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Social Constraints: A Critical Component of Global Humanitarian-based Projects

Amy Wood, Brigham Young University
Mr. Parry Fader Garff, Brigham Young University
Prof. Carol J Ward, Brigham Young University

Carol J. Ward is associate professor in the Sociology Department.

Prof. Eric C. Dahlin, Brigham Young University
Dr. Randy S. Lewis, Brigham Young University

Dr. Randy S. Lewis is professor and chair of Chemical Engineering at Brigham Young University (BYU). He received his B.S. and Ph.D. in Chemical Engineering from BYU and Massachusetts Institute of Technology, respectively. He currently serves as vice-chair of the Education and Accreditation Committee of the American Institute of Chemical Engineers (AIChE) and as an ABET commissioner for accrediting engineering programs. He previously served in several national positions of AIChE. His research interests include biomaterials development, engineering education, product design for developing areas, and the utilization of renewable resources for the production of chemicals.

Social Constraints: A Critical Component of Global Humanitarian-based Projects

Abstract

Since 2007, a two-semester multi-disciplinary course in the College of Engineering and Technology at Brigham Young University University has enabled engineering and technology students from multiple disciplines to design and implement humanitarian-based engineering projects in developing nations. The course, which is associated with the Global Engineering Outreach (GEO) Student Organization, has provided an opportunity for engineers to work in conjunction with communities on global problems, researching not only technical but economical and socio-cultural issues. Following the course, projects have been implemented during a two week trip. Energy, water, sanitation, and health projects have been implemented in Tonga, Ghana, and Peru.

The popular class has traditionally involved students from Mechanical, Chemical, Civil and Environmental, and Electrical and Computer Engineering programs, as well as students from technology disciplines. Assessments from the various years have demonstrated that students learn skills and attributes that are not easily taught in a campus setting. Over the years, lessons have been learned regarding the importance of social constraints related to the design and implementation of projects.

Recently, material related to social constraints has been implemented in the course to strengthen the incorporation of social constraints in the design and implementation process. Specifically, student learning related to social constraints has involved a) a review of lessons learned from our experiences in the past, b) a workshop on design that included the importance of identifying and tracking social constraints, c) design reviews by faculty and class alumni that included a critique of social constraints, and d) sociology instruction that addressed how to effectively communicate with community members and how to gather information towards identifying and refining social constraints.

This paper provides the details of the social constraint material incorporated into the course along with a review of specific examples related to past projects. The understanding and incorporation of social constraints is critical towards the development of sustainable projects.

Introduction

In 2007, a two-semester multi-disciplinary course in the College of Engineering and Technology was established at Brigham Young University. One focus of this course is to broaden the learning experience of engineering students by solving real-world engineering challenges in developing nations using multi-disciplinary teams. Previous publications and presentations related to the course have discussed training internationally responsible engineers[1], student learning[2], and the sustainability and impact of the projects[3]. Projects have been implemented in Tonga, Ghana, and Peru. Product design is a critical part of the learning experience and involves an understanding and application of both technical and social constraints that are essential for the sustainability of the design projects. Over the years, lessons have been learned regarding the importance of social constraints related to the design and implementation of projects. Although technical constraints are often discussed in design textbooks[4], information regarding social constraints is minimal. Social constraints are just as critical, if not more so, for a sustainable project. However, these constraints are not as easily identified because of differences in culture and the lack of integrated social experiences between a design team and a community.

In this paper, we share what we have learned about how social behavior affects the implementation of humanitarian-based engineering projects in developing nations. We use the term *social constraints* to refer to the social behaviors and attributes that influence the sustainability of an implemented design project within a community. Specifically, we define social constraints as patterns of behavior that provide opportunities for and constraints on implementation of engineering projects. Social constraints can include formal practices such as government regulations or informal norms including cultural preferences.

Recently, material related to social constraints has been implemented in the course to strengthen the incorporation of social constraints into the design and implementation process. Projects over the years have been increasingly successful because of a heightened awareness of these social constraints. Specifically, student learning related to social constraints has involved a) a review of lessons learned from our experiences in the past, b) a workshop on design that included the importance of identifying and tracking social constraints, c) design reviews by faculty and class alumni that included a critique of social constraints, and d) sociology instruction that addressed how to effectively communicate with community members and how to gather information towards identifying and refining social constraints. This paper provides the details of the social constraint material incorporated into the course.

Lessons Learned From Our Experience

During the past six years, projects were developed and implemented, often in collaboration with community members. Several projects were identified by community members prior to the design process and feedback was often received from community members during development. However, our experience has shown that incorporation of social constraints in design is not always straightforward, even when interacting with the communities. In the examples noted below, some constraints should have been obvious but were not recognized prior to project implementation. Other constraints, although not directly affecting the technical design, played a role in the implementation and sustainability of the design. Since students do not know all of the questions to ask to learn these social constraints from community members, it is easy for some of these constraints to go unidentified by not asking the question that would lead to identifying the constraints.

The following is not an all-inclusive list of social constraints but it does serve as a reference for initiating discussion that could lead towards developing a list of social constraints for a given design project. It should be noted that some of the constraints listed can actually be categorized as both technical and social constraints. However, the examples noted below illustrate the constraint from a social perspective. During the course, these social constraint examples were reviewed to help students understand the importance of recognizing and identifying social constraints.

Empathetic Design. While developing a product, it is important to focus on the end users. Designing a project in a location that differs from the implementation location can limit the focus on the community members who will actually be using the product. While designing the same solar cooker described above, the solar cooker was designed and tested by tall, male students from the United States. Unfortunately, the height of the women that would use the cooker was not considered and the cooker was too tall for the shorter women on the Uros Islands in Peru to use comfortably. Understanding physical characteristics of the people, the area where the project will be implemented, and the relevant customs or practices (e.g. the height of a person, the limited space where a project would be located, the weight of a device, the customary practices associated with how a device may be used, etc.) is critical in designing a sustainable project.

Tradition. Without carefully observing a culture, it is difficult to know the local traditions and how they can impact a project. While in Peru, a spring was capped and directed to a new water storage system. This project was wanted by the general community. Previously, water would flow from the ground source, across the ground, and into a storage tank but animals would contaminate the exposed water. Upon completion of the project, one community member informed us that he was unhappy with this new system and that he would break part of the water pipe since he needed to do his laundry. He had traditionally done his laundry in the area near where the water came from the spring. Capping the spring and transporting the water to the storage tank disrupted his life. Although another laundry location was established, this individual did not like the new location and he ended up breaking the line. The following year, the line from the capped spring was repaired and a water line was run directly to the home of this individual to ensure the safety of the community line. Although the problem was fixed, it is difficult to know the constraints of tradition and sometimes an awareness of these constraints may not occur until implementation of the project.

Trust. Trust is critical in designing a sustainable project since relevant and useful feedback is needed from the community during the design process and following the implementation of a project. While initially beginning our work in Peru, we noticed that most of the communication resulted in positive responses from the community. It was later understood that in this community, as with many others all over the world, it is customary to agree with outsiders and express gratitude for the help they are trying to give, even if it's not helping at all. It is customary to provide positive (but in some cases untrue and therefore useless) feedback to show appreciation to the design team. Real, true feedback did not occur until strong relationships were established. In some cases, this may take several years depending upon the amount of interaction.

Community Engagement. Community engagement can be affected by interactions between community members and other outside groups without knowledge of the design team. Learning about the workings of other groups interacting with the community can provide additional insights that may help with the sustainability of the project. Early in our work in Peru, the community engaged with the design teams to implement the projects. The community helped by digging trenches for pipes and providing other types of labor. Several years later, the community members were not as engaged in our projects and this was difficult to understand. It was eventually learned that the NGO working in the community had been paying the community members to help with our work and when the financial resources were no longer available, the community was no longer engaged. This financial incentive was unknown to the design team.

Protocol. During an implementation trip to Tonga, the delayed shipment of the chemical resulted in a change of plans. Originally, we were going to share the biodiesel project with the government prior to sharing the project with high school students. This plan was reversed to provide time to give the best presentation to the government. Local people were aware of this change, but no one notified us that this was not customary. After presenting to the students and to the government, it was conveyed that the presentation should have been to the government first. Although there were no hard feelings, it would have been beneficial to have a better understanding of the protocol. The difficulty was that there was not any indication that suggested the engineering students should be aware of this protocol. As noted, one unplanned social constraint (time) led to another unplanned social constraint associated with protocol.

Perceived Safety Risks. Safety should always be a key component of design. The safety of the user, particularly in the location where the project is implemented, should be strongly considered. Identifying safety issues regarding product use while developing the project (particularly while developing the project in a location different than where it will be finally implemented) may not be as obvious. It is critical that a project team discusses safety with people familiar with the location where the project will be implemented. For example, one team previously developed a solar cooker that was designed for the people living on the Uros Islands in Peru. The project was safely developed and tested at the university. Unfortunately, the project was not perceived as safe by the islanders because the focal point of the solar cooker was located outside of the physical structure. Thus, the people thought there was a possibility that the focal point could be accidently focused on an area of reeds on the island (such as a home) such that the reeds could catch on fire. Although a fire was highly unlikely, the *perceived* safety risk was addressed in the following year with another solar cooker design that had the focal point within the physical structure. The sustainability of a project is unlikely if the community perceives a safety risk even if the safety risk is minimized through engineering design. Training is a possibility to overcome the perceived safety risk but social behaviors in this area are often difficult to overcome.

Time. Time is often a constraint that can be overlooked upon implementation. This constraint can have a large impact on implementation and sustainability. While in Tonga, there was a need to obtain a chemical from another country. As students went to the airport to pick up the expected package, the airport personnel stated that the package had not arrived but that it would be there the next day. Returning the next day, the same information was relayed. During all of this time, the airport personnel were in no rush and this provided an inconvenience for the engineering students from the United States. Upon returning again and finding no package, we asked if the package could be tracked. Following several phone calls, the airport personnel determined that the package had never been shipped. In this example, time was of the essence for the students but time was not as critical for the island airport personnel. This is common in the culture of many developing countries and should be accounted for when making an implementation plan, especially if there is limited time in introducing the project since first impressions are often critical for sustainability.

Tools. The sustainability of implemented products requires a good maintenance plan. It is important to consider the tools that are available to the community as part of the maintenance plan. Tool constraints may not always be appropriately identified without experiencing the culture. While implementing a windmill on the Uros Islands in Peru, we needed to drill a hole in some windmill blades. Based on experience in the United States, the students thought of buying a drill because they were common in stores in a nearby town. However, the cost was not reasonable for an islander. Interestingly, the islanders had a drill bit and once they were aware of the need to drill a hole, they utilized a bow and string to quickly drill the hole. Students did not predict that these kinds of homemade tools would be available or that they would even work. Although tools may appear to be a constraint, there are many methods to complete a task that do not always require the use of traditional tools familiar to design teams.

Materials. Materials are an integral part of nearly every project. Product designers often look at the technical constraint of materials such as corrosion, weight, strength, etc. A difficult material constraint to predict is a community's perception of the material. While implementing a cookstove with water heating capabilities in a small Peruvian village, a copper tube was used to heat the water. Unbeknownst to the design team, the villagers were leery of using copper pipe because of a previous project in that community where a copper line burst. Thus, the project was not sustainable in that community because villagers were uncomfortable having a material they thought was inferior. In contrast, another village in the same region had a water-heating cookstove implemented with different tubing material and the project was a success. One year later, the water-heating cookstove was still functioning very well and the family was very satisfied with the project.

Resource Availability. The ability to duplicate a product that is designed in one location (such as a university) and implemented in another location (such as another country) relies heavily on knowledge of the available resources. This communication can be difficult so care must be taken to accurately obtain this information. While working on a water delivery project in Peru that required a network of PVC pipe, a student team worked on a new design to provide better water flow to a village. The team physically worked on tube connections while at the university. The team regularly contacted individuals in Peru to ask if the appropriate size of pipe was available and the Peruvians told them that the appropriate pipe was available. Upon arriving in Peru, the team went to connect the pipes and found that the pipe tolerance was not the same as in the US. In Peru, pipe of the same size is sometimes difficult to connect and sometimes connects too loosely. It was not obvious to the students that they should ask about pipe tolerances since tolerances were known in the US and it was assumed they were the same in Peru. Identifying questions to ask regarding resource availability are not always clear in the beginning and it may be beneficial to brainstorm a variety of questions to ensure that resource issues do not inhibit the project implementation.

Cost. Cost is a social constraint that is well known but difficult to address. Average income in a community can sometimes be determined to help students understand the cost constraints of a project, but this often requires a good relationship between the product designer and the recipient. However, a good relationship does not always ensure that an appropriate cost is decided upon for project sustainability. For example, a product may require more than a months' income from a family or community but may be worth the investment. In other cases, it may not be appropriate. During a visit to Ghana, a windmill was developed to provide power for lanterns that could be used for reading and doing homework. The windmill performed for many years and was well-used by the community but it was too expensive to be purchased by that community and had to be donated. Thus, as with many engineering projects in developing countries, the product was technically sound but cost prohibitive. When addressing cost constraints, quality and cost should be addressed together since a low-quality product could be worse than nothing at all. People in poverty cannot afford to waste money on products that don't work.

Design Workshop

Most of the engineering students who take the course have not had a previous design experience. Therefore, a design workshop was implemented to provide a brief overview of product design to help the students get started on their projects. The workshop was taught by a professor of Mechanical Engineering whose research interests and experience are related to design for the developing world. Students learned about the design process and specifically how it applies when designing for developing communities. Methods for generating and evaluating design concepts were taught. Students learned about the importance of prototypes and how to effectively use them in testing and product development. Students were challenged to list the customer needs in order to generate a list of questions that must be asked of community members to clarify the needs and define a clear purpose for their product. However, the ability to effectively communicate with a community and to appropriately gather information to further clarify the needs and appropriate social constraints (without offending the community) were addressed through instruction and interaction with sociology students in a Sociology course.

During the design workshop, students learned how to organize and evaluate both technical and social constraints associated with the design. Monitoring progress on both technical and social constraints provides guidance in making important design decisions that lead to a sustainable product that better meets the customer needs. Table 1 shows the organization and evaluation of representative social constraints for a water filter.

Table 1: Social Constraints

Social Constraint	Metric	Units	Target Value	Acceptable Low Value	Acceptable High Value	Current Value
Used by the community	Survey of 30 people	%	100	70	100	20
Is comfortable to use	Height from floor	m	0.75	0.25	1	1.1
Can be carried by a Peruvian woman	Test of 10 women	%	100	50	100	Unknown

The table is a quick way for students to measure their progress of addressing the social constraints. The list of social constraints in the table is often more detailed than the social constraint examples described earlier. In general, social constraints address the question "Does it work in the community environment?" The metrics used to evaluate social constraints are often more subjective than the metrics used for technical constraints. The metrics are often evaluated by surveys or interviews with community members, whether over the phone or internet or during the implementation trip.

The technical constraints have to do with how well the product performs from a technical standpoint. Primarily, technical constraints address the question "Does it technically work?" Table 2 shows the organization and evaluation of representative technical constraints for a water filter. The table is a quick way for students to measure their progress of achieving the technical constraints.

Table 2: Technical Constraints

Technical Constraint	Metric	Units	Target Value	Acceptable Low Value	Acceptable High Value	Current Value
Filtration speed	Flow rate	L/min	5	2	n/a	4.2
Total weight	Weight	lbs	50	n/a	80	67
Height from the floor	Height	m	1	0.5	1.25	1.1
Water storage capacity	Volume	L	40	20	80	10

In some cases, constraints can be categorized as both technical and social constraints and it can be difficult to assign the constraint to only one table. Constraints such as height may have a technical purpose, like providing a certain head pressure to the filter, and also a social purpose, like being at a comfortable height for a person living in the community to use. Generally the student teams must decide how to categorize these types of constraints in whatever way works best for their team.

Design Reviews

Engineering students in the course participated in two or three design reviews each semester. These reviews are similar to design reviews for any type of design project because students are expected to describe their progress since the last review, discuss the challenges they faced and how they overcame the challenges, and describe the current challenges. However, these reviews are unique in that projects are reviewed by students and faculty who have participated with the course in the past. The reviewers may not be the best designers, but they focus on making current students aware of the social constraints that affected their team's design and implementation experience in the past. The reviewers gave suggestions for how to make the product more acceptable to the community or how to implement the project more sustainably based on their experience with that community. These alumni offered current students suggestions for materials that are available in country and shared their knowledge of available tools and resources. The reviews were an opportunity for current students to learn about what to expect when they travel to the implementation country and how to implement their products more effectively based on experiences of previous course participants.

Sociology Instruction

To help refine and further identify the community needs and social constraints addressed in the Design Workshop, engineering students recently participated in a course in the Sociology Department called Applied Social Research Methods. The engineering students joined sociology students for two lectures to help the engineering students more effectively communicate with the community and gather information from the community. The interaction of engineering students with sociology students and faculty was an important benefit since many engineering students often only associate with other engineering students during course projects. Having a perspective of sociology behaviors from those trained in the sociology field provided additional insights that would not have been easily achieved in the setting of a traditional engineering course.

The first lecture focused on learning to effectively communicate with the community that the students were designing for. The instructional goals for the first lecture included:

a. Helping students understand the logic and importance of Social Impact Assessment – assessing the social impacts of new technology on rural communities.
b. Helping students understand the importance of the social contexts (opportunities and constraints) in which their technology designs will be implemented and the value of involving community members in the assessment process.
c. Helping students identify ways to address the challenges of learning about the communities from a distance in order to improve designs.
d. Helping students learn how to obtain feedback on project designs in the field and assess preliminary impacts of projects on community members.

In particular, students learned about linking community needs to project designs and the impacts of the projects. Specific instructional activities during the first lecture related first to the needs assessment/scoping phase of Social Impact Assessment. Classroom activities involved teaching data collection techniques, identification of individual/household/community needs and identification of important features and conditions of the community context (social, economic, political, and cultural).

After learning about Social Impact Assessment, the engineering students had a better idea of what information they needed to gather to design products that will be sustainable in the community. However, gathering this information from a distance is a real challenge. Thus, the second lecture focused on information gathering. The methods for information gathering of community needs leading to better defined social constraints involved the use of several key strategies and sources that included:

a. Available data from community, regional or national organizations.
b. Interviews with key stakeholders and key informants.

c. Documentary sources.
d. Photos taken while in the field or by others from previous trips or by community members.
e. Archives of materials from students previously involved in these projects.

Classroom activities included learning participant observation techniques, taking field notes, conducting informal interviews with community members, and identifying central themes and patterns in transcribed notes that will facilitate re-designing projects. Additionally, activities included helping students consider designs and their possible benefits or negative consequences. Discussion of alternative concepts is intended to contribute to designs that mitigate or minimize possible negative impacts.

Assessment Plan

Following the recent design workshops and sociology instruction, engineering students in the current course are continuously involved in data collection on community reactions to designs, obtaining feedback on design elements, and reviewing and using feedback for refining social constraints and re-designing the projects as needed. In the future, we will continue assessing the influence of social constraints on development projects by collecting data on (1) project design and (2) whether the project has been successfully implemented and is sustainable. First, students and members of the research team will travel to the country of implementation for several weeks to introduce a prototype to members of the community. In addition to presenting the prototype, the research team will obtain feedback from users about the utility of the project's design and whether local materials are available to build the product. Interviews with users of the prototype will include questions about ease and likelihood of use, potential problems, and how to improve the design. A survey will also be administered to members of the community (specifically, those who have used the prototype and those who have not used it) that asks about the project's perceived usefulness, especially compared to alternatives, the likelihood of use and potential difficulties that may limit its use, and identifies reasons the product may not be used. Feedback from interviews and surveys will indicate whether students have successfully incorporated social constraints into the product design, be used to make minor adjustments to the project during the team's visit, and to further identify social constraints that have not been obvious to previous design teams.

Additional assessment will occur after the project has been introduced into the community to evaluate the implementation process and its sustainability. Again, data collection efforts will include a survey instrument and interview guide. Interviews will consist of questions that ask community members to identify reasons they used or did not use the product. The survey will include items that ask if anyone influenced the respondent's decision to use the product, factors that limited the accessibility or use of the product, and whether respondents would recommend the product to someone else. The data will be analyzed and the findings regarding the factors associated with successful implementation will be used to inform future development projects undertaken by the engineering students.

Although we are in the process of assessing whether the instruction students receive is increasing their awareness of social constraints, students are obtaining feedback from local community members and other resources to provide guidance on the product design. For example, students conduct interviews with community members via telephone and email; consult with faculty and students at the university who have visited the community; and review articles, books, and documentaries about daily life in the community. As an example of how this information can influence product design, last year an engineering team designed a washing machine for a Peruvian community. Interviews with community members informed the engineering team that the 20-gallon wash drum included in their prototype was not large enough, especially for the Peruvian women who washed bedding and sheets for tourists in addition to their own laundry. Based on this feedback, the engineering team was able to increase the capacity of the wash drum before they visited the community and solicited further feedback from users about the prototype.

Product designs are also improving from year to year as students learn from the past. For example, the washing machine was extensively tested in Peru following the 2012 implementation trip. Feedback from the Peruvians has resulted in new changes to the design that will be implemented during the 2013 trip. Again, the changes in the design are regularly being discussed with those in Peru.

Conclusions

Social constraints are an integral part of designing products for the developing world. We use the term *social constraints* to refer to the social behaviors and attributes that influence the sustainability of an implemented design project within a community. Specifically, we define social constraints as patterns of behavior or attributes that provide opportunities for and constraints on implementation of engineering projects. Recognizing critical social constraints for a design can be difficult and, in some cases, key social constraints may not be identified. Incorrect identification and incorporation of social constraints can lead to unsustainable projects. This paper reviewed lessons learned from our experiences in the past in relation to social constraints. Reviewing past experiences with current students provides an opportunity for students to recognize the importance of social constraints and to provide new ideas to explore in relation to identifying social constraints. In addition, specific training engineering students received with regards to recognizing and identifying social constraints was outlined. The training involved a design workshop, design reviews, and sociology instruction. In general, design teams must appropriately address social constraints in addition to technical constraints to design a sustainable product.

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