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Global Humanitarian-based Projects: A Documentation Strategy for Strengthening Project Sustainability

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Introduction

Opportunities for students at higher learning institutions to participate in global development projects has been enhanced since the establishment of Engineers Without Borders in 2002[1]. To provide similar opportunities at Brigham Young University, a two-semester Global Engineering Outreach (GEO) course was established in 2007. Students in this course come from a variety of engineering and technology programs, making the course truly interdisciplinary. For example, one team may include students from chemical engineering, electrical engineering, and industrial design. The course is designed to give the students real-world design capabilities and an international service experience on a scale commensurate with the 3-credit hour course. Because of this, one project may be redesigned for several years in a row. Subsequent years are often dedicated to system and product improvements. Projects have been implemented in Tonga, Ghana, and Peru with over 200 students participating over the years. Communities within Peru have been the focus since 2009.

The GEO course, with an emphasis on the design of small-scale projects, typically involves four teams of five members each. Students in the course, many of whom speak Spanish fluently, regularly interact with the Peruvian communities during the two-semester design process. Projects address needs identified by the community leaders and are identified during the implementation trip prior to the academic year in which the projects are developed. During the course, students are involved in concept generation, prototyping, and design reviews. A 16-day implementation trip occurs during the first part of May following project development in the two-semester course. Previous publications related to the course have discussed training internationally responsible engineers[2], sustainability and impact[3], integration of sociology and engineering[4], GEO course insights[5], and social connectivity between students and communities[6].

Sustainability is an important aspect of implementing projects in the developing world. There are three pillars of sustainable development- economic growth, environmental stewardship, and social inclusion.[7] Although not explicitly stated in the three pillars, effective product design is important towards achieving sustainability. Nine principles for effective design for the developing world have been have been identified.[8] Several of the principles include: 1) co-designing with people from the developing world, 2) testing the product in the actual setting, 3) developing technology within the appropriate developing world context, and 4) using project management techniques adapted to the developing world context. In addition to the nine principles, documentation of the design process is critical for design projects that have aspirations for social change.[9] Basically, process documentation enables a team to reflect, analyze, and improve the ongoing project. “Documentation … supports the process itself … and looks at the change of the process through the eyes of those involved in it”.[9] Thus, without good documentation, the design process and project sustainability could be compromised.

The focus of this paper outlines a recently implemented project documentation strategy associated with the GEO course and implementation trip to help strengthen project sustainability. The documentation strategy focuses mainly on the sustainability pillar of social inclusion and implements several of the nine principles by incorporating the following: 1) documenting communication that fosters co-design between students and the community, 2) reporting on the testing in an actual setting, 3) identifying the societal and technical constraints to provide context for the design, and 4) incorporating milestones and tasks for project management that includes societal interactions. Effective documentation is important since projects are designed by students who generally only work on the projects for a single academic year. Course instructors may change as well, but the documentation can assure that there is continuity from one year to the next. Thus, effective documentation is critical for project sustainability, allowing for future students and instructors to assess past community engagement efforts, identify community engagement challenges, maintain information of past societal and technical design constraints, access concepts and prototypes previously assessed, and review videos documenting community and project information. Documentation also serves as a method to convey information to course instructors for evaluation, to help students see the big picture in their design, and recognize what parts may need more development or testing for robustness.

This paper addresses the recently implemented (2015-16) documentation strategy used in the GEO course in which the documentation is updated and submitted three times each semester and one time following the implementation trip, leading to a large database for all implemented projects. The desire was that this database would be used by existing teams to help in the design process. Prior to 2015-16, documentation was still required but not to the same extent. The current documentation is composed of (1) Project Management, (2) Communication, (3) Technical and Social Constraints, (4) Concept and Prototype Development, (5) Project Design (6) Finances, and (7) Project Implementation & Assembly/Instruction Manuals. A description of each section as well as its intended use is below. In addition, this paper addresses assessment related to the effectiveness of the documentation process.

Project Documentation

(1) Project Management: A basic project schedule with milestones throughout the two semesters and tasks specific to the project is updated with each submitted documentation report. Thorough task plans are only required to be detailed for the few weeks after each document submission since the project can take a different turn in that time. The team leader is responsible for preparing this section with the team's input. Each successive report adds to the previous schedule. The schedule helps the team to think ahead, plan for the future, and it helps instructors evaluate the direction the project is taking.

(2) Communication: Each week, project teams are required to contact a representative from the Peruvian community with which they are working. A contact log is utilized to document the process. The contact log is a gold mine of information for future project teams since students list who they contacted, identify the contact method (phone, email, text, etc.), and specify whether or not the contact answered. Each team typically has two fluent Spanish speakers who participate in calls or emails. To facilitate discussion and maintain a focus on project development, a list of questions categorized by subject material is also continually updated with responses. Recorded answers provide a wealth of information such as basic questions (such as "When is the best time to call?") and social information (such as who will use the product, or what clothing the people wear that may be caught in a machine, etc.).

(3) Technical & Social Constraints: Student teams create constraint tables for both technical and social aspects of their projects. Constraint tables define the limitations and scope of the project. Technical constraints mostly include measureable limitations to the function of the final product, such as size, weight, temperature, flow rate, etc. Table 1 is a sample of a technical constraint table for developing a fish smoker. Social constraints can also be measurable, but generally have human components to them, such as the average height of the person who will use the product or how much time the final design product takes to build.

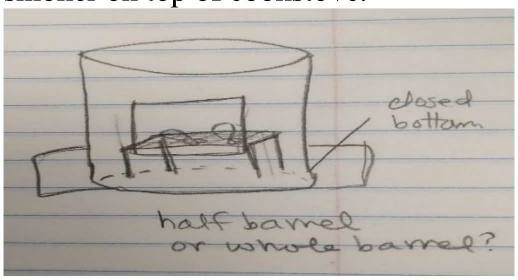
For both constraint tables, teams are encouraged to work with the communities and other reliable resources to provide an ideal value or range of the constraint. Initially, many of the ideal ranges may be guesses but progress is expected towards identifying reliable sources and ranges for each constraint. The numerical values are expected to change throughout the two semesters, as each team learns more about what is required for a successful outcome and what is physically possible with the resources they have available. Constraint tables also provide information for future teams to see what requirements the project had and how the team obtained the measurements.

Table 1: Technical Constraint Table

Constraint	How measured?	Units	Ideal Value or Range	Source of Ideal Value or Range	Current Value	Date Updated
Temperature	Thermometer	deg F	above 180 F	Ford's Locker	230 F	11/5/16
Height	Tape measure	meters	Guess	1-1.5	3 meters	11/5/16
Air flow	Anemometer, flange size opening	m^3/s	trial and error	varies depending on food	No long pursuing	11/10/16
Time required to cook	Clock	hours	Lindaura	1 hour	Fish: 45 mins Turkey: 90 mins	11/5/16

(4) Concept & Prototype Development: As the project progresses, teams develop concept ideas and physical prototypes to demonstrate and test the viability and performance of the product or components of the product. Teams are required to document each concept and/or prototype with a sketch or photo, a written description, and an evaluation of that concept. This helps future teams know what ideas have been generated in the past as well as the thought process behind why the concept/prototype was used or rejected. It also provides a database of ideas for future teams to work from, which prevents having to regenerate those same ideas. This saves significant time and allows a team continuing a project in a following year to move forward from where the last team left off. An additional benefit of this documentation is that teams working on other projects may glean some ideas from concepts previously used. Table 2 shows an example of concept and prototype documentation for a fish smoker.

Table 2: Concepts and Prototypes

Concept/Prototype	**Description/Evaluation**
1. Testing concept: using top half of barrel smoker on top of cookstove.  	**Date:** 11/8/16 **Description:** Half barrel with closed bottom and door on top of cookstove **Evaluation:** This is a potential idea. We want to see how high we need the meat away from the heat source in order to successfully smoke it (rather than just cooking the meat). We will test the idea by using our current "bullet smoker" on top of the cookstove.
2. Grill-top Smokebox 	**Date: 11/10/16** **Description:** Grill-top smokebox. Chips go on the bottom and tray separates the meat from the chips. **Evaluation:** The distance between the fish and the heat source was too small. The fish was basically baked instead of smoked, and the alder chips gave it a little bit of flavor. This is a good prototype, but the distance from the heat source and the fish needs to be increased.

(5) Project Design: Each project team is required to provide a complete description of the final design for their product. These descriptions include pictures with labeled parts, detailed written explanations of how parts function and work together, and safety aspects. Key dimensions are also provided with CAD Models and part drawings. Final design descriptions must also be supported with significant testing results to demonstrate robustness. The documentation for the first semester is expected to have significantly less detail for this section than the final documentation for the second semester since the design progresses throughout the process. The project design is also updated following the implementation trip. The Project Design description is key information for anyone involved with the final product, from the people using it in Peru, to the students who may need to make updates or improvements the following year, to the professors evaluating the project. This is how the design information is transferred and sustained through the following years.

(6) Finances: Project teams are required to track and report on prototype and testing expenditures throughout the two-semester class. Student must also create a Bill of Materials for the final product to estimate what it will cost and then ultimately document what it costs to build in its final design. All financial information becomes more detailed as the project progresses throughout the two semesters and the implementation trip.

(7) Project Implementation & Assembly/Instruction Manuals: Project Implementation and Assembly/Instruction Manual Documentation are only required just prior to the implementation trip—with an update following the trip. Project Implementation is the plan that the students create for how they will spend their time building and testing the project once the teams arrive in Peru. This plan includes such items as time spent purchasing & modifying materials purchased, and time spent building and teaching Peruvians how to build, use, and maintain the final product. Each student has particular tasks assigned to them so that the project can be completely implemented while the team is in Peru. Assembly & Instruction Manuals are written in both English and Spanish and must be simple enough for the Peruvians to follow and use so they can fix parts if something breaks as well as know how to use the product correctly. These manuals also help future project teams know how to create the same product and how it should be used properly.

In addition to written documentation, student teams are also required to record their work on the project with a 10-minute video which they create while they are in Peru, and then compile and edit once they return from the trip. The video includes: (1) Introduction of project by the team, (2) Introduction of people in Peru who worked with the team, (3) Panorama of all important aspects of the area in Peru where the project was implemented, (4) Phases of the construction of the project, (5) Finished project with explanation of how it works, where it is implemented, appropriate dimensions, and any other information that would be appropriate for someone not familiar with the project to know, and (6) Closing comments, including challenges faced. Additional video is also recorded to help identify cultural aspects and places that may be valuable for students participating in successive years.

Document Management

All documentation and videos are stored on a secure server at Brigham Young University. Access to the server is given to course instructors and students taking the current course. Since numerous videos are recorded beyond the required 10-minute video noted above, additional videos are categorized during the summer to provide a more efficient method for future teams to review the videos as needed. These videos are particularly helpful for students who work on improvements and/or other aspects of a continuing project or for students in general to get a feel of the Peruvian communities where they will work. The use of videos eliminates an expensive aspect of having students travel to a location prior to project development. Fortunately, many students from previous GEO projects are also available to meet with teams in the GEO course to help facilitate the transition each year. As for sharing the documentation beyond the class members, efforts are planned to provide opportunities to share the documents beyond the secure server once privacy information is removed. It should be noted that the new required documentation following the implementation trip typically covers 80-100 pages, thus providing a very extensive coverage of the project. Videos for each team are typically several hours long.

Assessment

The new documentation strategy described above requires an extensive collection of information throughout the semester, particularly for answering questions, identifying constraints, and developing and evaluating concepts and prototypes. Table 3 shows a summary from the most recent semester (19 students) of how often students utilized an information source for their design.

Of particular note is that 63% of students relied heavily on contacting Peruvians a few times or more during the month (most were through phone calls). Additional data (not shown) showed that each time students called, 46% of the calls resulted in no answer or a busy signal, 19% of the calls resulted in conversations that did not impact the design but still provided information, and 34% of the calls resulted in conversations that impacted the project design. As expected, students relied heavily on the internet, GEO instructors, and class TA (who had participated the year before). To substantiate the importance of past documentation, nearly half of the students also utilized previous GEO written reports many times throughout the month, although some students never or rarely accessed the reports. It is unclear from the assessment as to whether some students did not access the reports because other students on the team were assigned to read the reports. Interestingly, the videos were not regularly utilized. This could be that video documentation has recently been initiated but that the videos have not been extensively categorized to this point.

Table 3. Utilization of Information

Information Source	**Never or rarely**	**Once a month**	**A few times a month or more**
A phone call with a contact in Peru	10.5%	26.3%	63.2%
An email from a contact in Peru	42.1%	47.4%	10.5%
Reports written about other GEO class projects	36.8%	15.8%	47.4%
The Internet	0.0%	5.3%	94.7%
Videos of Peru	47.4%	47.4%	5.3%
Instructors	0.0%	0.0%	100.0%
The Geo Class TA	15.8%	42.1%	42.1%
Other groups in the GEO class	42.1%	42.1%	15.8%
NGOs operating in Peru	94.7%	5.3%	0.0%
Students who previously took the GEO class	21.1%	57.9%	21.1%
Other Peruvians or returned missionaries at BYU	84.2%	10.5%	5.3%
Other faculty	57.9%	26.3%	15.8%
Others in the Utah area	84.2%	15.8%	0.0%

Since the new documentation strategy was initiated in the 2015-16 course, it was beneficial to assess how past documentation was utilized by teams. Table 4 provides insights as to the use of past documentation from students participating in the course during the last three years.

Students in the 2014-15 and 2015-16 course had to rely on previous documentation that was not as extensive as the newly implemented documentation strategy described in this paper. The earlier documentation included project management but not as much detail on goals, communication without detailed documentation of every call, technical and social constraints, project design, instruction manual, and a general article about the implementation trip. Key aspects that were missing included detailed communication information, concept and prototype development, and finances. Thus, the earlier documentation had less details and essentially no information about what concepts and prototypes were tested but not implemented. Students in the 2016-17 year were the first students to have the extensive documentation. As shown in Table 4, the past documentation was utilized more often by the 2016-17 students. This suggests that the new documentation strategy is much more effective in helping students in the design process.

Table 4. Utilization of past documentation.

Year	**Other**	**Once a month**	**A few times a month or more**
2014-15	38%	31%	31%
2015-16	23%	50%	27%
2016-17	37%	16%	47%

Although Tables 3 and 4 showed that students were accessing past documentation reports, it was important to assess how helpful past reports (using the latest documentation strategy) were in the project design. Only 2016-17 students were assessed since they were the only students that had access to past reports that used the latest documentation strategy (i.e. reports from 2015-16 students). Table 5 summarizes the student responses as to how helpful each section of past documentation reports has been in the project design with (1) representing not helpful and (5) representing very helpful. For ratings of (3) or higher, more than 75% of students felt that technical constraints, socials constraints, and concept and prototype development were the most helpful. It is likely that these sections of past projects had the greatest impact since they are the main components of the design process and could provide ideas and guidance for current projects. As noted by the higher percentages of (1) responses, past project designs, finances, and instruction manuals had less impact for several students. This may be that these sections were primarily related to the final design and not the design process. In general, Table 5 shows that students valued past project documentation towards helping with current projects.

Table 5. Assessment of past documentation helpfulness.

Document Section	**1**	**2**	**3**	**4**	**5**
Project Management	15.8%	21.1%	36.8%	15.8%	10.5%
Communication	15.8%	21.1%	36.8%	15.8%	10.5%
Technical Constraints	10.5%	10.5%	26.3%	26.3%	26.3%
Social Constraints	10.5%	15.8%	21.1%	31.6%	21.1%
Concept and Prototype Development	10.5%	15.8%	21.1%	31.6%	21.1%
Project Design	26.3%	5.3%	10.5%	36.8%	21.1%
Finances	21.1%	10.5%	15.8%	36.8%	15.8%
Instruction Manual	31.6%	5.3%	15.8%	31.6%	15.8%

Since part of the recent documentation strategy was also developed to keep the students focused on their current project, students were asked how well each section kept them focused on the design process. Table 6 summarizes the results with (1) representing not helpful and (5) representing very helpful. As shown, all sections helped keep the students focused on the project with project management and technical constraints providing the greatest focus. The instruction manual seemed to have the least focus although this part of the documentation is not completed until a few weeks before the implementation trip.

Table 6. Effectiveness of Document Sections on design focus.

Document Section	1	2	3	4	5
Project Management	0.0%	5.3%	5.3%	52.6%	36.8%
Communication	0.0%	10.5%	31.6%	36.8%	21.1%
Technical Constraints	0.0%	0.0%	5.3%	52.6%	42.1%
Social Constraints	0.0%	10.5%	26.3%	42.1%	21.1%
Concept and Prototype Development	0.0%	0.0%	31.6%	36.8%	31.6%
Project Design	11.1%	0.0%	16.7%	38.9%	33.3%
Finances	5.3%	5.3%	42.1%	31.6%	15.8%
Instruction Manual	16.7%	5.6%	22.2%	33.3%	22.2%

Finally, it was important to assess the difficulty in documenting each section. Table 7 summarizes the student responses with (1) representing very difficult and (5) representing very easy. Looking at (1) and (2) responses, it is evident that the technical constraints, social constraints, and instruction manual were the most difficult sections to document. The constraints were likely harder to document because they involved the least student control; students had to rely on outside help for identifying the constraints. On the other hand, less than 10% of students chose (1) or (2) for communication, concept and prototype development, and finances. Students had greater control in the latter two areas since these sections relied more on the application of knowledge. As for communication, all students felt that the communication section was not hard. This is the only section that did not have responses in the (1) or (2) categories. This aspect shows that students felt comfortable documenting both their questions and interacting with the Peruvians during phone calls.

Table 7. Ease of documenting each section

Document Section	1	2	3	4	5
Project Management	0.0%	26.3%	42.1%	21.1%	10.5%
Communication	0.0%	0.0%	47.4%	31.6%	21.1%
Technical Constraints	10.5%	31.6%	31.6%	21.1%	5.3%
Social Constraints	21.1%	21.1%	26.3%	21.1%	10.5%
Concept and Prototype Development	0.0%	10.5%	42.1%	26.3%	21.1%
Project Design	5.6%	22.2%	33.3%	27.8%	11.1%
Finances	5.3%	5.3%	15.8%	31.6%	42.1%
Instruction Manual	11.1%	44.4%	33.3%	5.6%	5.6%

Finally, the effectiveness of calling Peruvians to help with the design process was assessed. Students were asked as to what percent of changes in the product design were driven by feedback from a variety of constituents. The survey showed that 19 ± 15 % change was driven by the Peruvians, 15 ± 7 % change was driven by the internet, 29 ± 6 % change was driven by the team members, 20 ± 8 % change was driven by the course instructors (who had significant experience with the communities), 7 ± 9 % change was driven by previous GEO students, and 9 ± 5 % change was driven by design reviews. It is clear that team members contributed to most of the change. However, communication was reasonably effective in enabling Peruvians to contribute to the design process throughout the course.

Conclusions and Future Work

Effective documentation is critical for strengthening program sustainability. Data presented on the new documentation strategy shows that the more extensive documentation was useful for obtaining information from past projects and generally kept students focused on their current design. Project documentation was harder for some sections, specifically sections over which students had less control. With regards to communication, students were able to communicate on a regular basis with Peruvians and the Peruvians were able to make some contributions during the project design process. Program sustainability is critical since students in the GEO course change each year. Extensive documentation of projects as described in this paper has enabled students in successive years to draw on information from past projects.

As for future documentation opportunities, enhancing video documentation, utilizing sociology students to better document the societal context for future students participating in the course, and strengthening community project documentation for projects implemented the following year are current priorities. Since students starting a project each year have not interacted with the community, the videos can potentially provide greater sustainability in community relationships, project development, and cultural understanding. Sociology students will also be traveling with the GEO students this coming year to enhance the video documentation and provide a greater social context related to the projects. Efforts will also be extended to have the community have greater participation in documenting projects that will be implemented for the coming year. Finally, the documentation strategy will be continually assessed to strengthen the documentation towards continually improving project sustainability.

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