Assessing Student Design Work in Social Entrepreneurship Projects

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Introduction

Increasingly, engineering educators challenge students to develop designs for people living in poverty. These educators may have commitments to teach sustainable community development,[1] desire to tackle challenges posed by designing *for the other 90 percent*,[2] design for real human problems,[3] use grand challenges as a means to develop social responsibility,[4] or expand students' opportunities to undertake global design.[5] Moreover, engineering educators use design-centered pedagogies like service-learning[6,7] and entrepreneurial technological incubation[2,5,8] to develop professional engineering competence and to support students' efforts to create products for people living in poverty. The students in these courses undertake holistic forms of design, frequently devising strategies for social enterprises so their designs can reach the intended population. In this paper, I discuss how engineering design educators can align their assessment of student work with essential components of social entrepreneurship.

Social entrepreneurs establish social businesses. Social businesses are viable business ventures where businesses adopt a social mission. These businesses seek to deliver economic, social, and environmental benefits, deriving value using metrics like the "triple bottom line."[9] Therefore, social entrepreneurship is one pathway by which communities can meet wellbeing objectives. Theorists differ on how social businesses should be evaluated. Some strategists evaluate the ability of social businesses to capture market share of the large emerging consumer class found in countries like India and Brazil. These strategists[10,11] speak of finding "the fortune at the Bottom of the Pyramid" and target consumers earning less than 4USD/day. Other strategists[12] evaluate the ability of social businesses to alleviate poverty. These strategists argue businesses focused on meeting people's needs can create a world without poverty. Social entrepreneurs position their businesses within larger social systems to encourage large-scale positive social change.[13] In this paper, I seek to improve engineering design instruction and assessment by integrating theoretical frameworks of wellbeing[14-16] developed within international development scholarship. These theoretical frameworks are especially well suited for assessing student design work in social entrepreneurship projects because they can be generalized across many contexts.

Understanding Theoretical Frameworks of Wellbeing

Definitions of wellbeing fundamentally explore the relationship between what a person has, what a person wants, and what a person chooses to do. Many international development practitioners working to improve wellbeing look to the writings of Amartya Sen.[17] As an economist, Sen[18] argued that assessing whether an individual could derive full benefits from her or his income necessitated considering individual diversity. Sen demarcated individual diversities that arose from five factors: 1) personal heterogeneities: disparate physical characteristics associated with disability, illness, age, or gender, 2) environmental diversities: different climatic conditions and available natural resources, 3) variations in social climate: access to public goods and differing amounts of social capital, 4) differences in relational perspectives: effects of wealth distribution within communities, and 5) distribution within the family: how income gets allocated to meet needs of income earners and non-income earners.[18] Sen's early work on wellbeing established definitions at the individual level, whereas the later work of scholars attached to the *Voices of the Poor*[19] project and the *Wellbeing in Developing Countries* project[15] created community-based wellbeing frameworks for development professionals.[16]

Although Sen had previously integrated wellbeing into broader development discussions of technology choice[20] and famines,[21] wellbeing entered international development discussions after the World Bank *Voices of the Poor* project.[19] The researchers engaged in this participatory project needed to define poverty in local languages. They began to realize that poverty is principally a state of ill being mediated by various factors. This project created a definition where *wellbeing*, or "the good life," consisted of material sufficiency, bodily health, social connectedness, security, and freedom to make choices about one's actions.[19] Later theoretical frameworks of wellbeing built upon this holistic multi-dimensional understanding of poverty and defined poverty as the *systematic failure to achieve wellbeing objectives*. Unlike other instrumental definitions of poverty like an income below an established national poverty line, the wellbeing definition arose from a large-scale participatory process with people living in poverty.

Current wellbeing frameworks consider many distinct wellbeing outcomes. Individual aspirations and cultural goals frequently complement each other as people try to achieve wellbeing objectives.[22] Researchers conceptualize wellbeing along three dimensions: the material, the social, and the human.[16] All dimensions incorporate objective and subjective assessments. Theoretical frameworks of wellbeing offer structure when analyzing multi-dimensional poverty by acknowledging the complex interplay between individuals and society. Because theoretical frameworks of wellbeing acknowledge the complex interplay between individuals and society, these frameworks can help inform pedagogical content knowledge needed to teach engineering students social entrepreneurship if these research frameworks can be translated into an accessible structure for engineering educators.

Translating Theoretical Frameworks of Wellbeing for Purposes of Design Assessment
I have begun translating theoretical frameworks of wellbeing by defining the critical components of *design to improve the quality of life*. These components may help educators create strong learning scaffolds to help students manage the complexity of designing for people living in poverty.[23] I found engineering design educators[24, 25] who used reflection to identify learning needs of their students developed these stronger scaffolds intrinsically. Furthermore, I wanted to offer guidance to engineering educators assessing student work that targeted marginalized communities around the world. *Design as improving the quality of life* has four components.
   1. Design activities center on wellbeing objectives.
   2. Critical knowledge to understand wellbeing objectives rests in diffuse communities.
   3. Designers use social networks to manage design activities.
   4. Assessing designs requires a willingness to observe designs in use.
Below I describe key features of using these four components to assess the quality of student social entrepreneurship projects.

1. Design activities center on wellbeing objectives.
For this component to be addressed properly, students must identify key wellbeing objectives that would improve the quality of life in a community. Some student teams may explicitly describe their motivations or engineering educators assessing student work may make inferences about why students select particular wellbeing objectives. Engineering educators should consider how students identify systematic failure of existing solutions to achieve this wellbeing objective, especially if the research process manages to foster deep discussion within both the immediate

design team and the broader community. Asking "What wellbeing objectives are designers trying to help a community achieve?" may encourage more thorough analysis of values that motivate design activities. Particular wellbeing objectives undergird the expressed social mission of social enterprises and inform strategies for social innovation.[9, 12, 13]

2. Critical knowledge to understand wellbeing objectives rests in diffuse communities.
Identifying wellbeing objectives requires gathering information within the target community of users. The international development scholars who have pioneered the wellbeing definition argue for participatory methods that involve diverse stakeholders within the community.[16, 19, 26-29] Theoretical frameworks of wellbeing position individuals within local, regional, national, and global communities. As such, these theoretical frameworks acknowledge that different communities help individuals achieve wellbeing objectives because communities can provide public goods. Social businesses need to help develop the public goods of market infrastructure and well-integrated supply chains in order to become successful enterprises.[9-12, 30, 31] Engineering educators assessing student work should consider how student teams gathered information about their target community. Student teams should show evidence of exploring how the community tries to meet key wellbeing objectives while actively reflecting on other potential solutions in order to develop successful designs.

3. Designers use social networks to manage design activities.
This component reiterates Chamber's[27] question of "Whose reality counts?" Engineering educators can look at how students construct their definition of the problem. Do the students consider the expertise of the people living in poverty when defining the problem?[19] Moreover, engineering educators can ask how student teams interact within different communities. Specifically, student teams frequently negotiate access to particular communities, partner with relevant experts, manage provided financial and manufacturing resources, and try to understand potential users of the team's solution.

4. Assessing designs requires a willingness to observe designs in use.
When conceiving of *design as improving the quality of life*, proof lies in successfully implemented designs. Any designed solution should improve people's ability to achieve their wellbeing objectives. Engineering educators should consider asking questions about technical feasibility, cultural appropriateness, and incomplete aspects of proposed solutions. Evaluations can focus on the likelihood of whether people can more easily achieve a particular wellbeing objective, whether more people have capability to achieve a particular wellbeing objective, or whether the design removes structural obstacles that block achieving a particular wellbeing objective. Professionals attempting to alleviate poverty should be wary of always seeing the "success" of their projects.[26] New cook stoves or solar-powered lanterns will never, of their own accord, eradicate poverty. The same technology can have markedly different impacts in different social environments.[32] The success of an innovation needs to be evaluated within a complex social landscape.[8]

Research Question
In this paper, I ask the following research question: "How can the components of *design as improving the quality of life* be used to assess social entrepreneurship projects?" Specifically, I

hope to demonstrate how this framework can support better student learning in social entrepreneurship courses.

The Data Set
The data used in this paper came from the Milking the Rhino Innovation Showcase. The Humanitarian Engineering and Social Entrepreneurship Program at Penn State sponsors the showcase as a way to reward high quality student work. Students work in teams to propose a solution that can alleviate poverty in Africa, describing their solution in a 3 minute YouTube video pitch. The engineering educators who designed the showcase[33] take inspiration from the *Milking the Rhino* documentary; this documentary features the Maasai and Himba tribes in Africa proposing and implementing solutions to problems faced by the tribe. Judges at Penn State evaluate these videos along several criteria and award prizes to the most promising solutions. The Milking the Rhino Innovation Showcase maintains a playlist of all student videos for each year of the contest. All videos are publicly available for 2009, 2010, and 2011.

In this paper, I analyze five videos from the 2011 Milking the Rhino Innovation Showcase. These videos received the top monetary awards available. I selected these videos because the original judges thought these videos best responded to the challenge of the Milking the Rhino Innovation Showcase. The Milking the Rhino Innovation Showcase has five learning domains: 1) Appreciation of Indigenous Knowledge, 2) Ethics Education, 3) Non-Travel Based Global Experience, 4) User Centered Design, and 5) Frugal Innovation and Entrepreneurship.[33] The use of the *Milking the Rhino* documentary to foster student learning in these five domains suggests components of *design as improving the quality of life* will serve as a productive assessment tool.

Methods
To analyze these five student videos, I used discourse analysis. Researchers using discourse analysis must rely on highly structured forms of reading[34] to ensure rigorous data analysis. During the first reading cycle, the researcher explores the content and structure of a selected text. This reading can involve exhaustive detail, discussing textual components like typography or completing a thorough inventory of photographic elements. I created a transcript of each three minute video, describing what was happening in each section of the video, following Durmaz[35] and Russel.[36] Once a researcher feels confident he or she has captured key details of the text, the researcher moves to the second reading cycle and prepares a document summary. During the third reading cycle, the researcher reflects on what the text means. Parker[34] uses three questions to guide the third reading cycle: 1) What different meanings are at work in the text? 2) How are these meanings constructed? and, 3) What are these contradictory systems of meaning doing? I then performed thematic analysis[37] using the critical components of *design as improving the quality of life* with an eye to locating sites of student misconceptions. In this paper, I further ground my discussion within the original learning outcomes of the innovation showcase.

Summary of Results
I selected five videos that performed best in the Innovation Showcase. Each of these teams won at least $500 for their effort. The Johnson and Johnson Company sponsored two $1000 awards focused on recognizing high-quality Supply Chain and Health Care solutions. The videos detailed the following solutions:

1. Vision Driving Visions: delivering low-cost eyeglasses to rural farmers (Supply Chain Solution Winner)[a]
2. Pennsylvania Schools for Uganda Sister Schools Program: empowering American and Ugandan students to create health education resources around the world (Health Care Solution Winner)[b]
3. The Reservoir Studio Ceramic Water Filter: improving access to clean water with household-level water purification (Best Overall Pitch)[c]
4. Electronic Waste Jewelry: recycling an abundance of electronic waste through creating jewelry for an international market (Most Innovative Solution)[d]
5. Affordable Greenhouse: expanding the ability of smallholder farmers to grow cash crops year round by providing an appropriate greenhouse (Most Sustainable Business Model)[e]

All five videos used a standard engineering argument[38] of defining the problem, outlining specifics of the solution, and creating a business model. Some teams included a statement of their current progress realizing their solution. In the following sections, I use the components of *design as improving the quality of life* to analyze the student projects.

Design activities center on wellbeing objectives.
All five student teams focused their activities on clear problems. The problems these teams addressed include:
1. Improving vision with corrective lenses
2. Reducing the burden of diarrheal disease through changing hand washing behaviors
3. Increasing access to clean drinking water
4. Providing an alternate route for electronic waste
5. Creating a greenhouse capable of meeting the needs of smallholder farmers

The first three problems relate to improving healthcare. Professional engineers working in marginalized communities frequently design solutions related to water and sanitation.[39-41] Engineering students may gravitate towards health-related wellbeing outcomes because of physical health's clear connection with wellbeing,[42] the general visibility of health-related solutions in appropriate technology organizations,[43] and the widespread acknowledgment of improving access to clean water as an engineering challenge.[44] Additionally, students in the Milking the Rhino Innovation Showcase may have intentionally steered their design toward health care solutions owing to Johnson and Johnson sponsoring a $1000 award in this category.

The last two problems relate more directly to increasing income of people living in poverty. In the fourth problem, students redefine electronic waste as an abundant resource. The resources of discarded electrical components can be transformed into highly desirable luxury jewelry. Many Fairtrade stores operate under the pretense that customers will pay a premium for handicrafts produced in the developing world.[45] The Penn State student team plans to locate vendors who

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[a] Vision Driving Visions pitch: http://www.youtube.com/watch?v=qkv6yytoJ6I
[b] PSU Sister Schools pitch: http://www.youtube.com/watch?v=Fn0lsyJKQR8
[c] Reservoir Studio pitch: http://www.youtube.com/watch?v=wubmNiSl4fE
[d] E-Waste Jewelry pitch: http://www.youtube.com/watch?v=s9xenzao3hc
[e] Affordable Greenhouse pitch: http://www.youtube.com/watch?v=cZGmy1Qv_Kc

will sell the jewelry produced by the Kenyan students. Money from jewelry sales will go back to Kenya to fund educational advancements. The last problem wants to increase agricultural productivity of smallholder farmers, which is a common approach in development.[46] Farmers should be able to generate more income if they can harvest during alternate cropping seasons.

The electronic waste problem warrants further discussion as this problem highlights difficulties students may have in connecting a clear technical problem to a wellbeing outcome. The students spend the first minute of their pitch describing why the volume of electronic waste threatens to overwhelm capacity of Kenyan landfills. In the students' narrative, electronic waste itself poses a threat to Kenyans. Even though the students feature several images of trash scavengers, the students seemingly do not make the connection that people living in poverty use trash scavenging as a way to increase their income.[47] The students know that electronic waste must be handled carefully, indicating their awareness of health hazards posed by working with electronic waste. The students presume that precious metal jewelry will always be desirable to consumers. If the Penn State student team had framed the problem in terms of youth unemployment, shifting materials available to trash scavengers, or as a fair trade enterprise to direct benefits from international trade back to marginalized communities, then the student team may have reconsidered key aspects of their solution.

Critical knowledge to understand wellbeing objectives rests in diffuse communities.
Three of the five student teams discuss gathering information within their served community. The team behind the Pennsylvania Schools for Uganda Sister Schools traveled to Uganda on a research trip to test the suitability of their Tippy Tap hand washing technology. The Penn State students advocating for electronic waste recycling conducted training workshops at a youth center in Kenya and brought jewelry samples back after the trip. The team creating the affordable greenhouses has spent three years designing and field-testing their concept in Kenya and Tanzania. Additionally, Reservoir Studios discloses their connection with Center for Youth and Children's Empowerment in Kenya. Yet even these few observations should raise some concerns to the engineering educators responsible for the Milking the Rhino Innovation Showcase.

The first issue of concern is that the engineering educators want to provide a non-travel based global experience.[5] If three out of the five winning teams plainly discuss their global travels, then other students may see travel as a requisite part of doing well during the showcase. The one team who did not expressly cite travel, Vision Driving Visions, framed their narrative using an image of a vision-impaired smallholder farmer who accidently planted corn instead of the more drought-resistant sorghum. Incorporating personas can encourage engineering students to take a more user-centered design approach to problems faced by marginalized communities.[23, 24, 48]

The second issue of concern is less readily apparent. Listening carefully to the students presenting their solutions, many projects have been developed over several years. Students took reasonably well-developed prototypes and training materials with them when they traveled to the various countries. By waiting until a team had a reasonably developed prototype, the students undercut best practices in participatory design[49] and user-centered design.[50] Students could manage to develop these prototypes by relying on external authorities to define problems. Specifically, the winning teams of the Milking the Rhino Innovation Showcase cited statistics about vision impairment, diarrheal disease, illnesses attributed to unsafe drinking water,

electronic waste, and food scarcity. Students used the statistics as a way to argue the presence of a legitimate problem. Relying on expert-defined problems can lead to counter-productive professional behaviors in developing countries[26, 51, 52] and can foster design arrogance in engineering students[23] and in engineering professionals.[8] Since the engineering educators behind the Milking the Rhino Innovation Showcase want students to practice user-centered design, the educators might reflect on how to help students recognize community-defined problems.

Designers use social networks to manage design activities.
Videos receiving awards in the 2011 Milking the Rhino Innovation Showcase indicate students have awareness of the need to build relationships. The Vision Driving Visions team received the award for the best supply chain solution. In their video, the team stressed a unified supply chain in which manufacturers based in Kenya partnered with trained prescribers and small retailers to ensure that rural farmers had access to prescribers and retailers near them. Team Tippy Taps argued that strong relationships between Pennsylvania schools and Ugandan schools had potential to empower children as global health educators. The Reservoir Studio team identified the need to have a local manufacturer for their ceramic water filters and highlighted an emerging partnership with the Center for Youth and Children Empowerment in Kenya. The team behind electronic waste jewelry conducted workshops with students the Center for Youth and Children Empowerment in Kenya and is networking with jewelry vendors in Reading, Pennsylvania. The students working on the affordable greenhouses have spent considerable time, energy, and effort in field-testing their design in Kenya and Tanzania. These students have started to establish partnerships with local agro-business enterprises, technology transfer companies, social venture capital providers, educational institutions, and development organizations connected to their targeted communities.

While all projects display some awareness of relational complexity, the project on affordable greenhouses displays evidence of necessary relationship building for the innovation to be successful. The students have actually field-tested their designs in two countries, getting feedback from farmers and suppliers. Notably, the students included some of this feedback in their three-minute video pitch. Students identified that PVR piping used in plumbing could be repurposed as the support structure and are exploring the potential to replace the greenhouse-grade plastic with repurposed rice sacks. Additionally, this student team has pursued diverse partnerships in order to make their business dream a reality. The team has partnered with prospective end users of the greenhouses, potential suppliers, and diverse organizations capable of providing business capital. By positioning their solution in a complex network of actual organizations, the student team displays commitment to realizing their situation.

The engineering educators attached to the Milking the Rhino Innovation Showcase may benefit from reflecting on how they present the importance of relationships to students. Engineers trying to alleviate poverty manage complex relationships with diverse stakeholders.[8, 43, 53] All five videos showed students defining problems with statistics while building relationships to advanced team-designed solutions. Student teams brought in a number of significant assumptions related to the quality of their social networking. These assumptions affect different aspects of the design cycle. Vision Driving Visions assumed that rural farmers would be willing to see a Kenyan prescriber. Team Tippy Taps assumed that health education material designed by students in a different country could change hand-washing behaviors. Reservoir Studios assumed

the Center for Youth and Children Empowerment could produce their ceramic water filter. The electronic waste team members assumed they could find vendors in Reading, PA interested in selling electronic waste jewelry. International aid donors frequently make assumptions that limit their effectiveness in implementing new business models.[31]

Assessing designs requires a willingness to observe designs in use.
Because the innovations proposed by students in the Milking the Rhino Innovation Showcase are early-stage innovations, engineering educators should not assess these innovations by measuring their impacts in targeted communities. Rather, engineering educators should consider the quality of student research about existing solutions, evidence of building viable relationships, and feasibility of the proposed solution helping the targeted populations improve their quality of life. Specifically, engineering educators may benefit from familiarizing themselves with the successes and failures of the Appropriate Technology movement,[43, 54] assorted business models trying to reach people living in poverty,[11, 12, 55] and best practices to partner with people living in poverty.[26-28, 56-58] Engineering educators may also have connections to improve the quality of a particular design team's network.

Engineering students can default towards replicating common appropriate technology approaches like ceramic water filters and solar cookers.[2, 23, 43] Moreover, engineering students, like professional engineers working within marginalized communities,[8, 32, 53] can make cultural assumptions that drastically limit building viable relationships. Engineering students erroneously assume that drastically different cultures have a high degree of similarity.[59] For example, the Pennsylvania Schools for Uganda project assumes that Ugandan students can make sense of health education materials prepared by their American counterparts and vice versa. Sanitation practices can have widely different cultural meanings.[53] Lastly, many solutions can look plausible until evaluating the feasibility of different components. A particular technology creates a system around manufacture, use, and distribution of those technologies. The team creating affordable greenhouses worked over three years to integrate farmer feedback. Additionally, several teams field-tested their prototypes in the country to gain feedback about the requisite technological systems. However, these teams may overlook key technical details as evidenced by the fact that Team Tippy Taps did not address how they planned to get safe water for their hand washing system.

Implications
In this paper, I have assessed the final design deliverable of five student design teams using the components of *design as improving the quality of life*. I reviewed which problems student teams selected, how student teams gathered information, and with whom student teams partnered while raising critical observations of using user-centered design. Using this framework as an assessment tool reveals implications for assessing student designs, identifying student learning outcomes, and structuring learning experiences.

Using *design as improving the quality of life* to assess student designs changes assessment criteria. This framework highlights the importance of respecting people in the targeted communities and building relationships in order to advance prospective solutions. A panel of interdisciplinary judges has previously evaluated these videos, asking questions about the

context, target audience, problem, and solution. The framework of *design as improving the quality of life* asks a different set of questions:
- What is the wellbeing objective you are trying to help people achieve?
- How have you learned about this problem?
- Who are you working with, and why did you decide to work with these people?
- What evidence indicates the feasibility of your solution with the targeted communities?

The different questions shift student learning outcomes away from developing a demonstrative prototype that proves technical concepts towards a more sociotechnical approach. Social businesses need to demonstrate efficacy within communities in order to create viable ventures.[13] Engineering educators should consider structuring learning experiences to provide deeper insights into communities through devices like design personas to help students conceptualize the problems and through explicit discussion of how culture influences people's pursuit of wellbeing objectives.

Engineering students may have several difficulties in identifying appropriate wellbeing objectives. Engineering educators may consider asking students questions about what they, as students, need in order to live well. This reflective exercise should also include components about how various kinds of relationships are needed in order to live well. Without thoughtful engagement around topics like wellbeing objectives, engineering students may gravitate towards commonly assumed problems like clean water and agricultural technologies. Additionally, students may conceptualize problems not clearly connected to livelihoods of people living in poverty. As previously discussed, the team advocating for electronic waste jewelry did not conceive of their problem as trying to increase the income of people working as trash scavengers. Framing the design challenge in terms of helping people achieve wellbeing objectives may expand students' approaches to gathering information as students may perceive people as a more important source of information. Moreover, students might look at alterative systems that enable people to meet wellbeing objectives in other communities. Systems-based approaches can help designers identify relevant and appropriate community partners.

Debrief
Extracting meaningful observations from design artifacts requires that a researcher make conscientious commitment to a framework for analyzing design. All design artifacts have extremely complex elements that invite considerable interpretation. I purposefully chose to analyze design *artifacts* because many engineering design educators assess students by analyzing the artifacts produced by the team. By integrating theories of wellbeing into *design as improving the quality of life*, I had a robust framework to compare the artifacts of five different student teams. This framework translates theoretical frameworks of wellbeing into questions engineering educators can use when teaching about social entrepreneurship.

Video-based data can pose challenges to researchers. In this project, I restricted myself intentionally to working exclusively with the five 3-minute videos. The judges of the Milking the Rhino Innovation Showcase look exclusively at these videos when assigning awards. By working across one 3-minute video from five different teams, I gained some sense of misconceptions shared across teams. These videos suggest that students prefer to gain information from official bodies capable of generating statistics, wait to involve users until the final stages of prototyping, and may have difficulties in building relationships with

organizations. Engineering educators frequently have more information about how student teams proceeded with their work. As a researcher, I typically triangulate my findings with other information about the project. I have observed similar issues in other engineering designers creating solutions for marginalized communities in my previous work,[23, 43] which suggests engineering educators teaching social entrepreneurship may benefit from using more intentional educational interventions to help student teams work collaboratively with communities.

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