (ABET) includes "an ability to function on multidisciplinary teams" among its eleven program outcomes for all engineering programs.[5] The National Architectural Accrediting Board (NAAB) requires the "ability to recognize the varied talent found in interdisciplinary design project teams in professional practice and work in collaboration with other students as members of a design team."[6] The American Council for Construction Education (ACCE) says, "Curricula topics should address the constructor's role as a member of a multi-disciplinary team."[7]

Project Description

Purpose and Expectations

The basic purpose of the research was to explore the nature of multidisciplinary student collaborations complicated by the issue of distance. The additional factor—distance—was prompted partly by the desire to mimic professional practice but mostly by necessity: UW engineering students have no architecture or construction students locally as potential collaborators.

We expected that distance collaboration would be difficult for students. Cheng noted: "Collaboration in its professional sense is hard to simulate in an academic setting. Professional collaboration forms among participants who have clearly defined (and complementary) roles, responsibilities and expertise. Collaborators come to the table with experience and maturity gained over many years of practice."[8] In a draft proposal, we wrote: "Frankly, we don't know what kinds of problems and opportunities will arise during this process."

Structure

The participants included:

- 21 third-year architectural engineering students enrolled a three-credit (introductory) architectural design studio at UW
- 23 fourth-year architectural engineering students enrolled a three-credit (terminal) architectural design studio at UW
- 50 fourth-year architecture students enrolled in a four-credit construction documents class at MSU
- 15 fourth-year architecture students enrolled in a five-credit architectural design studio at UNL
- (30 construction management students at UNL who interacted only with their UNL counterparts)

It is especially noteworthy that the architectural engineering students—some structural-emphasis and some mechanical (HVAC)-emphasis—participated as architectural designers

Team formation was managed rather loosely: most students prepared and circulated a biographical summary, then the students distributed themselves into 23 teams with a variety of compositions. Most teams consisted of 2 students from one institution and 2 from another. The project budget did not accommodate face-to-face meetings or collective presentations.

It was agreed that each instructor should maintain his own syllabus, learning objectives, specific requirements for student work submittals, and deadlines. Furthermore, each instructor would communicate only with his students, so that a student would not directly receive conflicting advice or expectations. (Indirect 'noise' was unavoidable, and we believed it would be good 'real world' training for teams to cope with it.)

Design Problem

The design problem specified a 57,500 square-foot Performing Arts Center for a specific site in downtown Lincoln, Nebraska. The instructors selected this problem based on its conceptual complexity, including the functional mix of spaces (assembly, performance, administration, food service, and support), opportunities for long-span structural systems, acoustical challenges, urban relationships, fire safety issues, etc. The requirements also addressed sustainability issues by asking students to evaluate their design decisions using LEED (Leadership in Energy and Environmental Design) criteria.

Communications Technology

Preparation for the project also involved several technical considerations. We expected students to work together simultaneously on a single BIM file from remote locations. In industry, interoperability of software is a major obstacle. In 2002, NIST estimated a $15,800,000,000 annual loss in the U.S. capital facilities industry due to inadequate interoperability.[9] In this case, each institution was already equipped with Autodesk Revit software, and we expected to test various 'plug-in' programs on a no-risk basis.

It was quickly discovered, however, that real-time filesharing would require a dedicated server and wide-area network (WAN) or remote desktop. WAN proved to be cost-prohibitive, and our respective IT managers would not allow existing institutional servers to be accessible to other students for security reasons. The best compromise solution that could be devised on rather short notice was to acquire a file transfer protocol (ftp) website, where students could exchange large files via upload-download, but simultaneous work within a file was unfortunately not possible.

We expected e-mail and cell phones to be the other major tools of collaboration, and that no special infrastructure would be required for these tools.

Assessment

The instructors collected quantitative and qualitative data from students in a variety of ways throughout the semester-long project. Of the 109 total participants, 76 students submitted an informed consent form and constituted the formal participants in the study.

We employed fieldwork methods such as artifact collection (learning journals, self and peer evaluations, and student design outcomes) and direct 'participant observation' methods recorded in raw field notes. We also conducted in-depth interviews with twelve of the 76 students. Ten of the twelve interviewees represented five teams—one architect and one engineer from each team—to help construct portraits of successful and unsuccessful occurrences of collaboration. We also conducted a quantitative study in the form of a written questionnaire.

Characterizing the Results: A Bumpy Ride

An engineering student reflected: "Though this semester has been a bumpy ride, I do feel that I have learned some valuable lessons"—a double-edged conclusion whose spirit was shared by many of the participants, including the faculty.

Most of the 23 teams completed the project to a satisfactory level of resolution with their collaborative structure intact. At least three teams proved to be unworkable (one disintegrated in a wholly unprofessional manner), while several other teams amicably ceased collaboration near the end of the term, perhaps to accommodate differential deadlines and presentation requirements at their home institutions.

Theme 1: Lost in Translation

The principle conclusion of this project, certainly generalizable, is that distance collaboration requires highly-developed communication skills. Because issues of interpersonal communication dominated the students' workload, some of the architectural design learning objectives were to some extent crowded out. Many of the final designs were (subjectively) observed to be less developed than expected.

Student learning journals and interviews were preoccupied with communication problems. Some representative examples:

- "Communication has been the road block throughout the duration of this project for us."
- "Email can be frustrating at times during the design process because written words can be interpreted many ways."
- "The biggest disadvantage was that the entire design process was slowed by a lack of efficient communication."

Likewise, my own journal at mid-semester reveals: "I've had to focus much more on communication issues than on the design process. I worry that I'm not delivering what the course is intended to deliver…"

One team that exhibited excellent cooperation and coordination was queried about their success. They had developed a clear chain of communication. Each local pair had one representative, a single point of contact. Interestingly, the notion of hierarchical communication follows traditional professional roles where lower-level team members do not communicate across disciplines.

Theme 2: Too Many Cooks

We found, predictably, basic problems related to creative control:

- "They won't listen to any of our techniques or methods."
- "They don't want any advice or guidance at all."
- "Not really open to criticism."

Issues such as these, while important, are not necessarily characteristic of either the multidisciplinary or distance factors—they would likely be encountered in any setting—but perhaps more pronounced here.

We observed that some architectural students were hesitant to release creative control of major architectural decisions. Survey data revealed that 47% of the architects and 68% of the senior engineers disagreed with the statement: "My distance teammates treated me as an equal project stakeholder regardless of my role." Moreover some engineering students willingly abdicated their (architectural) responsibilities. A sample reflection: "I feel that if both groups were more on the same level this project would be a good experience for all. There's often times when we feel like hindrances to our teammates and that we're not producing as much work as they are. Feeling like that decreases our confidence and it also keeps us from speaking up and making sure our opinions are heard."

We strongly concluded that students need to have clearly defined and understood roles for distance collaboration. Because the engineering students were supposed to act as architects, along with the architectural students, a sometimes-counterproductive 'blurring' of disciplines occurred.

Success stories, again, merit attention. One team chose to list and exchange their individual strengths and weaknesses. This technique, we observed, helped foster a mutual respect across disciplines.

Self-Criticism

We encountered several negative unintended consequences which should have been easily anticipated and avoided.

The asymmetrical experience level of the students became a serious obstacle. (The engineers had zero or one semester background in architectural design; the architects had seven or eight.) Many reflected on the frustration of feeling either 'inferior' or 'held back': "I feel that if both groups were more on the same level this project would be a good experience for all." In some cases, more experienced students explicitly used their status as a justification not to compromise. Clearly, a more level condition would be preferable. On the other hand, surprisingly, some of the most disparate teams developed productive mentor-protégé relationships.

The project also featured a problematic lack of consistency in terms of time commitment, expectations, and deadlines. The credit-hour discrepancy (each student did not necessarily have the same time commitment as his/her teammates) meant that the amount of work was not evenly distributed, leading to understandable conflict. Also, the instructors demanded different areas of detail focus and different presentation styles, due to their habits and differing educational objectives. Lastly, the deadlines for work submittals were not coordinated, and teams never presented their work together. We concluded that such inconsistencies are intolerable to a project of this type. For successful collaboration, the students need to be working in step towards common outcomes.

We found ourselves, as instructors, sometimes underprepared with regard to communications tools and necessary infrastructure. The lack of ability to simultaneously work within a file (mentioned above) proved to be a major obstacle. On a more basic level, for example, a failure of foresight meant that my own students initially lacked a private office with a speaker-phone, leaving them unable to conduct a basic conference call. Some students wished to use 'incompatible' architectural software tools which meant that their partners could not fully participate.

Lastly, this particular architectural program was too complex for these circumstances. Students in a first-time multidisciplinary and distance collaboration should begin with a simpler design problem.

Broader Lessons Learned

For instructors considering distance multi-disciplinary collaboration:

Students will need help with communication skills and tools. These are not 'secondary' issues, and students will not learn better by figuring it out themselves. Instructors should prepare specific guidance about successful models of communication (oral, written, and graphic). This may require advice from industry partners. Furthermore, communication issues will necessarily steal time and effort from the other subjects being developed. With distance collaboration, projects are likely to be less resolved due to the demands of communication.

Students should have well-defined roles and responsibilities that match their level of experience and expertise. Here, the engineering students should have been acting as engineers rather than as architects.

Face-to-face meetings are essential. In this case, the participants simply did not know one another well enough. This led to a general lack of empathy, and in some cases unprofessional behavior. Ideally a capstone course of this type would more closely mimic industry practices, where distance collaboration always includes periodic in-person team meetings.

Instructors should establish common deadlines and a single work-product. While there may be a reasonable desire to maintain discipline-specific responsibilities, if work is submitted and evaluated individually, there is incentive not to collaborate and teams will drift apart. Also, common (in-person) final presentations will help foster *esprit-de-corps.*

'Balanced' teams are not necessarily important. Some of our best outcomes came from teams with an irregular composition (one student at one school and three at another, for example). This is not to be confused with the serious problem of asymmetry of experience discussed above.

The technology demands will be time-consuming and expensive. Of course these will vary case-by-case and perhaps will become easier in the future. Currently, simultaneous remote BIM collaboration seems to require a dedicated server and wide-area network (WAN) or remote desktop, which may be prohibitive.

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