A Bridge in Panama: Case Study of Messiah College Project-Based Learning

Russell Woleslagle and Brian Swartz

***Abstract*— The Collaboratory for Strategic Partnerships and Applied Research offers unique collaborative project opportunities for students in Engineering while meeting real world needs. A pedestrian bridge initiative for a poor community in Panama this past year is a prime example of the value that this project delivery method brings to the student experience. A Messiah College alum (Dan Cotton) who now serves as a missionary (Rio Missions) in Panama established a relationship with the community and identified the need. The pastor that he partners with operates a very humble church and community center that is seasonally separated from residents during high water times in rainy season. Dan Cotton communicated his visions for a bridge at this site, and sought out the technical design services offered by the Collaboratory to meet the need.**

A team of six students spent a semester designing a timber truss bridge, carefully considering locally available materials and labor capabilities. One student – Russ Woleslagle – then spent the summer interning with Rio Missions and serving as construction manager for the project. He had the unique opportunity to lead the bridge design team, and to see the project to completion through the construction process. This opportunity reinforced some of the technical skills Russ has learned in the classroom, while developing him as a leader in the context of a project that meets the needs of real people.

I. Introduction: Messiah College Engineering Project Curriculum

LIKE many Engineering programs, Messiah College has historically employed a senior-capstone project model that aimed to be a culminating experience and required students to use many of the skills they developed in the previous three years towards a real, or at least realistic, project objective.

Messiah College Engineering recently replaced the senior capstone with an Integrated Projects Curriculum (IPC). In the IPC, students engage project work beginning in the spring of their sophomore year and continue through their senior year. This curriculum change was made possible by the presence of a successful and growing organization on campus called the Collaboratory for Strategic Partnerships and Applied Research. The Collaboratory had developed a track record of soliciting projects from NGO's or large funding agencies and staffing them with student and professional volunteers.

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The IPC formalizes a mechanism by which Engineering students can complete an internship with the Collaboratory and receive academic credit for the work accomplished. The Collaboratory continues to be responsible for soliciting projects, recruiting volunteer or professional advisors, and training project teams to be successful.

Messiah College Engineering is committed to providing the Collaboratory internship experience to all students in the program. This relationship benefits both parties. Specifically, the commitment to continue sending student interns to the Collaboratory provides an opportunity for them to pursue large multi-year projects that could never be possible in the senior capstone model. Furthermore, by mixing class years on the project team, each team continues to make incremental progress. The juniors are ready to step into a leadership role as soon as the seniors graduate. This arrangement is much more productive than the senior capstone model that essentially requires starting fresh each year.

Partnership with the Collaboratory creates an opportunity for Engineering to craft a curriculum that emphasizes both project-based learning and service-learning strategies. The projects in the Collaboratory/IPC model are all service-oriented. Generally speaking, they either serve underprivileged populations or sustainability initiatives. Students are naturally motivated in their work on these projects because they all have a compelling story and a genuine need at their roots.

The Collaboratory touts a shared leadership model. There are faculty and professional advisors at all levels, but as much as possible the students are involved with the leadership. For example, there is a student board of directors that vets new project proposals to consider whether the incoming project aligns with the ethos of the Collaboratory and is poised to be successful.

The Collaboratory organizes projects of similar types into Groups. Each group has a student leader and faculty advisor who consider personnel and resource issues for the group. For instance, if a high priority project in the group falls behind schedule, staff and other resources can be shifted to it from another project. Students are generally committed to a group, and trained specifically in the skill areas common to the projects in that group.

The Collaboratory's flagship groups are Water and Energy. The Water Group houses several projects that deal with water access, filtration, and quality. They have project sites throughout the developing world, particularly in Africa. The Energy Group focuses on alternative energy solutions, including solar and biodiesel.

The case study that will be focus of this paper is the founding project of the Infrastructure Group. The

Infrastructure Group was initiated in Spring 2014 in order to provide projects that will be interesting to the Civil Engineering students at Messiah. Civil Engineering has just this year been added as a program of study in the Engineering program.

II. Introduction Panama Pedestrian Bridge Case Study

A recently completed bridge is one example of the work being done in the IPC/Collaboratory model, and will be presented here as a case study.

Messiah College maintains strong relationships with many missional organizations throughout the world. Many of those connections lead to important partnerships in offering students off-campus experiences. One such partnership involves Messiah alum Dan Cotton and his organization Rio Missions in Panama. An extracurricular club for Messiah athletes called AROMA (A Revolution of Missional Athletes) frequently travels to Rio Missions' hostel to provide sports camps for the local community; they often typically distribute water filters and train local communities on their use while conducting the camp.

Russell Woleslagle (author) traveled with AROMA to Panama in August 2013. During that trip, he worked with Dan Cotton and a local pastor to identify a site where a pedestrian bridge was needed. He returned to campus and shared the project idea with the Collaboratory. The bridge project provided the impetus to start an Infrastructure Group which has an eye towards soliciting projects that will be of interest to the Civil Engineering students.

III. Defining the Need

Any good engineering project takes care in articulating the need before workings towards a solution. Many of the Collaboratory projects include a site visit early in the process in order to clearly define and understand the problem that must be solved. In the case of the bridge project, two different site teams worked together to collect the data needed for the engineering work.

Russell's AROMA team first recognized that a pedestrian bridge would serve the local community in Arraijan, just west of the Panama Canal near the Pacific coast. The in-country partner, Rio Missions, had developed a relationship with a pastor in a poor community. He has a vision to provide basic life essentials, including clean water, for the local population. But his church and community center are near a ravine that floods seasonally, dividing the community and cutting off dozens of families from the community center, the local school, and other amenities. It was clear to Russell's team that a pedestrian bridge could serve this community well.

A second team that traveled to Panama a few months later visited the site to conduct a full site survey. Bridge designs rely heavily on survey data for the site. This information helps the design team set the abutment locations, the bridge span length, and the height of the structure. Among other things, the designers take care to keep the bridge above the flood stage water level.

The data collected by the site team enabled the engineering students to develop a bridge site profile (Figure 1) that was used to set the abutment locations and other key features of the bridge design.

IV. Designing the Solution

The focus for the engineering students in the IPC/Collaboratory model is designing a solution to meet the needs that have been identified. In the case of the pedestrian bridge project, a team of six engineering students, a faculty advisor (co-author), and a professional mentor worked to develop design documents for the bridge.

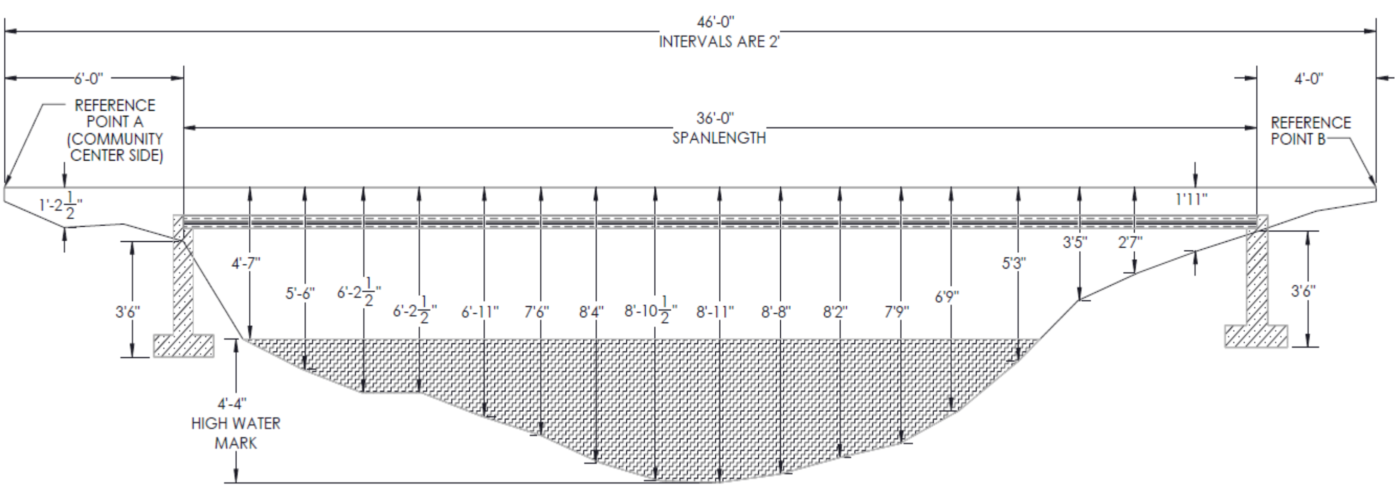

Fig. 1. Bridge Site Profile

The bridge design process begins by determining the span arrangement and bridge type. The span length was only 40 feet, so cable-supported structures were not considered as a viable solution. Instead, after confirming local availability of pressure treated lumber, a timber truss bridge was pursued. This bridge type made sense in the context of locally available equipment, labor, and materials.

Bridge design always requires a careful balance between span length and number of piers. The in-country partner initially envisioned a shallow superstructure spanning short distances supported by multiple piers in the valley. The design team recommended – and the client agreed – that the bridge superstructure should be designed more substantial so that it could span the entire distance without piers in the valley. The engineering team feared that the absence of powered excavation equipment would make the additional foundation construction prohibitive. Furthermore, at the time of design, the team did not know whether any professional oversight would be present during construction and feared that a poorly built pier foundation could be susceptible to failure by scour during flood events.

The timber design followed the AASHTO LRFD Bridge Design Specifications. Design iterations vetted various truss configurations and floor system concepts while also considering the material availability. Careful accounting of each member required was included in the material requirements as the design team strived to minimize waste while maximizing quality for the dollar. The design team developed a full solid model of the design (Figure 2), a full set of design drawings (Figure 3), and shop drawings that provide the detailed information needed to fabricate each member (Figure 4). Additionally, the engineering team assembled a material cost estimate and step-by-step construction guidance (Figure 5).

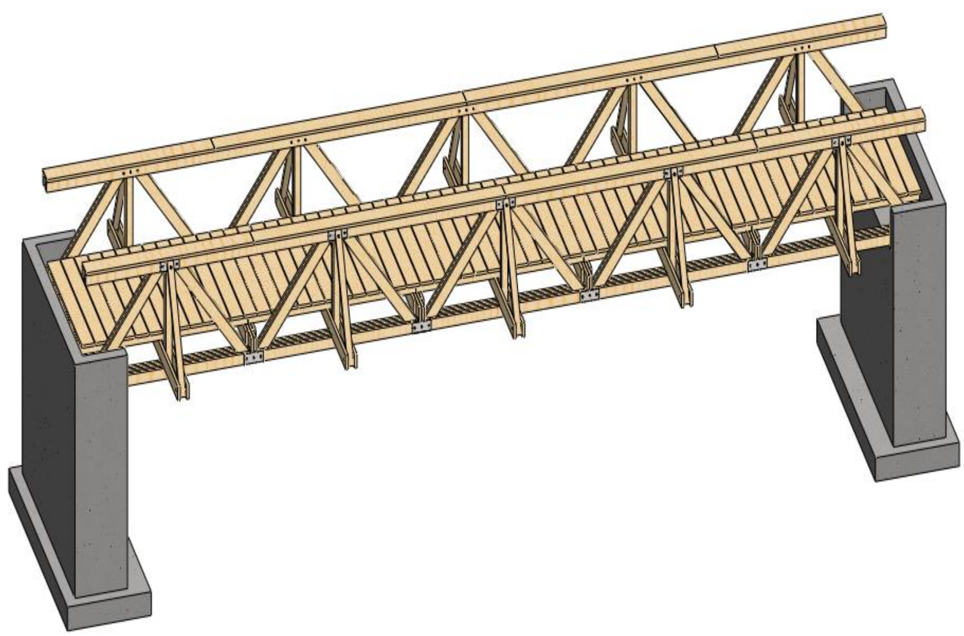

Fig. 2. Full solid model rendering of the bridge design.

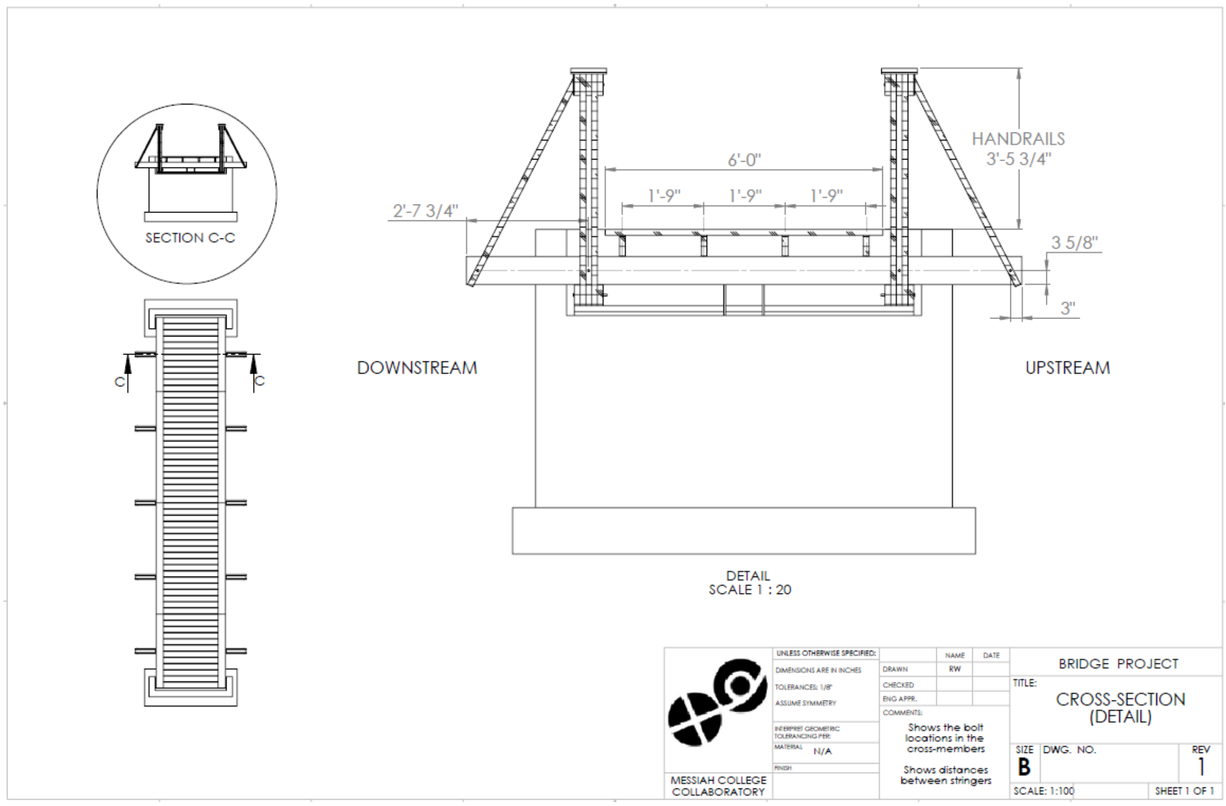

Fig. 3. Sample of the design drawings for the bridge design.

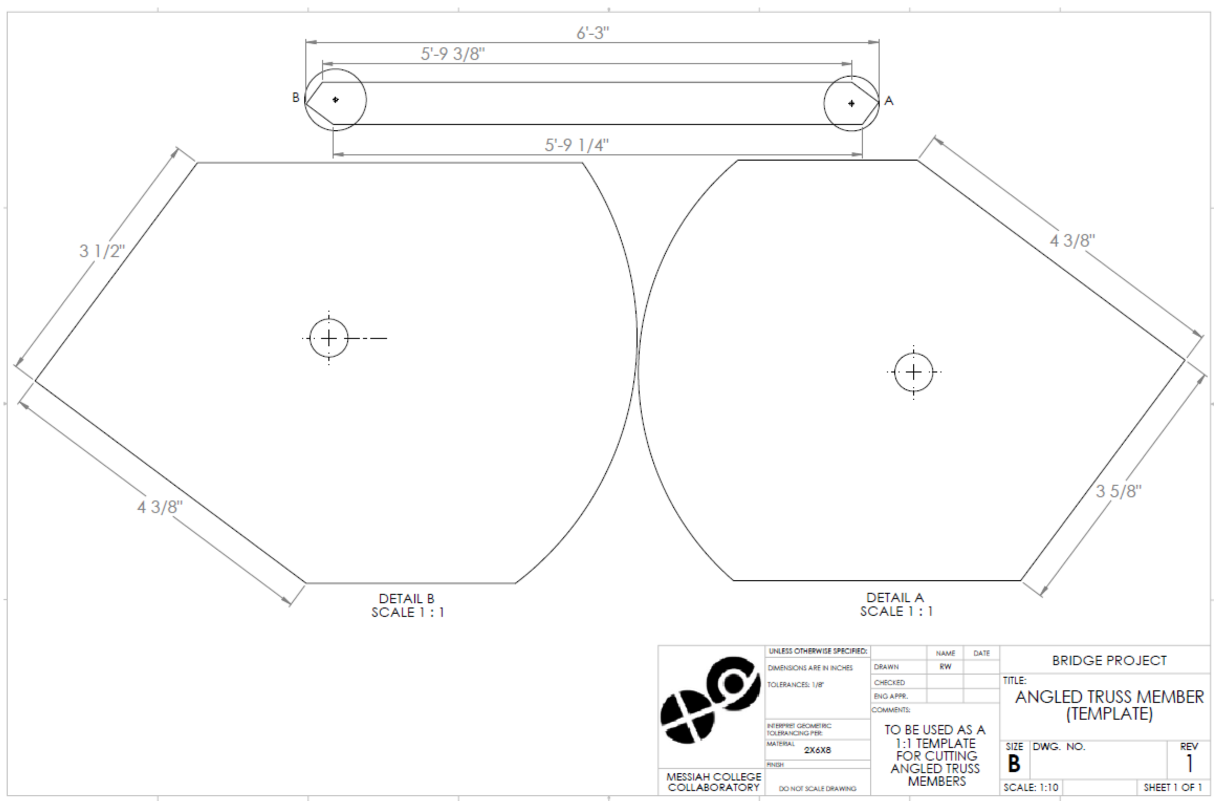

Fig. 4. Sample of the shop drawings (details for each member) developed as part of the bridge design.

Timber Schedule

Tables 1-3 list the lumber needed for each section of the overall structure. Table 4 lists the totals of the quantities specified by Tables 1-3 and serves as a complete shopping list.

Table 1: Lumber needed for the floor and exterior braces

Floor/Braces		
Floor Boards	31	2"x8"x12'
Joists	20	2"x6"x8'
Floor Beams	10	2"x8"12'
	20	2"x8"x8'
Exterior Braces	5	2"x4"x10'

Table 2: Lumber needed for the vertical truss members

Vertical Members		
Diagonal Chords	40	2"x6"x8'
Vertical Chords	10	2"x4"x10'

Table 3: Lumber needed for the horizontal truss members

Top/Bottom Chords		
Splice Boards	40	From Diagonals
Chords	40	2"x6"x12'
Railing Cover	8	2"x12"x10'

Table 4: Lumber totals needed for the entire structure

Totals		**Individual Price**	**Total Price**
2"x4"x10'	**15**	6.95	104.25
2"x6"x8'	**60**	7.95	477
2"x6"x12'	**40**	11.95	478
2"x8"x8'	**20**	11.75	235
2"x8"12'	**41**	17.60	721.6
2"x10"x10'	**8**	24.95	199.6

Item: 2"x6"x12'
Total Qty.: 40

Qty.	**Cut**	**Use**
8 cut:	8x 10'	top/bottom chords
	8x 2'	top/bottom chords
4 cut:	8x 6'	top/bottom chords
28 uncut:	[28x 12']	top/bottom chords

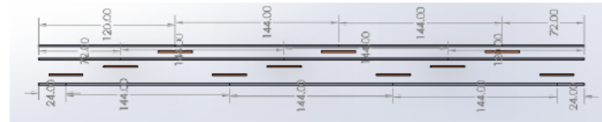

Figure 2: Construction of the top and bottom truss chords including individual lengths (in inches) and splice locations. The top of this image corresponds to the side of the chord on the outside of the bridge. This image illustrates the top and bottom chord of both the upstre am and downstream trusses.

Item: 2"x8"x8'
Total Qty.: 20

Qty.	**Cut**	**Use**
10 cut:	10x 88" (7'4")	short floor beams (double thick at diagonal panel joints)
10 cut:	10x 76" (6'4")	short floor beams (double thick at diagonal panel joints)

Left over:
10x 8" (2"x8")
10x 20" (2"x8")

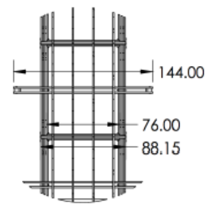

Fig. 5. Sample of the construction plan developed as part of the bridge design

FUNDING THE SOLUTION

The IPC/Collaboratory projects are funded by many different models. In some cases, the Collaboratory funds projects from its own private donor pool. In instances where significant funding is required, grants are often pursued. Or the client may be capable of funding the solution themselves.

In the pedestrian bridge case study, Rio Missions agreed to fund and manage the construction themselves. Rio Missions raised money from their donor pool in order to build the bridge.

V. IMPLEMENTING THE SOLUTION

Many of the IPC/Collaboratory projects involve developing and testing a prototype, and demonstrating its use for the client. In the case of the bridge project, a prototype was not necessary. Instead, the design team played a significant role in constructing the bridge at the site.

Woleslagle had the unique opportunity to serve as an intern with Rio Missions for the summer of 2014. His primary responsibility with Rio Missions was managing and coordinating construction of the bridge. He had the unique opportunity to follow this project all the way from initially identifying the need to managing all stages of construction.

Woleslagle first managed excavation and foundation construction. Much of the work was done by local labor under his guidance (See Figure 6).

The construction scheme for the superstructure assumed that the individual trusses could be constructed horizontally on flat terrain, then carried across the ravine, set on the abutments, rotated vertically and braced in place while the floor system was constructed (Figures 7, 8). The timber superstructure construction was done mostly by a team of carpenters that traveled to the site from New Jersey for a one-week short-term missions trip. This created an opportunity for Woleslagle to practice some project management strategy with skilled labor.

Fig. 6. Foundation and abutment construction – cast-in-place concrete with reinforcement

Fig. 7. Moving the completed trusses into place at the site

Fig. 8. Floor system construction

VI. Opening the Bridge

Rio Missions hosted a bridge opening ceremony (Figure 9) to mark completion of the construction and formally asking the local community to take ownership of the bridge. Rio Missions acknowledged the important contributions of the Messiah College Engineering program that carried out the design.

Fig. 9. Official ceremony to mark the opening of the bridge

VII. Conclusion

The pedestrian bridge project in Panama is one example of the work being done by Messiah College Engineering students through partnership with the Collaboratory. The projects curriculum provides an opportunity for students to learn while meeting real needs in the world. As was the case for the bridge, most of the projects serve underprivileged or impoverished people in the developing world. The pedestrian bridge will provide safe, reliable access to a community center, school, and other life essentials for residents in a community of Arraijan (Figure 10).

Fig. 9. Local children enjoying the nearly completed bridge.