Online-Journals.org

iJEP International Journal of Engineering Pedagogy

iJEP | eISSN: 2192-4880 | Vol. 13 No. 4 (2023) | OPEN ACCESS

https://doi.org/10.3991/ijep.v13i4.38477

PAPER

Proposing a Multi-Stakeholder Lens to Examine Global Community-Based Design Projects

Libby (Elizabeth) Osgood(✉), Nick Landrigan, Wayne Peters

University of Prince Edward Island, Charlottetown, Canada

eosgood@upei.ca

ABSTRACT

One implementation of global, community-based engineering-student design projects invites students to engage in remote design practice. While it may not be feasible to physically bring an entire engineering design class to an international location for direct interaction between students and various stakeholders, a meaningful global experience can still be educational and beneficial for all stakeholders involved. Recognizing that the impact of community-based projects extends beyond just the students to numerous stakeholders, this paper proposes a multi-stakeholder lens to examine the roles, interactions, motivations, and responsibilities of stakeholders in a global, community-based design project. The lens was developed, in part, through a case study of a global design project that connected a first-year Canadian engineering design course, a rural Kenyan preschool, a non-profit organization, and additional stakeholders from both Kenya and Canada. The paper, authored by three stakeholders involved in the case study—the course instructor, a Canada-based community partner, and a design student—concludes with recommendations on how to incorporate global projects in a domestic setting. By adopting a multi-stakeholder lens, the focus shifts from being myopically student-centric to an inclusive experience for all stakeholders, fostering partnership in the design process and achieving a broader range of objectives.

KEYWORDS

case study, educational toys, service-learning, stakeholders, inclusive design

1 INTRODUCTION

Before students are introduced to a particular design challenge, instructors make numerous decisions that have lasting implications for the project's outcome. These decisions encompass functional aspects, such as the duration of the project, defined learning outcomes, and the expected project deliverables. A week-long project, for instance, will have different deliverables than a semester-long project, which may include logbooks, reflections, design reports, presentations, participation, and peer reviews. The students' lived experience will also vary based on factors such as team

Osgood, L.E., Landrigan, N., Peters, W. (2023). Proposing a Multi-Stakeholder Lens to Examine Global Community-Based Design Projects. *International Journal of Engineering Pedagogy (iJEP)*, 13(4), pp. 4–20. https://doi.org/10.3991/ijep.v13i4.38477

Article submitted 2023-01-30. Resubmitted 2023-03-04. Final acceptance 2023-03-07. Final version published as submitted by the authors.

size and how the groups are formed, particularly in projects with a longer duration. Once the course-related alternatives have been selected, the design details are defined to determine what the project is actually about. Is there a community partner for students to interact with or someone specific to design for?

In service-learning projects, also called community-based projects, students learn course-related material while simultaneously providing a valuable service to a community organization [1]. Considering the project from a course-centric point of view, the partnership is ideal for engineering design courses, as community partners have authentic challenges that instructors need for students to design. In addition to the technical learning objectives, students gain communication skills, critical thinking, autonomy, self-esteem, and civic-responsibility through community-based projects [2]. Research indicates that student engagement increases when they are involved in authentic design projects as opposed to canned problems [3, 4], and motivation increases further when the project is for a service-learning course [5]. Some students choose to study engineering due to their desire to help others [6, 7], and community-based projects provide an opportunity to cultivate and fulfill this ambition.

Further decisions must be made when selecting a community partner for the project. Considerations include whether the project will be conducted in a local or global setting? Will students engage with the end users or organizations advocating on the users' behalf? Working directly with the community leaders or end users affords more direct relationships for students and engages community members in the solution. However, it is important to note that such partnerships may be less stable [8, 9]. Non-profit or non-governmental organizations, on the other hand, have established ties within the community and previous experience to share [8]. However, as advocates rather than end users themselves, they may provide erroneous data. In the case of global projects, it is crucial to determine how the community's needs will be communicated and how end users can be welcomed as partners rather than recipients of a design.

International educational experiences can be categorized into different types, including: international enrolment, international projects, international work placements, international field-trips, and integrated class experiences [10]. Global projects that involve travel, such as those detailed in [11, 12] fall into the international field trip category, which allow for firsthand experiences and direct relationship with the end user [10]. However, international field trips are time-intensive, cost-prohibitive, and thus, less common than other international experiences. Global projects that do not involve travel, such as those in [13–15], fall into the international project category which has a "shared responsibility to bring a project to a successful conclusion" [10]. To ensure that the designs meets the needs of end users and assess their impact, an implementation trip can be undertaken where students or the advocating organization delivers the design to the end users [8].

As technology access increases in remote, rural areas, the feasibility of projects with international community partners increases. However, additional stakeholders are needed to ensure the success of such projects. The term 'stakeholder' is used to define the myriad people involved in the design project, which extends beyond the people connected to the final product, the design students, and course instructor. Potential stakeholders include the sponsor (advocating organization), end users, expert end users (with expertise in the field), and other stakeholders [16]. In a survey, students perceived interactions with expert end users to be the most significant to their design [16]. However, for global projects, multiple stakeholders should be included to ensure the designs not only meet the end users' needs but are also are sustainable, and the students' needs are met throughout the design process.

A literature review on community engagement in engineering education calls for research in partnerships that facilitate effective community engagement [17]. Also, the needs of the instructors and community partners should be considered in addition to the educational needs of the students [5]. Thus, this article seeks to move beyond the classroom to develop a multi-stakeholder lens to consider the responsibilities, motivations, roles, and interactions of all stakeholders for global community-based design projects, i.e. service-learning design projects between students and end-users who are in different countries.

The multi-stakeholder lens was developed through an examination of a case study involving a global community-based design project. The project connected Canadian engineering students, Kenyan preschool students, Canadian and Kenyan community partners, as well as additional stakeholders in Canada and Kenya. These stakeholders included preschool teachers, parents, manufacturers, university instructors, psychology students, and an early learning centre. This paper will (1) anchor the multi-stakeholder lens in socially-engaged design methodologies, (2) describe the development of the multi-stakeholder lens through a case study, and (3) recommend pedagogical practices for global design projects.

This paper is authored by three stakeholders of the case study: the course instructor, a Canada-based community partner, and an engineering student. By employing the multi-stakeholder lens in future global design projects, it becomes possible to welcome more stakeholders as partners throughout the design process. This approach moves beyond a student-centric view, as presented in the introduction, towards a more inclusive and holistic design process.

2 THEORETICAL FRAMEWORK: SOCIALLY-ENGAGED DESIGN

Socially-engaged engineering recognizes the interdisciplinary nature of design methodologies that consider the user's perspective. It combines engineering principles with elements of social engagement, sustainable community development, humanitarianism, social justice, and peace [18]. The theoretical framework of the multi-stakeholder lens is comprised of socially-engaged design methodologies, including humanitarian engineering, design-for-justice, user-centered design, empathetic-design, and community-based learning. While some of the methodologies are engineering-specific, such as humanitarian engineering, others have a broader application across multiple domains, such as community-based learning.

Humanitarian engineering is focused on community development and capacity building, which is accomplished through partnering with the community for long-term solutions "that are respectful of the community itself, its people, and its environment" [18]. The level with which the partners are incorporated in community-based learning varies by project, with limited partner involvement in some projects. Humanitarian engineering ensures community partners are respectfully heard [6] and is at the intersection of sustainable community development and engineering [9]. While technical details can be the emphasis of many design projects, in humanitarian engineering, the emphasis is to design for socio-cultural realities [20] and the "human element" [21]. Students situate themselves in a global reality, recognizing their social responsibility, connectedness, and sustainability [7].

Design-for-justice incorporates steps to decolonize the need/help paradigm inherent in many design-for-charity methodologies [22]. Traditional service-learning projects are steeped in the history of colonialism, which can create an "other-ing" effect by providing help to communities that are perceived as "disadvantaged" [22].

In contrast, design-for-justice requires students to critically examine their power and privilege, recognize the design knowledge and practice of the community partners, include community partners in decision-making, and identify structures of inequity [22]. Design-for-justice empowers the community partners and requires stakeholders to work towards decolonization and fostering more equitable design practices.

Much of community-based learning research is focused on the student [17], and because the learning objectives are a major focus of the projects, the student becomes the customer instead of the community being supported [22]. User-centered design shifts the focus to the needs of the end user rather than the designer themselves [24]. User-centered design also reorients students' focus from the design itself to the person they are designing for, from object-based to people-focused.

Empathetic design is a "human-centered" design approach that emphasizes all stakeholders involved in a design [25]. Empathetic-design looks beyond the end user that is the focus of user-centered design [24], and is a methodology used in conjunction with community-based design. When paired, community-based design and empathetic design broaden the number of stakeholders in a design project and thoroughly consider the perspective of each throughout the project.

Design methodologies are continuously evolving in response to pedagogical and societal advances. At their core, socially-engaged design methodologies aspire to support community development while providing students with learning opportunities. These methodologies form the theoretical framework of the multi-stakeholder lens. The next section of the paper presents literature on how to inclusively engage community partners, which serves to inform and shape the multi-stakeholder lens.

3 BACKGROUND RESEARCH: BEST PRACTICES FOR COMMUNITY PARTNER INVOLVEMENT FOR GLOBAL PROJECTS

Involving community partners throughout the design process can be challenging due to the rigidity of the academic calendar and ill-defined definitions of their roles [17]. Global projects can necessitate a community partner who advocates on the international stakeholders' behalf. To embrace the role of community partners in design projects where advocacy organizations are involved, stakeholders should have a shared vision of the organization's values, collaborate with internal and external stakeholders, and regularly meet to ensure community desires are being considered [19].

Students are challenged in meetings with other stakeholders to ask the appropriate question and interpret the responses, particularly when they are from different cultural backgrounds [16]. While this presents an opportunity for growth and interpersonal communication skills, students can disengage. Similarly, if a project is too complex or conflicting information is received, students may shift from human-centered design to product-centered design [16]. Fostering reflection in students can help them to shift focus to other stakeholders [23]. Community partners should be the "driving force with a vision of partnering with engineering students" [26, 17]. If community partners are passionate and students resonate with the organization's mission, they will be less likely to disengage.

Recommendations drawn from a literature review of 49 papers in [27] highlight the importance of involving a local community partner and engaging local resources and expertise. These practices contribute to increasing the number of stakeholders

with whom students directly interact. Similar reasoning would suggest finding ways for global community partners to be more directly engaged. Furthermore, a literature review focusing on factors that impact the success of projects [8] summarized 49 factors into five categories: institutional support and logistics, community interaction, student preparation, design and technical, and implementation trips. These categories provide valuable insights for understanding the key areas that influence project outcomes. Students' ability to calculate the amount of time required for tasks can be limited [4], necessitating a thoughtful structuring of the schedule based on the students' experience with design projects and maturity. Focusing on the community interaction, factors that can benefit projects include having a long-term relationship with the community, involving community members in the design process, testing the product in the community, having multiple contacts in the community, and consistent communication. The guiding principles found in the literature can be synthesized as fostering a respectful, long-term relationship with the community partner, engaging multiple stakeholders, and involving stakeholders in decision-making. The next section of the paper will present the methodology used to develop the multi-stakeholder lens.

4 METHOD

The multi-stakeholder lens was developed to encourage and assist design instructors with planning projects that are more respectful and inclusive of stakeholders, in alignment with the recommendations from the literature. This lens comprised of a set of questions designed to facilitate an examination of the roles, interactions, motivations, and responsibilities of each stakeholder involved. By doing so a comprehensive understanding of how each stakeholder contributes to the global community-based design project is obtained. To develop the lens, an unstructured evaluation of a case study was performed retroactively by three stakeholders: the course instructor, a Canada-based community partner, and an engineering student. Through a post-hoc, unstructured, informal process, the insights gathered from this evaluation, along with a reflection from an additional engineering student, and background research, were synthesized into the criteria and questions of the multi-stakeholder lens. This synthesis was carried out by one of the stakeholders, specifically the Canada-based community partner who has experience as both a design instructor in Canada and a community development partner in Kenya. In the paper, the case study will be presented first, followed by the introduction of the lens itself.

5 CASE STUDY: EDUCATIONAL TOYS FOR KENYAN PRESCHOOL STUDENTS

5.1 Reflection on stakeholders in a case study

Rather than using student-centric language such as "design problem," which implies there is a specific problem for students to solve, the project description is to design educational toys for preschool children in rural Kenya. It is important to recognize that each design project possesses unique characteristics and challenges. In the case of this project, there are several complicating factors to consider. These include using materials available near the remote preschool, developing long-term

sustainable solutions, and maximizing the limited storage space in the preschool. The description is framed in a cultural context that differs from the dominant culture of the engineering students. Additionally, the preschool utilizes three languages: Kimeru, Kiswahili, and English, and the age of the Kenyan preschool children could be up to 10 years old, which is older than Canadian preschool children. Lastly, the lack of direct communication between the engineering students and preschool students impacts the engineering students' understanding of the challenge. This is due to the limited technological access and language barriers, which hinder the engineering students' understanding of the specific challenges and needs faced by the preschool children. The project began in February 2014 and concluded in February 2017, marked by the delivery of transportable prototypes to the preschool. The prototypes that were too large to be transported, were donated to an early learning centre in Canada. Additionally, students enrolled in a developmental psychology course at the same Canadian university prepared educational lesson plans to accompany the toys, enhancing the educational value of the project.

During the evaluation of the case study, the first step was to identify the stakeholders: Canadian engineering students and Kenyan preschool students, the Canadian course instructor and Kenyan teacher, and the Canadian community partner and partners on the ground (Kenyan community partners). Casting a wider net, additional stakeholders identified as integral to the project: parents of preschool students, manufacturers near the preschool, psychology students, and an early learning centre in Canada.

Next, the motivations for each stakeholder to participate in a global community-based design project were examined and are presented in Table 1. In a student-centric project, the evaluation can be limited to the assessment of learning objectives or whether the final design solves the problem. Rather, socially-engaged design necessitates identifying the various stakeholder motivations, developing project objectives, and evaluating whether all stakeholder objectives are satisfied.

Table 1. Stakeholder motivations

Stakeholder	Objective/Motivation
Engineering students	Learn how to design
Preschool students	Desire fun toys
Course instructor	Engineering students accomplish learning objectives through community-based project: • Ability to perform analysis • Document information in reports, logbook, and presentation • Develop understanding of design process • Develop civic responsibility
Canada-based community partners	Increase awareness of the organization, support the preschool, and easily transport the final product
Partners on ground (Kenya-based community partners)	Increase awareness of their community and support the preschool
Preschool teacher	Desire toys that are educational, safe, and easy to transport as there is no storage at the preschool
Parents of preschoolers	Want children to be educated
Manufacturers near preschool	Betterment of community
Psychology students in Canada	Learn developmental psychology skills
Early learning centre in Canada	Desire toys that are educational and safe

The following project objectives were synthesized from the stakeholder motivations:

1. Create safe, educational, and transportable toys with accompanying lesson plans
2. Support community and preschool children's learning in Kenya and Canada
3. Raise awareness of Canadian organization and Kenyan community
4. Meet engineering student learning objectives to develop technical communication, analysis, civic responsibility, and understanding of the design process
5. Collaborate globally on a common goal

Next the roles and responsibilities for each stakeholder were examined and are shown in Figure 1. A delineation of the tasks and responsibilities provide clarity, particularly for a global project with many stakeholders sharing the overall responsibility.

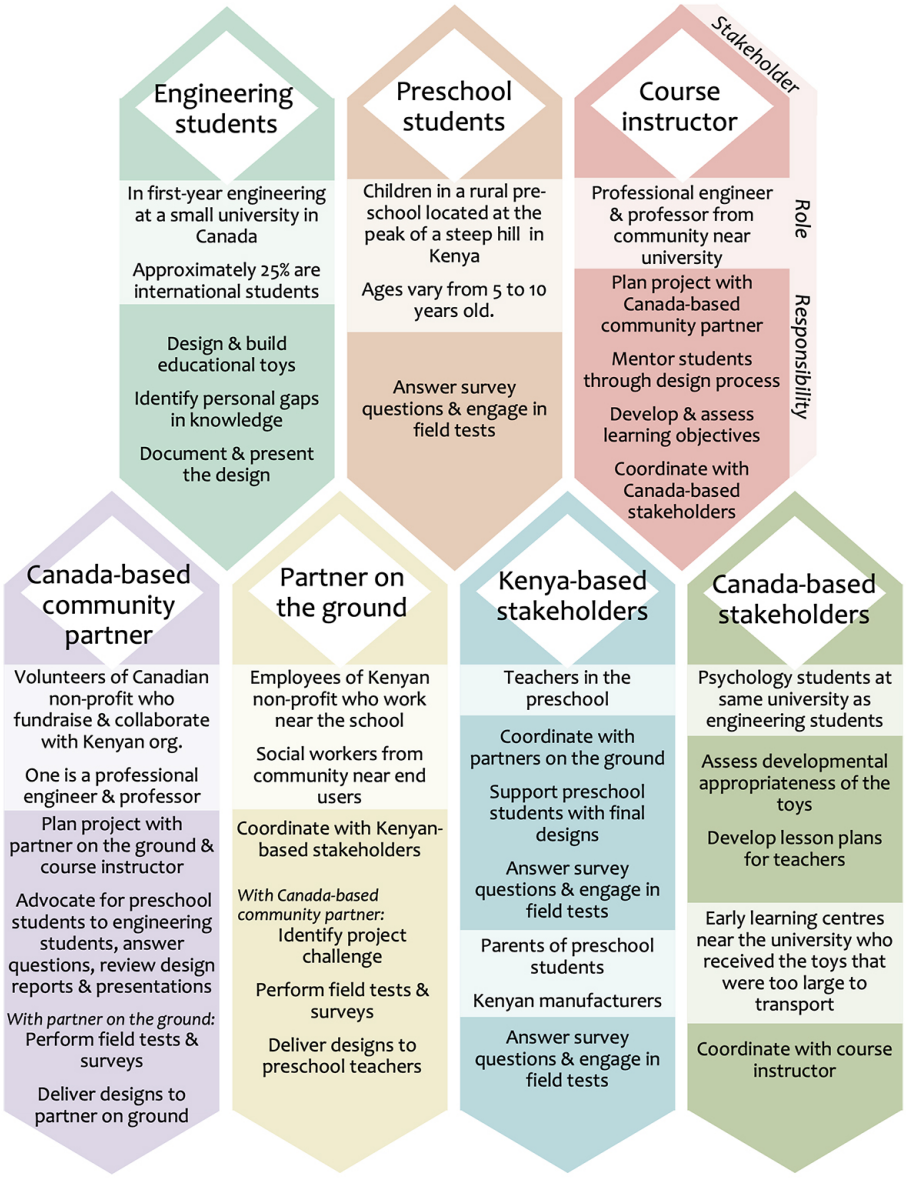

Fig. 1. Stakeholder roles and responsibilities

The expansive geographic project sites necessitated the mapping of stakeholders interactions, including lines of communication, as shown in Figure 2. The Venn-diagram in the background of the map indicates the location of the stakeholders: the Kenyan community, Canadian community, and Canadian engineering class. Although two of the locations are within Canada, insight can be gained by further delineating these sites. The placement of the stakeholders within the three circles visually demonstrates their travel patterns, with the color of each stakeholder box identifying their primary location. For example, the Canada-based community partner travels to both Kenya and the engineering classroom, but their primary location is within the Canadian community. In Figure 2 solid arrows represent the primary lines of communication, while dashed arrows indicate infrequent direct communications, which are generally facilitated by the connecting stakeholder. For example, the preschool teachers and Canada-based community partner typically interacted through the Kenyan partners on the ground, but they also had direct communication at key stages of the design. It is important to note that this mapping is intended to clarify communication and interaction rather than restrict them.

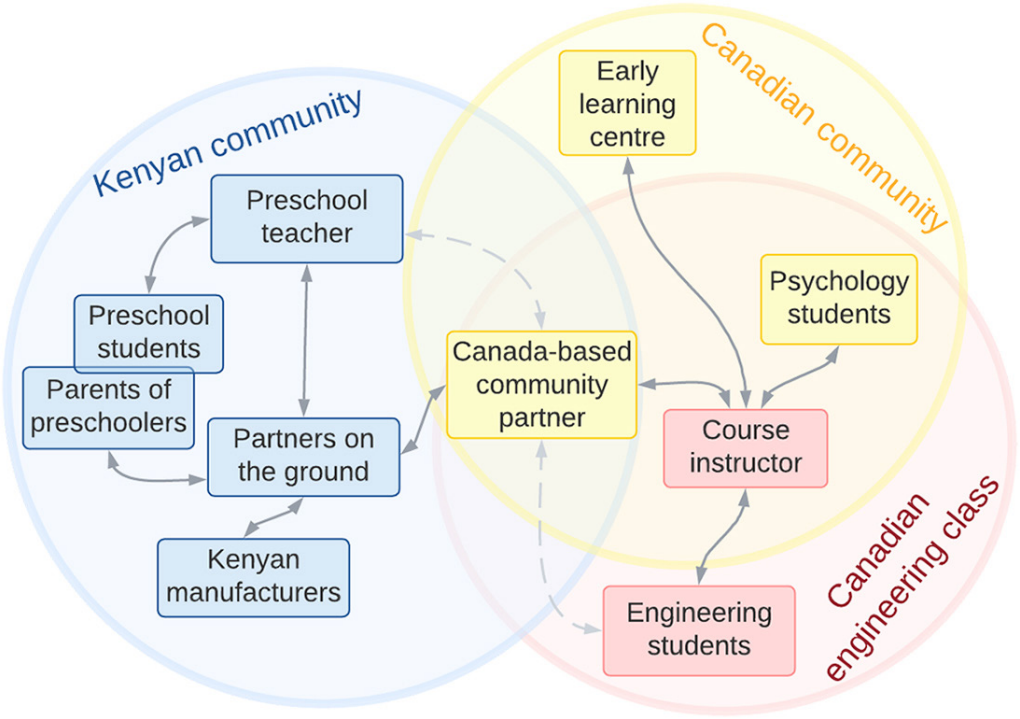

Fig. 2. Stakeholder mapping and lines of communication

Next the stages of the project were taken into account, and a timeline was developed, as displayed in Figure 3. Global design projects often have an extended timeline due to the need for early coordination between community partners and instructors, as well as infrequent trips to the international location for data collection or prototype delivery. While the engineering students perceived the design project's duration as five months, it actually spanned three years for community partners. Key stages include:

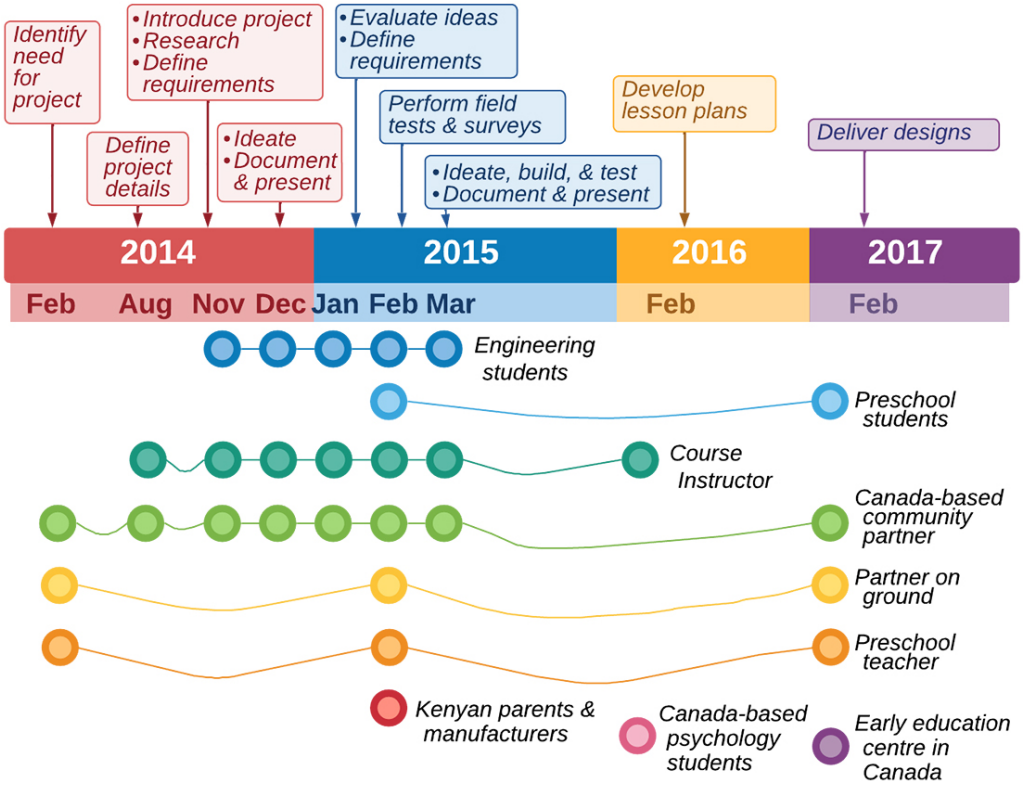

Fig. 3. Project timeline showing stakeholder involvement within each major task

In February 2014 in Kenya, the teachers, partners on the ground, and the Canada-based community partner identified the need for the educational toys. In August 2014 in Canada, the instructor and Canada-based community partner defined the project details.

In November 2014 in Canada, engineering students were introduced to the global project by the Canada-based community partner followed by a Q&A session. The engineering students then worked in groups of three to perform research on various aspects of the educational level of preschool students, the Kenyan curriculum, available local resources, and the cultural context in the international setting. In December 2014, the Canada-based community partner received technical reports from the engineering students, which contained research, requirements, and initial ideas. A formal design presentation was held, facilitating the exchange of information and feedback between the Canada-based community partner and the students.

In January 2015, the engineering students started a new semester and reorganized into new teams from the newly shuffled sections. They evaluated the ideas generated during the previous semester using qualitative and quantitative assessment techniques. They then adapted the evaluation criteria into project requirements.

In February 2015, the Canada-based community partner facilitated an opportunity for the stakeholders to connect during their trip to Kenya. The engineering students prepared surveys for Kenyan teachers, parents, and manufacturers to gather quantitative and qualitative information about the capabilities and interests of the preschool students. Recorded videos were used to capture interviews with Kenyan stakeholders and field tests where preschool students interacted with the toys. After returning to Canada, the Canada-based community partner provided the collected data and answered questions based on the new information. Additionally,

the engineering students performed a reverse engineering project to evaluate educational designs and strengthen their analytical abilities.

In March 2015, the engineering students performed a final round of ideation, constructed prototypes, and tested their designs. They showcased their educational toys at an end-of-year engineering exposition, presented them in a design report, and participated in a formal presentation alongside the Canada-based community partner.

In February 2016, the course instructor shared the educational toys and design reports with a developmental psychology class at the same university. Psychology students then developed lesson plans to accompany the toys when they were sent to Kenya.

In February 2017, the community partners delivered the transportable toys that met the design requirements to the preschool teachers in Kenya. The toys that met safety requirements but were not transportable were shared with an early learning centre located near the Canadian university.

The final stage of examining the case study involved evaluating whether the project objectives were achieved. Objectives 1 and 2 were fulfilled through the successful delivery of safe, educational toys and lesson plans to both the Kenyan preschool and the Canadian early learning centre. Informal feedback from teachers and end users confirmed that the designs were satisfactory. However, conducting a more formal evaluation after the toys were used in the preschool would have provided a more accurate assessment. Due to the significant time gap between the design and delivery of the toys, the feedback received was not useful to aid the learning of engineering and psychology students, as they had completed the courses associated with the project. However, in order for stakeholders to truly be partners, it is important not to assume the efficacy of the designs and instead feedback should be elicited to ensure the project objectives are met from all stakeholder perspectives. Objective 3, which focused on increasing Canadian awareness of the organization and Kenyan community, was accomplished through various channels. Regional media attention, the involvement of engineering students and their spheres of influence, the developmental psychology class, the early learning centre, and attendees at the end-of-year exposition in Canada all contributed to the heightened awareness. The student learning outcomes, as outlined in objective 4, were evaluated by the instructor for each student. This assessment was based on design reports, test reports, presentations, and analysis reports. The final objective, which aimed to foster global collaboration was successfully met through the pedagogical design of the project. Though more interactions between stakeholders is always desirable, people worked together across continents to help preschool students.

The next section contains a reflection by one of the authors from their experience as a first-year engineering student. Coupled with the review of the case study, the reflection provides data on interactions with stakeholders and how that informed the design.

5.2 Reflection on experience

Working on a global project provides an opportunity for first-year students to develop skills that will benefit them throughout the duration of their Engineering program. While most first-year students may not have developed the technical skills required to solve complex problems, global projects offer a design experience that can be brought to completion and help cultivate important skills. These skills enable first-year students to address the complex problems they will face in later years.

Reflecting on the project, skills such as client communication, research, and working within set constraints were all very pertinent and are required for every other project throughout engineering curriculum.

The initial ideas that were brainstormed were primarily based on the materials and replicability of the toys. The educational considerations for each idea were quite different and included math, spelling, and musical abilities, which aligned with activities that each individual team member enjoyed. These ideas derived from the first communication with the international community partner, who emphasized financial, material, and space constraints. There was considerable uncertainty as to whether the ideas would be suitable for preschool students, which was an important factor as the team wanted to develop something that would be enjoyable, educational, and interesting enough to be used repeatedly. This demonstrated motivation and engagement in the project illustrating an advantage of working on a project that involves real clients.

The next revision of the ideas was based on video footage taken by the community partner, showing the preschool students actively engaging with some of the items that were brought over. This provided information for the team to further develop the ideas and gain confidence in selecting one idea to proceed with. The selected design is a game called "Blocks" that was developed from an initial concept of a dice rolling game. During the field tests, it was observed that the preschool students were playing with Jenga blocks, but they were not strictly following the rules of the game. This observation helped the team understand the specific interest levels of the preschool students in certain types of activities. The Blocks game, as shown in Figure 4, were made of light weight wood and were developed to be modified by the manufacturers to incorporate the recommended educational content suggested by the school teachers.

Fig. 4. Design of blocks

As more information provided to the team, we gained a deeper understanding of the limitations that were provided at the start of the project. One of the most

challenging aspects was determining the most beneficial educational topics to be incorporated into the games, as this information was not readily available on the Internet. This project provided us with a valuable learning experience to understand the importance of asking the right questions to obtain the necessary information for a successful project outcome.

The next section of the article will discuss the multi-stakeholder lens for global design projects.

6 MULTI-STAKEHOLDER LENS FOR GLOBAL COMMUNITY-BASED PROJECTS

The proposed multi-stakeholder lens for global community-based design projects, synthesizing the unstructured process from the case study review, reflection, and literature, is shown in Figure 5.

Fig. 5. Multi-stakeholder lens for global community-based design projects

The lens can serve as a planning tool for project development after identifying a design challenge or as a retroactive guide for reflection and evaluation of a design project. The lens is comprised of six criteria accompanied by guiding questions, following the structure of the case study. These questions aim to stimulate conversation or facilitate reflection on various aspects of the project.

7 DISCUSSION AND LIMITATIONS

The multi-stakeholder lens is offered as a tool for both planning and evaluation purposes, in the context of socially-engaged design methodologies. A key characteristic of global community-based projects is the active engagement of stakeholders as partners, shifting away from a student-centric focus. Admittedly, it is acknowledged that the tool was developed exclusively by the Canadian stakeholders, and it would have been more advantageous to inclusively involve Kenyan stakeholders in reflecting on the case study. For future design experiences, it is recommended to employ the lens from the project's outset and document the perspectives of all stakeholders throughout the process, ensuring a more comprehensive and inclusive approach. This discussion presents pedagogical recommendations derived from the case study that are important to consider when planning global design projects.

From a student-centric perspective, in order for engineering students to produce designs that address the complexities and specific context in which the design will be implemented, they need to understand the setting in which the design will be used. To achieve this consistent communication is essential to understand the community needs [8]. However, in global projects where the stakeholders themselves may not be able to directly communicate with students, conveying the information becomes a significant challenge. With increasing access to technology, it is ideal for engineering students and international stakeholders to have direct communication channels, facilitated through community partners, enabling effective collaboration and understanding.

When it is not possible for the engineering students to interact with the international stakeholders, the community partner located near the university is responsible for 'setting the scene' and conveying the context. At a minimum, this community partner should have extensive experience in the project community and maintain regular communication with the partner on the ground to clarify any questions they cannot address on their own. It is vital for this community partner that they identify their limitations in presenting the information as well as acknowledge their own positionality in relation to the project. The design project should derive from stakeholders in the international community, and the community partner near the university should understand the details well-enough to convey to the engineering students. Having multiple community partners share their experiences can supplement gaps of knowledge, though direct communication with international partners is ideal.

As highlighted in the student reflection, the connection to the international stakeholders through the surveys and field tests developed the engineering students' understanding of the project, albeit through an indirect communication. The ideas presented after the information exchange were more comprehensive in addressing the problem compared to the designs presented earlier in December 2014. If direct communication between stakeholders had been possible, it is interesting to consider whether designs could have been further improved.

Assuming that the context of a global project is different from engineering students' lived experience, the complex challenges require spending time understanding the stakeholders' needs instead of the tendency to jump to ideation. For example, designing educational toys in multiple languages that are interesting for preschool children aged five to ten requires more thoughtful understanding than searching for preschool toys from a nearby store. If the project setting was near the university, the material availability and need to transport designs would be less constraining, and engineering students may be tempted to jump to ideation without fully understanding the needs of preschoolers. Thus, global projects invite human-centered design approaches, where the focus is on emphasizing with the stakeholders and designing solutions that truly meets their needs.

Before a global project begins, there are several complicating factors that must be negotiated. The timing must align between community partners' travel plans and the academic calendar. The complexity of the project scope must align with the learning objectives for the course and abilities of the engineering students. The availability of materials for the design may be limited to what is available in the international community, and the challenge could be extended to include the requirement of manufacturing the designs within the community. In this case study, the engineering students were constrained in terms of materials but not the manufacturing methods. This allowed them to gain knowledge in using programmable laser cutters and advanced manufacturing techniques. A local project may have fewer constraints.

When data gathering is required, engineering students are reliant upon the community partners to execute the field tests and surveys. The community partners must determine how to transfer data in remote locations with limited access to Internet, acquire information requested by engineering students (whether documents, pictures, or video), and perhaps ask questions not on the survey should have been. Additionally, global projects often require a longer timeframe as compared to a local project. This necessitates coordination and planning. Examining complicating factors through a multi-stakeholder lens can ensure stakeholders are considered through the project as partners, rather than recipients of the design, which contributes to a more inclusive project.

Through the process of writing this paper, the authors realized that choice of descriptors for stakeholders was student-centric. Initially, terms like 'local' and 'international' were used to describe the community partners, which unintentionally created an 'other-ing' effect. Similarly, the preschool students were referred to as 'end users,' implying a passive role as recipients of the design rather than active partners. Despite an attempt to be more inclusive, community-based design projects fall back to being student centric [17, 23]. While many aspects of the project need to be considered from students' perspective to ensure that the learning objectives are met, a multi-stakeholder lens ensures the perspectives of stakeholders are also included, and thus the language was revised throughout.

8 CONCLUSION

Using a multi-stakeholder lens, a successful global project goes beyond solely focusing on student learning objectives and involves stakeholders as active partners throughout the process. This begins by recognizing and welcoming all of the stakeholders into the planning process. Next, stakeholder motivations should be clearly communicated at the beginning of a project and converted into objectives, which are evaluated throughout the project. The roles and responsibilities

for each stakeholder should be clearly defined, along with establishing clear lines of communication and interactions between them. The timeline should then be considered keeping in mind all the stakeholders and possible opportunities for communication.

While a global project has more complications than a local project, they offer valuable opportunities for stakeholders to develop global citizenship and foster collaboration towards a shared goal, connecting people across vast distances. Whenever possible, direct communication between stakeholders becomes instrumental in effectively conveying the specific needs of community members to the engineering students. Being aware of student-centric processes and language allows for a reframing of the project, incorporating socially-engaged design methodologies. Incorporating a multi-stakeholder lens can ensure all people involved in the design are able to achieve their objectives while being respected as partners throughout the project.

9 ACKNOWLEDGMENT

The authors are grateful for the time that the stakeholders invested in the project and for the support of the administration, faculty, and staff who supported the global project. With particular gratitude to Ted Grant for his collaboration as a community partner on many projects and the teachers, parents, and students at Thuuri Preschool.

10 REFERENCES

[1] M. Lima and W. Oakes, *Service-learning: Engineering in your community.* Okemos, MI: Great Lakes Press, 2006.

[2] A.-P. Castro and A. Dapena, "Service-learning projects in university degrees based on sustainable development goals: Proposals and results," *Sustainability*, vol. 12, no. 19, pp. 1–23, 2020. https://doi.org/10.3390/su12197940

[3] M. Frank and C. Roeckerath, "Augmenting mathematics courses by problem-based learning," *International Journal of Engineering Pedagogy*, vol. 6, no. 1, pp. 50–55, 2016. https://doi.org/10.3991/ijep.v6i1.5368

[4] R. Wood, A. McGlashan, C.B. Moon, and W.Y. Kim, "Engineering education in an integrated setting," *International Journal of Engineering Pedagogy*, vol. 8, no. 3, pp. 17–27, 2018. https://doi.org/10.3991/ijep.v8i3.7857

[5] D. Budny, L. Lund, and R. Khanna, "Designing service learning projects for freshman engineering students," *International Journal of Engineering Pedagogy*, vol. 3, no. S1, pp. 31–38, 2013. https://doi.org/10.3991/ijep.v3iS1.2371

[6] A.R. Bielefeldt and N.E. Canney, "Humanitarian aspirations of engineering students: Differences between disciplines and institutions," *Journal of Humanitarian Engineering*, vol. 4, no. 1, pp. 8–17, 2016. https://doi.org/10.36479/jhe.v4i1.43

[7] J.J. Park, M. Park, and J. Smith, "Engineering students' concepts of humanitarian engineering and their identity development as humanitarian engineers," *Sustainability*, vol. 13, no. 16, pp. 1–14, 2021. https://doi.org/10.3390/su13168845

[8] A.G. Armstrong, C.A. Mattson, and R.S. Lewis, "Factors leading to sustainable social impact on the affected communities of engineering service learning projects," *Development Engineering*, vol. 6, p. 100066, 2021. https://doi.org/10.1016/j.deveng.2021.100066

[9] A. Mazzurco and S. Daniel, "Socio-technical thinking of students and practitioners in the context of humanitarian engineering," *Journal of Engineering Education*, vol. 109, no. 2, pp. 243–261, 2020. https://doi.org/10.1002/jee.20307

[10] G.L. Downey, et al., "The globally competent engineer: Working effectively with people who define problems differently," *Journal of Engineering Education*, vol. 95, no. 2, pp. 107–122, 2006. https://doi.org/10.1002/j.2168-9830.2006.tb00883.x

[11] R.M. Camus, C.H.Y. Lam, G. Ngai, and S.C.F. Chan, "Service-learning exchange in developed cities: Dissonances and civic outcomes," *Journal of Experiential Education*, vol. 45, no. 4, pp. 453–476, 2021. https://doi.org/10.1177/10538259211065971

[12] B. Dick, T.S. Nguyen, and M. Sillem, "Field school for first-year engineering students," In *Proceedings of the Canadian Engineering Education Association (CEEA) Conference*, June 18–21, 2020, Montreal, QC, Canada. https://doi.org/10.24908/pceea.vi0.14185

[13] A. Ndubuisi and J. Slotta, "Using global virtual teams to support a sustainability mindset in engineering education," In *Proceedings of the Canadian Engineering Education Association (CEEA) Conference*, June 20–23, 2021, Charlottetown, PE, Canada. https://doi.org/10.24908/pceea.vi0.14920

[14] N. Ibrahim and A. Van Beek, "Global classroom: A case study in online learning on sustainable cities," In *Proceedings of the Canadian Engineering Education Association (CEEA) Conference*, June 9–12, 2019, Ottawa, ON, Canada. https://doi.org/10.24908/pceea.vi0.13862

[15] J. Membrillo-Hernández, W.J. Cuervo Bejarano, L.A. Mejía Manzano, P. Caratozzolo, and P. Vázquez Villegas, "Global shared learning classroom model: A pedagogical strategy for sustainable competencies development in higher education," *International Journal of Engineering Pedagogy*, vol. 13, no. 1, pp. 20–33, 2023. https://doi.org/10.3991/ijep.v13i1.36181

[16] I. Mohedas, K.H. Sienko, S.R. Daly, and G.L. Cravens, "Students' perceptions of the value of stakeholder engagement during engineering design," *Journal of Engineering Education*, vol. 109, no. 4, pp. 760–779, 2020. https://doi.org/10.1002/jee.20356

[17] M. Natarajarathinam, S. Qiu, and W. Lu, "Community engagement in engineering education: A systematic literature review," *Journal of Engineering Education*, vol. 110, no. 2, pp. 1049–1077, 2021. https://doi.org/10.1002/jee.20424

[18] K. Litchfield and A. Javernick-Will, "'I am an engineer and': A mixed methods study of socially engaged engineers," *Journal of Engineering Education*, vol. 104, no. 4, pp. 393–416, 2015. https://doi.org/10.1002/jee.20102

[19] B. Amadei, R. Sandekian, and E. Thomas, "A model for sustainable humanitarian engineering projects," *Sustainability*, vol. 1, no. 4, pp. 1087–1105, 2009. https://doi.org/10.3390/su1041087

[20] A. Arshad-Ayaz, M.A. Naseem, and D. Mohamad, "Engineering and humanitarian intervention: Learning from failure," *International Journal of Humanitarian Action*, vol. 5, no. 7, pp. 1–14, 2020. https://doi.org/10.1186/s41018-020-00073-5

[21] A. Sheroubi and G. Potvin, "Humanitarian engineering: A new interdisciplinary course on the application of engineering skills to local and global humanitarian challenges," In *Proceedings of the Canadian Engineering Education Association (CEEA) Conference*, June 3–6, 2018, Vancouver, BC, Canada. https://doi.org/10.24908/pceea.v0i0.12963

[22] B. Reynante, "Learning to design for social justice in community-engaged engineering," *Journal of Engineering Education*, vol. 111, no. 2, pp. 338–356, 2021. https://doi.org/10.1002/jee.20444

[23] C.H. Birzer and J. Hamilton, "Humanitarian engineering education fieldwork and the risk of doing more harm than good," *Australasian Journal of Engineering Education*, vol. 24, no. 2, pp. 51–60, 2019. https://doi.org/10.1080/22054952.2019.1693123

[24] J. Walther, S.E. Miller, and N.W. Sochacka, "A model of empathy in engineering as a core skill, practice orientation, and professional way of being," *Journal of Engineering Education*, vol. 106, no. 1, pp. 123–148, 2017. https://doi.org/10.1002/jee.20159

[25] C. Zoltowski, W.C. Oakes, and M.E. Cardella, "Students' ways of experiencing, human-centered design," *Journal of Engineering Education*, vol. 101, no. 1, pp. 28–59, 2012. https://doi.org/10.1002/j.2168-9830.2012.tb00040.x

[26] A. Bielefeldt and M. Lima, "Service-learning and civic engagement as the basis for engineering design education," In *New Innovations in Engineering Education and Naval Engineering*, N.M.S Hassan and S.A.N Lousada, Eds. London: Intechopen, 2020, pp. 17–36. https://doi.org/10.5772/intechopen.83699

[27] A. Mazzurco and B.K. Jesiek, "Five guiding principles to enhance community participation in humanitarian engineering projects," *Journal of Humanitarian Engineering*, vol. 5, no. 2, pp. 1–9, 2017. https://doi.org/10.36479/jhe.v5i2.80

11 AUTHORS

Libby (Elizabeth) Osgood, CND, PhD, PEng was the Canada-based community partner for the project. She teaches Sustainable Design Engineering and is the Engineering Success Centre Coordinator at the University of Prince Edward Island, 550 University Ave, Charlottetown PE, C1A 4P3, Canada.

Nick Landrigan was the student author for the project and graduated with a degree in Sustainable Design Engineering from the University of Prince Edward Island in 2022. He is currently working for Charlottetown Metal Projects (CMP) in PEI, Canada.

Wayne Peters, Ph.D, P.Eng was the instructor for the course and is the Interim Dean for the Faculty of Sustainable Design Engineering at the University of Prince Edward Island, 550 University Ave, Charlottetown PE, C1A 4P3, Canada.