

Inter-Collaborative Learning in Capstone Design: How Do We Optimize Costs and Benefits?

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Abstract

The civil engineering programs at Rose-Hulman Institute of Technology (RH) and Gonzaga University (GU) have been seeking to understand how to best facilitate capstone projects in collaboration with students at other institutes. We have the following questions –

- How beneficial is it for student teams to spend time together in person to understand their cultural differences and to develop a team rapport?
- How beneficial is it for student teams to visit the site in person and get to know the community that will benefit from their project design?
- Are the costs (time, travel safety, funding) associated with student and mentor travel to support inter-collaborative international projects acceptable when compared to the benefits?

We agreed to support two project teams of four students each between our two institutes. Each team of four students were comprised of two from GU and two from RH. One project was located near RH and the other near GU. Our programs supported student and mentor travel to the sites so that the teams came to know each other face-to-face. An assessment plan was devised and implemented with the help of experts at RH. Some of the assessment is part of a larger program that will be reported later. This paper reports the findings from focus groups and interviews of the participants.

We have concluded that

- Inter-collaborative senior project experiences provide opportunities for students to learn in ways that more traditional senior projects do not. They positively impact not only the students on the inter-collaborative teams, but also their friends and colleagues who are watching them.
- Inter-collaborative experiences provide opportunities for faculty mentors and coaches to learn about other programs and also in broadened empathy for others and appreciation for challenges in engineering designs in other parts of the world.
- Domestic inter-collaborative projects will enhance student learning, despite less cultural differences. Cost of domestic collaborations can be high, especially if they are not in the same region.
- The cost of inter-collaborative senior projects may be too high to become the norm for all senior design teams in a program. Commitment of faculty members at both institutes is crucial to the success of these kinds of arrangements.

We believe there may be ways to gain the learning experienced by these senior design teams at less cost. This could include inter-collaborative projects with a lesser scope or shorter duration, or perhaps formation of a cooperative of universities participating in inter-collaborative project work independent on its own schedule, independent of the restrictions of any single institute. The results of this study seem to confirm these projects should not be abandoned and we should work to acquire more information to better understand the benefits in learning through intercollaborative projects.

Introduction

The civil engineering programs at Rose-Hulman Institute of Technology (RH) and Gonzaga University (GU) wish to understand optimization of inter-collaborative capstone projects. Inter-collaborative capstone projects are typically service learning projects conducted by students from multiple institutes. Such projects are often local to one of the institutes, but remote to the other(s). They are organized to promote intercultural learning by students from both institutes and to overcome accessibility to the site and client for the remote institute. They also allow an international experience for students who are unable to travel due to affordability, access, or other reasons.

Prior to the work reported in this paper, students at Rose-Hulman have successfully collaborated on multiple projects in Ghana, Africa with civil engineering students at Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi, Ghana (Aidoo et al., 2012, 2014). Unfortunately, due to timing, cost, and other travel restrictions, Rose-Hulman's students have not been able to travel to meet in person with their teammates in Africa. We think face-to-face activity with teammates is a crucial part of team formation, and that travel to visit a project site in a different cultural setting is an important part of project development. The travel is also likely to be a greatly enriching experience for the students. However, we are uncertain the benefits justify the costs.

We have the following questions –

- How beneficial is it for student teams to spend time together in person to understand their cultural differences and to develop a team rapport?
- How beneficial is it for student teams to visit the site in person and get to know the community that will benefit from their project design?
- Are the costs (time, travel safety, funding) associated with student and mentor travel to support inter-collaborative projects acceptable when compared to the benefits?

Project Approach

Our two institutes decided to investigate these questions by starting with a simple approach. Rather than facilitate inter-collaborative international projects with combined student teams, we organized two teams to work on projects local to our institutes, one near Rose-Hulman in Indiana and one near Gonzaga University in eastern Washington State. Each of the two teams was comprised of four students, with two from each of our institutes. This permitted simpler travel for face-to-face meetings, organization of an approach for remote student collaboration and mentoring without language barriers, and development and testing of an assessment plan that could be applied to international collaborations. This approach also constituted a lower-risk exploration of our questions compared to an international collaboration.

Schedules. Both of our institutes conduct capstone design projects that extend over a traditional academic year from September through April. Gonzaga University is on a semester schedule while Rose-Hulman is on quarters. Despite the different schedule types, 2014-15 capstone design projects initiated and finished at both schools within a week or two of each other. However,

between initiation and completion of the projects, deadlines and breaks were different. Table 1 compares the two schedules. The RH schedule includes about 27 weeks for capstone projects while the GU schedule includes about 29 weeks. Weeks when students were not in class and thus unavailable to work with their teammates are shaded in grey. During 4 of GU's 29 work weeks, RH students were not available and GU students were not available during 3 of the 27 RH work weeks. Thus, students were unable to collaborate about 25% percent of the total project work time. The conflicting weeks are shaded black between the two schedules in the figure. The schedule also shows when the teams were face-face at one or the other institute and project site.

On prior inter-collaborative projects, Rose-Hulman had volunteered to adopt the work schedule of the partner institute, and thus had some experience with adjusting schedules. So for this study, the senior design coordinators agreed to have the RH students and coaches conform to the GU work schedule, presentations, and deliverables, with the exception of RH break and exam weeks.

Projects. The scopes of both projects were identified in advance by the senior design coordinators at both institutes as appropriate in light of the inter-collaborative nature of the projects. The students selected the projects knowing about the inter-collaborative aspect. The two projects were

1. Sand Creek Fish Passage Channel. Client: Spokane Indian Reservation. Description: A fish passage channel and access road is required on Sand Creek of the Spokane Indian Reservation. The creek experiences periods of no flow in the rugged terrain, preventing fish passage. The access road will be several miles in length over rugged terrain.
2. Indiana DNR Centennial Shelter. Client: Indiana Department of Natural Resources. Description: Indiana DNR is seeking several alternative designs for picnic shelters and supporting infrastructure celebrating their 100th anniversary. They have requested seismic design and consideration of the role of the shelters as a tornado shelter.

Each project team had two coaches, one at GU and one at RH. Both institutes agreed that, as far as practical, the coaches should follow mentoring processes typical of the home institute.

Face-to-Face Group Interactions. A primary focus of the study was to investigate the benefits of face-to-face interactions with team members. Both institutes budgeted funds for travel expenses for the teams. The teams collaborated face-to-face for a few days in the fall term, and again at project completion in the spring. As shown on Table 1, the two RH students from Team 1, Sand Creek Fish Passage, visited GU and the site with the RH lab manager during their Fall Break on Thursday-Sunday, October 9-12, 2014. The two GU students from Team 2, DNR Centennial Shelter, visited RH and their project sites on Friday-Sunday, October 24-26, 2014. The fall visits allowed time for the teams to get to know each other and their project sites while conducting field work at sites. The site visits near RH were accompanied by a department faculty member, and the GU site visit was accompanied by the GU Team Coach and RH lab manager. Three of the four RH students also attended the GU Senior Design Expo at the end of their projects, traveling Tuesday-Thursday, April 28-30, 2015 to participate in the final project presentation at the Expo. They were accompanied by the Team Coach and senior design coordinator from Rose-Hulman.

All other meetings and group work were conducted by phone, email, and text. Presentations at RH and GU that required all team members were facilitated using internet-based interactive meeting software. Besides the schedule, travel, and meeting accommodations described previously, the senior design project work was conducted normally at both institutes.

Table 1. Comparison of 2014-15 Academic and Senior Design Schedules at RH and GU

Week of	Rose-Hulman Inst. of Tech.		Gonzaga University	
	Week	Activity	Week	Activity
9/1	0	Fall classes begin Thu	1	Fall classes begin Tue
9/8	1	Teams formed Mon	2	Teams formed Wed
9/15	2		3	
9/22	3		4	
9/29	4		5	
10/6	5	Fall Break Thu/Fri, Team 1 visit GU	6	
10/13	6		7	
10/20	7		8	30% Rvw Wed, Team 2 visit RH
10/27	8		9	
11/3	9		10	
11/10	10	30% Design Rpt due + presentation	11	
11/17		Final Exams	12	
11/24		Term Break	13	Thanksgiving Wed-Fri
12/1	1	Winter classes begin Mon	14	
12/8	2		15	30% Presentations Wed
12/15	3			Final Exams
12/22		Christmas Holiday		Christmas Holiday
12/29				
1/5	4			
1/12	5		1	Spring classes begin Tue
1/19	6		2	
1/26	7		3	
2/2	8		4	
2/9	9		5	
2/16	10	Design appendices due	6	60% Presentations on Wed
2/23		Final Exams	7	
3/2		Term Break	8	
3/9	1	Spring classes begin Mon	9	Spring Vacation
3/16	2		10	
3/23	3		11	
3/30	4	Final Rpt due for faculty review	12	
4/6		Spring Break	13	
4/13	5		14	
4/20	6	Final Rpts complete, attend GU Expo	15	Design Expo Wed
4/27	7			
5/4	8			
5/11	9			
5/18	10			

Assessment Plan

The civil engineering program at Rose-Hulman, with the assistance of the RH office of Institutional Research and Program Assessment (IRPA) has an ongoing study investigating a variety of elements related to international senior design projects (Aidoo et al., 2007, 2008, 2012,

2014; Hanson et al., 2012; Howser et al., 2008). The project described herein is being assessed in part within the framework of that broader study. Four assessment tools are in use for this project:

- Focus Group interviews about the experience were conducted with the GU and RH students
- The Coaches for both teams were interviewed by IRPA
- Assessing changes in empathy for others in the RH inter-collaborative project students as compared to other senior design students in the RH civil engineering program, as indicated by the results of a Global Competency and Intercultural Sensitivity Index (ISI) survey (Olson and Kroeger, 2001).
- Comparison of RH inter-collaborative project students' skill development in self-directed learning as compared to other senior design students in the RH civil engineering program using the PRO-SDLS survey technique (Stockton and Brockett, 2011)

This paper examines only the results of the first two of the four assessment tools listed above. The sample set for the RH students was too small for the results of the ISI and PRO-SDLS surveys to be effectively studied, plus the GU students were not asked to complete these surveys. The results of those surveys are being combined with findings from other international experiences and will be shared in the future.

Student Focus Groups. The focus group interviews for the GU students and RH students were conducted separately. The discussions were themed around the following questions:

1. Should all of the senior design teams collaborate across schools? Why or why not?
2. What were the benefits of collaborating with another school for senior design?
3. What were the costs of collaborating with another school?
4. How do you feel your time investment in your project compares to the time invested by teams comprised of all students in your department?
5. Tell me about the travel component. Was this a necessary aspect of the trip?
6. What did you learn during your travels that you could not have gotten working virtually?
7. Would you have gone to the other institute and site if you had to pay the travel costs? Why or why not?

The student interviews were recorded and transcribed for synthesis.

Faculty Interviews. The Team Coach interviews were conducted separately. The questions asked and discussions were themed around the following questions:

1. Should all of the senior design teams collaborate across schools? Why or why not?
2. What were the benefits of collaborating with another school for senior design?
3. What were the costs of collaborating with another school?
4. How do you feel your time investment with your team compares to the time invested by mentors of teams comprised of students all from the same school?
5. Tell me about the travel component. Was this a necessary aspect of the trip?

Note the faculty interview questions coincide with the student focus group questions, except for questions 6 and 7, which were posed only to the students.

Findings

Should all Senior Design Teams Collaborate Across Schools? The students and faculty all agreed inter-collaborative projects should be an option that is available to students, but not all teams should be required to conduct projects in this way. The students noted the separation, lack of

familiarity with each other, and different learning experiences in the curriculum made the collaboration difficult and time consuming. They indicated that their acceptance of this aspect of the project when they requested it was important for their acceptance of the circumstances. The faculty observed that coordination of the projects was much more time-consuming than projects on their own campus, and that coordinating multiple projects across multiple campuses would inevitably be even more difficult.

What were the benefits of collaborating with another school for senior design? Students and faculty alike agreed that the collaboration broadened their understanding of similarities and differences between engineering programs, engineering students, and communities. Learning how to facilitate audio/video presentations and meetings and just manage a time change of three hours across the U.S. was particularly enlightening for the students. The faculty greatly appreciated what they learned about the similarities and differences in the capstone design programs and changes improve both programs have already been implemented or are under consideration. Students and faculty also agreed the inter-collaborative aspect provided a better appreciation for differences in geography, geology, culture, and construction methods.

What were the costs of collaborating with another school? Students and faculty agreed one of the greatest costs was time. Most aspects of student and faculty involvement in projects required more time. Students recognized and faculty agreed the monetary cost was also high.

How do you feel your time investment in your project compares to the time invested by teams comprised of all students in your department? This was already addressed in the prior response. The students and faculty agreed the time for coordination and management of the project, not to mention the travel time, was much higher.

Was the travel component a necessary aspect of this project? Students and faculty alike agreed that meeting face-to face and allowing the teams to conduct field work together was highly beneficial to the students' understanding of each other, of their client, and of the site itself. Arranging for the RH students to be able to attend the GU Expo at project completion was also particularly gratifying to both teams. Both teams presented posters about their projects to the GU community and conducted presentations. Both expressed this was a great opportunity for the students to reach closure on the project together as a team.

The students were also asked about what they learned in their travels and whether they thought the cost was so worthwhile to them personally that they would have paid for the travel themselves, if it had not been paid by the institutes. These two questions were not posed to the faculty. In response to these two questions, the students reported a greater appreciation for others' perspectives and the differences they will encounter in their travel after graduation. They reemphasized learning the value of really getting to know the client and site when preparing engineering designs. However, the students were not certain the travel was so valuable that they would have paid for the travel themselves. They also expressed in particular that, at the time they were traveling, they felt less positive about the trip and would probably be less likely to recognize its value. These observations by the students about their perceptions before and during the travel could in part be due to the domestic nature of the project. They may have perceived the travel experience to be less valuable because of staying in the U.S. and merely traveling to another part of the country. Even so, they

all agreed that, based on what they learned upon project completion, they value the travel much more and would take the time in the future to meet design colleagues face-to-face and complete site visits, if funds were available.

Conclusions

We have reflected on the findings of the interviews, on their observations of learning while the projects were under way, and observations from prior inter-collaborative projects at RH. We conclude that

- Inter-collaborative senior project experiences provide opportunities for students to learn in ways that more traditional senior projects do not. They represent great student experiences that, in general, positively impact not only the students on the inter-collaborative teams, but also their friends and colleagues who are watching them complete the project work
- Inter-collaborative experiences provide opportunities for faculty mentors and coaches to learn as well. The faculty members gain perspective from observing project mentoring and facilitation at the other institutes, and also gain similar perspectives as the students in broadened empathy for others and appreciation for challenges in engineering designs in other parts of the world.
- Domestic inter-collaborative projects enhance student learning, despite less cultural differences particularly if conducted over greater distances and time zones, though they are just as time-consuming as international collaborations. The cost of domestic collaborations can be high, especially if they are not in the same region.
- The cost of inter-collaborative senior projects may be too high to become the norm for all senior design teams in a program, but one or several such projects seem to be a worthwhile time investment. Commitment of faculty members at both institutes is crucial to the success of these kinds of arrangements.

We believe there may be ways to gain the learning experienced by these senior design teams at less cost. This could include inter-collaborative projects with a lesser scope or shorter duration, or perhaps formation of a cooperative of universities participating in inter-collaborative project work independent on its own schedule, independent of the restrictions of any single institute. The results of this study seem to confirm these projects should not be abandoned and we should work to acquire more information to better understand the benefits in learning.

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