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Unlearning Abundance: Jugaad and the Decolonization of Engineering Education, a Case Study in Tanzania

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1. Introduction

In the summer of 2024, a group of engineering students from universities in the United States (US) and Tanzanian (TZ) arrived in Kasisa, a small village in rural Northwestern Tanzania, to build a sustainable toilet system as part of a collaborative humanitarian engineering initiative. Co-design*,* the process of engineers and community members sharing the work of problem-framing and solving (Gahlot et al., 2024; Gazulla et al., 2020), was the guiding praxis underlying both the broader engineering initiative and the specific sustainable toilet systems project. To engage in co-design, the students would need to work closely with community members from Kasisa to learn about sanitation systems currently in use in the village, design and construct an initial prototype of the toilet system and collect data to evaluate this prototype. While co-design has been shown to produce sustainable and locally adapted technological solutions (Liang et al., 2026; Little, 2025), learning to engage in co-design is a difficult process, for student engineers and community members alike.

Three months prior to their journey to Kasisa, US and TZ students were introduced to the problem of limited sanitation access in the village. Working virtually and asynchronously using WhatsApp, the students explored sanitation technologies used in other resource-constrained areas of the world and discussed possible prototypes to design, build, and test in Kasisa. By June 2024, the team settled on an initial design, informed by precedent studies, that involved separating solid and liquid waste. Before traveling to Kasisa, one of the team members from the U.S. fabricated a 3D-printed waste separator and planned a low-water, sitting-style composting toilet that separated solid and liquid waste using a bucket-based collection system. It would seem that the student engineers figured out the solution to sustainable sanitation, without ever having stepped foot in Kasisa.

Once on site in Kasisa, the team focused on constructing this initial prototype with local materials to prove that their design could be made in Kasisa. Despite efforts by their engineering professor (the second author of this study) to engage the community members in deeper conversations *before* constructing the prototype, the students pressed on. On the third day of their visit, the students presented the newly constructed seated composting toilet to a group of community members gathered under the village meeting shelter. As the community members gathered around the model, discussion quickly shifted from polite curiosity to detailed critique. Although the prototype appeared technically functional, community members quickly raised critical concerns. Women members explained that the separator's placement would make direct contact with their bodies, making the design uncomfortable and impractical. They were accustomed to a squatting toilet type, and the sitting-style design did not accommodate their lifestyle. The seated model was also perceived as unhygienic. Finally, questions were raised about the physical prototype; how would the community get access to a similar 3d printed separator, and how would the wooden based stand up to termites.

The first prototype thus revealed a clear cultural and material mismatch between technical design assumptions and lived realities. This moment became an early turning point in the project, as student-engineers began to recognize that technical functionality alone was insufficient for community adoption. They realized that their design assumptions had overlooked important social and cultural dimensions. This marked a shift in how they understood engineering within a situated context. This vignette, and others like it, situate the context of this study. We set out to examine how student engineers learn to design in real-world, resource-constrained settings through collaboration with community members. By following the development of the Kasisa toilet project, this study explores how field-based community engagement shaped students' approaches to problem-solving beyond the technical assumptions.

2. Background

Engineering education increasingly emphasizes sustainability and global engagement, yet many programs struggle to prepare students for the socio-technical complexity of real-world design. Although sustainability has become part of engineering curricula globally (Thürer et al., 2018), traditional training remains predominantly grounded in technicality, liner-problem-solving and efficiency-oriented logics (Hadgraft & Kolmos, 2020a). It inadequately addresses system-level skills that enables engineers to holistically look at sustainability challenges situated in socio-technical, political, ethical and environmental contexts of the society (Fitzpatrick, 2017; Sabri, 2025; Shields et al., 2014; Sigahi et al., 2023). To truly engage with sustainability issues, engineering education needs to depart from liner technically focused models of problem-solving and better integrate systems thinking methods that recognize entangled relations among societal values, cultural norms, and technical realities (Fitzpatrick, 2017; Theis et al., 2008).

Expansion of field-based projects and engagement with real-world applications are some of the proposed approaches for reorienting student thinking and increasing contextual awareness (Beagon et al., 2023; Hadgraft & Kolmos, 2020b; Shields et al., 2014; Sigahi et al., 2023; Theis et al., 2008). Literature further emphasizes that sustainability engineering education requires more interdisciplinary, community-engaged collaborations and project-based learning approaches that reflect real-world issues (Sabri, 2025; Shields et al., 2014). However, while field-based learning is widely promoted, there remains a gap in empirical work examining how students develop systems thinking when confronted with real-world complexities. Little attention has been paid to how students work within situated challenges such as resource scarcity, material limitations, and local norms in field-based sustainability projects. The community-based toilets project in Kasisa is a study that helps address this gap. This paper examines how systems thinking and contextual-awareness emerged through community-engaged design in a humanitarian engineering project in Tanzania.

This study introduces *jugaad* as a framework for understanding how context-responsive engineering practices and systems-thinking emerge in the Kasisa project. Jugaad is a colloquial Hindi word that loosely translates as innovative fix, clever improvisations, and quick-fix solutions (Kaur, 2016; Radjou et al., 2012). It is a subaltern practice of innovating solutions by "doing more with less" (Radjou et al., 2012). In this study, jugaad is not treated as a strategy explicitly taught to students, but as an interpretive lens for understanding how adaptive, community-responsive problem-solving unfolded in the Kasisa project.

Through sustained engagement with the community, students shifted from linear design assumptions toward approaches grounded in local constraints and socio-technical realities. The case demonstrates how engineering learning becomes place-based and system-aware when shaped through participation.

3. Kasisa Case Context

3.1 The Kasisa Engineering Initiative

The Kasisa toilet project is part of a multi-year humanitarian engineering collaboration between universities in the United States and Tanzania and a locally rooted nonprofit. Located in northwest Tanzania on the shores of Lake Victoria, Kasisa village sits on a peninsula and is a highly isolated community that relies largely on subsistence agriculture and fishing. In collaboration with the Kijiji Integrated Sustainable Systems (ISS) NGO, students and faculty from several universities in the United States and Tanzania have worked with community members over multiple years on a range of interconnected sustainable rural development projects, including water procurement and filtration, sustainable building material development, and education initiatives. The mission of the Kijiji ISS NGO is to support community livelihoods through locally grounded and adaptive approaches to sustainable development.

While much of the collaboration between community partners and the NGO occurs throughout the year virtually, each summer students and faculty travel to Kasisa for a ten-day intensive, site-based co-design process. During this visit, pairs of students (one from a U.S. institution and one from a Tanzanian institution) work with two to four community members across six different projects. Development of a sustainable toilets system was one of those projects.

For most families in Kasisa village, basic uncovered pit latrines are the primary form of sanitation. Challenges related to water collection contribute to low levels of handwashing, while poor construction and limited maintenance often result in odor and contamination concerns. Furthermore, annual flooding from Lake Victoria increases risk of water contamination from waste. In response, a low-water sanitation system was identified as a potential solution for domestic toilet construction. In 2024, two engineering students conducted a series of precedent studies examining existing sanitation solutions. Building on this initial work, a second team in 2025 focused on composting toilet designs in which solid and liquid waste are separated and managed independently, allowing solid waste to decompose over time into usable fertilizer.

The objective of the team during the first on-site visit was to bring ideas developed through the precedent studies and test them within the context of the site, the community, the existing material and social environment. The team then collaborated with community members in a co-design process to develop a first iteration of a sustainable toilet design. While the engineering students worked for several weeks in advance of the visit, the on-site design process itself was structured as an intensive six-day engagement.

3.2 Project Design and Student Teams

The toilet project team consisted of two engineering students, one from a U.S. university and one from a Tanzanian university, with faculty serving as mentors. Students led the design process, while community members participated as collaborative partners. Faculty encouraged co-design across projects but allowed teams flexibility and independence in managing how their own design processes unfolded on site.

Fieldwork for this study took place during the summers of 2024 and 2025. In each year, a student pair collaborated virtually prior to the field visit to discuss and develop the technical aspects of the sanitation system. In 2024, this pre-field work focused on designing and fabricating components of the initial prototype to be constructed and tested on site. In 2025, the preparatory phase built upon lessons from the previous year, refining and modifying the design for further testing and iteration in the field.

During field visits, faculty and students collect site-specific technical and project outcome data for each initiative, including water and soil data, waste material analyses, cost assessments, ease of construction, measures of stability, strength, and workability, as well as potential for entrepreneurship. They work alongside community members to develop and refine technical solutions based on this data. Faculty members also collect process-oriented data related to the educational experience, including student reflections, photographs and videos documenting team processes, and post-visit interviews.

Community feedback sessions form a central part of the co-design process in these projects. For the 2024 phase of the toilets project, a primary feedback session took place on the third day of the site visit. The session was organized to test the prototype and gather input on the usability and feasibility of the toilet design. Because a physical prototype had been constructed, the session was highly interactive. The student team demonstrated how the toilet was intended to function, and community members physically tested the model, leading to discussion, questions, and detailed feedback.

Based on this feedback, the team rebuilt the prototype during the remainder of the visit, shifting to a raised squatting toilet design with a modified collection system intended to reduce direct contact with waste and improve usability. In 2025, a new student team engaged in collaborative design from the first day on site and developed a further iteration incorporating ventilation, handwashing, and cleaning features. The project remains ongoing, with future phases focused on reproducibility and long-term local use.

4. Methodology

4.1 Research Design and Data Collection

This study adopts a qualitative case study approach to examine how student learning and design practices evolved in the Kasisa toilets project. Data sources included post-fieldwork interviews with student-engineers who participated in the toilet project, video recordings of community feedback sessions, and design artifacts such as sketches, prototypes, and iterative design documents.

For this study, the post-fieldwork interviews were conducted with student-engineers and faculty mentors involved in the Kasisa Toilets project. The interviews included participants from the 2024 and 2025 toilet project cohort. A total of seven interviews were conducted, including four student-engineers, two faculty mentors, and one member of the Kijiji NGO. Community-members were not directly interviewed as part of this study.

In addition to the interviews, video recordings of the community feedback sessions were also analyzed as part of the dataset. These recordings from 2024 and 2025 were used to understand how the feedback sessions unfolded, including patterns of dialog between students and community members during the prototype testing, how participation was structured, and how design decisions were shaped through dialog and embodied interaction. Post-fieldwork interviews complemented this video data by capturing students' reflections on the design process, their interactions with community members, moments of challenge and adaptation, and perceptions of learning. Additionally, sketches and photographs of the prototypes were reviewed to trace how the design changed over time and how different iterations responded to feedback and site conditions.

4.2 Ethical Considerations and Consent

Institutional Review Board (IRB) approval was obtained for the study prior to data collection. Student-engineers and faculty mentors participated in the research under approved ethical protocols. For the post-fieldwork interviews conducted in Fall 2025, informed consent was obtained from all participants.

During fieldwork in Kasisa, students and faculty mentors conducted a verbal consent process before recording community feedback sessions. Participation in community meetings was open to all interested village members. A representative from the Kijiji NGO was present during feedback sessions to support translation, facilitate communication, and help ensure that community members' perspectives were clearly expressed and understood. Community members were invited to participate in discussions, testing, and co-design activities voluntarily and were free to engage at a level of involvement they felt comfortable with.

4.3 Positionality

Each of the authors of this study hold different social, cultural, and practice-based identities that shape both the broader collaboration itself as well as the data collection, analysis, and interpretation.

The first author is a Science, Technology, and Society (STS) postdoctoral scholar with a background in sustainability and development studies. Her research examines the socio-technical dimensions of engineering practice, particularly how technology development is shaped by social, cultural, and institutional contexts in sustainability initiatives. Within the Kijiji Engineering Initiative, the first author conducted post-fieldwork interviews with student-engineers and faculty mentors involved in the sustainable toilets project and analyzed interview transcripts, video recordings of community feedback sessions, and related project materials with a focus on how student–community collaboration contributed to systems-level learning. Drawing on prior ethnographic research in the Global South, particularly in India, she employs the concept of jugaad as an interpretive lens to understand adaptive, context-responsive innovation emerging through community engagement, rather than as a strategy explicitly taught to students.

The second author is an engineering professor with a background in sustainability and architecture who organizes the Kijiji Engineering Initiative. This organizational work involves many important tasks, such as identifying and matching students from the US and TZ to work on various projects, teaching the students principals of sustainability and co-design, organizing the travel and accommodations for the field work, and overseeing project teams throughout the field initiative. Because of this central role in the Kijiji Engineering Initiative, the second author holds a great deal of power shaping projects and mediating community-student interactions. More broadly, the second author has experience living and working in a variety of urban and rural contexts throughout Southern (Botswana) and Eastern Africa (Tanzania, Zanzibar) and therefore has familiarity and comfort with community collaborations involving cross-cultural and cross-language interactions. These personal and professional backgrounds allow the second author to readily spot conflicts during student-community collaborations. However, because of her central role organizing the Kijiji Engineering Initiative, some participants (i.e., students or community members) may not feel comfortable approaching the second author in the face of ongoing collaboration issues. Therefore, it is crucial to review the video recordings and interviews collected by the first and third authors to better triangulate the data.

The third author is an education professor with a background in STEM education and spatial reasoning who researches the learning that happens within the Kijiji Engineering Initiative. This work involves gathering consent from the many participants in the project, collecting data in the form of video recordings, photographs, and field notes, and leading the analysis of these data. The third author also has experience working in large collaborative research-practice partnerships and therefore is practiced at analyzing social activity from the various perspectives to account for sources of conflict and possible pedagogical or social interventions to ameliorate conflict. However, the third author had never worked in East Africa, did not speak Swahili, and was unfamiliar with social and cultural norms of the region. This lack of experience and familiarity with regional dynamics limited the initial cycles of data collection and analysis. To account for some of these limits, the third author engaged in member checking with Tanzanian colleagues and students, interviewed community members with the help of a translator to better understand community perspectives on the work, and continues to read and learn about local social and cultural norms.

The fourth author is an education professor with a background in learning sciences and STEM education who studies how people learn in authentic, problem-rich environments. His research focuses on the development of expertise in project-based and place-based settings, with particular attention to how situated experiences shape student understanding. Within the Kijiji Engineering Initiative, the fourth author contributed methodological guidance on analyzing student learning processes and helped frame the findings within broader learning sciences literature.

4.4 Analytical Approach

This study adopts a qualitative case study design (Yin, 2018) to examine Kasisa toilets project as the bounded instance of community-engaged engineering practice. Case study methodology is appropriate here given the use of multiple data sources including interviews, video recordings, and design artifacts to investigate a specific, contextualized phenomenon within its real-world setting (Yin, 2018). The bounded nature of the case, i.e a single sanitation co-design project conducted over two consecutive field years in one village, allows for in-depth examination of how student learning unfolded through sustained community engagement.

Data analysis followed an inductive analysis approach (Braun & Clarke, 2006). The analysis involved iterative reading of interview transcripts and review of video recordings to identify emergent themes related to systems thinking, contextual understanding, adaptation, and decision-making. The initial phase of analysis involved open coding of interview transcripts and video observation notes, allowing themes to emerge from the data rather than being imposed through a predetermined codebook. Through successive rounds of reading and comparison across participants and data sources, patterns were identified regarding how students moved from technically framed problem-solving toward engagement with socio-technical and systems-level considerations, such as affordability, maintenance, cultural norms, and material availability.

Jugaad was then used as an interpretive lens to make sense of these emergent patterns. Rather than serving as a coding framework, jugaad provided a conceptual vocabulary for understanding how adaptive, context-responsive problem-solving unfolded through community engagement. This two-stage approach of inductive thematic analysis followed by interpretation through jugaad allowed the findings to remain grounded in the data while drawing on jugaad's emphasis on resourcefulness, improvisation, and working within constraints to illuminate the broader significance of the patterns observed (Kaur, 2016; Radjou et al., 2012).

5. Findings and Discussion

The findings reveal how student learning unfolded through moments of disruption, adaptation, and dialogue with the community. The initial toilet design reflected a series of technical assumptions that were quickly challenged once introduced into the village context. This section presents three interrelated themes that emerged from the analysis: the role of community participation in fostering systems thinking, the operation of jugaad as an interpretive lens for understanding adaptive innovation, and the shifting dynamics of expertise, power, and authority. Each theme is supported with evidence from interviews, video observations, and design artifacts, and is discussed in relation to the broader literature.

5.1 Community Participation and Emergence of Systems Thinking

Community participation emerged as a central driver of students' engagement with systems thinking. Working alongside community members exposed them to constraints and interdependencies of the system. They confronted constraints like material availability, gendered uses, maintenance capabilities, local lifestyle and cultural norms, system-level factors that were invisible in classroom.

The initial prototype, designed in advance without community involvement, reflected a technically sound but socially disconnected approach. When the prototype was presented at the first community meeting, village members highlighted critical concerns. Women members explained that the separator's placement would make direct contact with their bodies, making the design uncomfortable and impractical. Community members were accustomed to a squatting toilet type and associated squatting with better hygiene. The feedback revealed how everyday practices and gendered use shaped design viability. What students assumed was functional was experienced by the community as misalignment with everyday practices. Reflecting on this shift, one student described learning to resist imposing external assumptions and instead center community needs in the design process:

"Designing it, knowing the people, is important and it helps you design something with them in mind and not with just, oh, my company did this and we have our name on there and that's about it." (Participant 2)

This moment of disruption marked the beginning of students' shift from linear, technically framed problem-solving toward systems thinking approaches. Student-engineers in the post-fieldwork interviews emphasized that the complexity of the project did not lie in designing or constructing a toilet itself, but in understanding how sanitation practices intersected with everyday life in Kasisa. The prototype's failure was not simply a design flaw, but an exposure of assumptions embedded in the students' approach.

Community participation functioned as a learning mechanism, and not just a design method. Participation developed awareness of the contextual factors that influence technology adoption in the real-world. Ongoing dialog, negotiation and feedback sessions with the community triggered deeper engagement with the situated realities of Kasisa. For students, it developed systems thinking spaces where they could learn how social norms, culture, materials and lifestyle differs across geographies.

Multiple iterations of the prototype based on community feedback also steered student-engineers away from a liner-problem solving to adaptive design methodologies. It helped them move away from assumptions of resource abundance and linear R&D processes toward an understanding of locally situated resources, needs, and knowledge. This shift resonates with calls in the literature for engineering education to move beyond technically focused models and integrate systems thinking that recognizes entangled relations among societal values, cultural norms, and technical realities (Fitzpatrick, 2017; Hadgraft & Kolmos, 2020a; Theis et al., 2008).

The learning outcomes for students here were not just limited to developing contextual awareness and adaptive problem-solving. The co-design process prepared engineers to recognize that effective solutions must align with the socio-technical realities of specific communities. Table 1 below maps how design problems identified by community members led to broader system-level learning outcomes.

Table 1: Problems identified, community feedback, and systems-level learning outcomes observed during the toilet development project.

Problem Identified by community members	Community Feedback	Design Adaptation	Outcome	Systems thinking learning
Initial toilet prototype was technically functional but socially unacceptable. Sitting toilet design conflicted with local sanitation practices	Community members stated they did not like the first prototype. They emphasized their preference for squatting toilets	Abandoned the initial prototype and redesigned the toilet based on community use practices. Shifted from sitting to squatting toilet model	Design became culturally acceptable and more likely to be adopted. Increased usability and alignment with everyday practices	Technology needs to align with cultural practices and lifestyle to be usable.
Toilet structure was too narrow, especially for women	Women reported the design was too narrow and difficult to use comfortably	Increased width and adjusted dimensions based on embodied feedback	Improved comfort, dignity, and inclusivity	Technology use is embedded in gendered social practices, making gender-sensitive usability a critical design consideration.
Composting human waste caused discomfort and reluctance	Community members were hesitant to engage with composting practices	Modified sanitation approach to reduce direct handling and discomfort	Greater community acceptance and willingness to engage	Cultural discomforts are a critical factor in designing
Use of imported or assumed “necessary” components increased cost	Community questioned the need for certain components, including buckets, and suggested simplifying the design	Removed unnecessary components and simplified the design	Improved affordability, repairability, and long-term sustainability	Affordability of users can impact technology adoption
Material shortages during construction	Community suggested alternative locally available materials when supplies ran out	Substituted with locally available wood, blocks, and familiar construction materials	Reduced cost from 32,000 to 8,000 shillings	Local knowledge and materials can be crucial in creating context-responsive and sustainable designs.

Problem Identified by community members	**Community Feedback**	**Design Adaptation**	**Outcome**	**Systems thinking learning**
Long-term maintenance was unclear in early designs	Community raised concerns about repair and upkeep capacity	Designed with materials and methods familiar to local builders	Increased likelihood of long-term maintenance and local ownership	Familiarity with materials and maintenance capabilities are central to developing sustainable solutions.
No proper ventilation in the toilet design	Community members suggested using locally available CEBs to create a vertical ventilation channel within the wall	Reconfigured the CEB blocks to align their hollow cores and form an integrated ventilation shaft for airflow	Improved odor control and dignity of use	Designing within resource/ material affordances

5.2 The Jugaad Lens: Adaptive Innovation Within Socio-Technical Systems

The second vignette draws from the 2025 field visit, when a new student team built upon the prior year's prototype and worked collaboratively with community members to refine the toilet design. Unlike the first year, engagement with the community occurred throughout the design process, particularly as students confronted material shortages, cost concerns, and functional challenges related to ventilation and handwashing. These constraints became sites of negotiation and collective problem-solving.

During the fieldwork, there was an instance when the student team ran out of materials. Community members pointed out that several of the planned materials were neither locally available nor affordable. They suggested material alternatives drawn from existing local supply systems. For example, instead of purchasing diameter-specific elbow joints and artificial plumbing fittings, the team used flexible irrigation PVC pipe inserted directly into a repurposed water dispenser bottle. As one Tanzanian student described:

> *"We used the water bottle... the dispenser water bottle... We cut it at the top... to make a funnel... So we invented the water bottle [as a handwashing basin]." (Participant 3)*

Compressed earth blocks (CEBs) were cut and strategically stacked to create a ventilation shaft, eliminating the need for additional vent components. The faculty mentor recalled this moment with evident admiration:

> *"So they said, why shouldn't we stack this oral blocks together and create some kind of a pipe inside it and then connect it to the roof? So to me that was really a very amazing thing that I really experienced." (Participant 1)*

These adaptations resulted in significant cost reductions. As one student reflected:

> *"Initially, when they planned about it the previous day, they had like 32,000 Tanzanian shillings... the price was reduced from 32,000 shillings to 8,000 shillings. You can see the amount of money that was reduced because just of working with the community." (Participant 3)*

A key expertise that community members brought was their familiarity with the locally available materials. Therefore, they felt confident in fully participating in the design and development, as well as carrying out repairs. The new material adaptations improved repairability and long-term viability of the design. Student-engineers began to recognize that component selection is not always shaped by performance, but also by availability, access, affordability, maintenance capacity and local constraints.

Rather than framing jugaad as "frugal innovation under constraints", this study demonstrates its value as a framework for understanding and working within socio-technical systems. Although jugaad emphasizes adaptive and resourceful problem-solving, jugaad innovation also requires engagement with interconnected systemic factors like community needs, social norms, and everyday practices (Kaur, 2016; Radjou et al., 2012). Without understanding the situated conditions of a specific socio-technical context, jugaad practices cannot meaningfully emerge.

In the case of Kasisa, the village itself functioned as a socio-technical system embedded in cultural norms, material ecologies and everyday practices. In the Kasisa project, jugaad required engineers to engage with these embedded complexities to develop a viable sanitation solution. Designing within system constraints such as affordability, maintenance, cultural norms, and material availability required students to understand how the system functioned beyond technical components alone. In this sense, jugaad operated not only as a method of innovation but also a way of understanding and working within a system.

This perspective aligns with Arturo Escobar's notion of the pluriverse (Escobar, 2018), which argues that design does not follow a single universal pathway but instead emerges from distinct social, cultural, and material contexts. It also connects to broader arguments in the literature that engineering education needs to integrate systems thinking methods recognizing entangled relations among societal values, cultural norms, and technical realities (Fitzpatrick, 2017; Shields et al., 2014; Sigahi et al., 2023). The Kasisa project illustrates how engineering practice shifted away from linear, resource-abundant assumptions and toward place-based, relational forms of design.

From this perspective, we argue that jugaad holds potential as a pedagogical lens through which engineering students can engage with socio-technical complexities and learn to design from within a system. The Kasisa case offers a concrete illustration: the CEB ventilation innovation emerged not from textbook knowledge but from the intersection of material constraint (running out of planned supplies), community knowledge (familiarity with locally produced CEBs), and student technical skills (understanding airflow requirements). This process where adaptive problem-solving unfolds through dialogue with community and material context is itself an enactment of jugaad as pedagogy. Further research is needed to explore how jugaad might be operationalized more systematically in engineering curricula, but this study suggests its value as a frame for adaptive, systems-oriented problem-solving that emerges through community dialogue rather than top-down planning.

5.3 Expertise, Power and Authority

The Kasisa project surfaces important questions about authority and expertise in this Global North-South engineering collaboration.

In 2024, student-engineers began building the toilet without community involvement, relying on imported materials and their disciplinary technical assumptions. When the prototype was presented to the community and ultimately rejected, that moment marked the first visible shift in authority and power within the project.

Student-engineers assumed that their technical expertise was enough to design an effective toilet model. This reflected an underlying assumed authority of the engineer, enacted through the decision to move forward with the first prototype without community involvement. However, the design failure in the field decentered their technical authority. One participant captured this realization directly:

> *"Technically, honestly, everything that we did in Tanzania is very easy. Like simple... It's not like they don't have technical expertise. We think they don't have technical expertise. But they do... So collaborate to make it a hundred percent." (Participant 4)*

Each moment of prototype failure and community feedback session became a site of dialogue. Through these interactions, community members gradually renegotiated their technical authority as experts. They did not simply "give feedback". They asserted themselves as local experts with situated forms of knowledge that directly shaped the design. As one of the faculty mentors reflected:

"When the local community got to understand that we are struggling with the cost and sustainability, they were now in a room to share their ideas." (Participant 1)

Community involvement in this project was not limited to consultation or ethical participation. They contributed experiential knowledge that was unavailable through technical analysis alone. Community interaction made students aware of some critical system-level constraints. Sustained interaction with community members revealed system-level factors including absence of infrastructure, affordability constraints, the importance of designing for repair using local skills and materials, and social and cultural norms shaping sanitation practices. Engagement with village members functioned as a knowledge-producing process that reshaped student understanding.

Getting to a point of open dialog was not easy. Discussions around bodily practices and waste were uncomfortable for women members of the village. They were hesitant to voice concerns in community settings, requiring trust-building around gender sensitive topics. To make women feel comfortable discussing sanitation issues, female members of the research team conducted informal meetings and conversations with women in the village, as they were uncomfortable sharing their opinions in front of male members of the community. These dynamics inform how engineering can involve trust building and normalizing conversations around issues of shame and discomfort.

Community participation reshaped not only technical design, but also the distribution of authority within the project. Authority over what counts as “functional” shifted from engineering calculations to community knowledge. The engineering benchmarks around a usable toilet design were redefined based on material access, maintenance capacity and cultural fit. Innovation was decentered from student engineers. Expertise shifted from engineers as sole designers to a distributed network of community members.

The design failures in the field revealed something deeper. It highlighted the assumptions embedded in traditional engineering education itself. The training that does not emphasize the value of local knowledge and community voices. Literature points out how classical engineering training often overlooks the socio-technical, cultural, economic, and situated epistemologies that are central to sustainable development (Fitzpatrick, 2017; Sabri, 2025; Theis et al., 2008). The students were not intentionally dismissing local knowledge, rather, their training had not prepared them to see it as expertise. This became especially significant given that the toilet was meant to be used and maintained by the very community whose voices had initially been excluded.

The fieldwork ultimately exposed the limits of a linear, efficiency-driven model of engineering design. Technical assumptions were quickly challenged because they were detached from social and material realities on the ground. In Tanzania toilet case, authority and expertise was not fixed or neutral. It was reshaped through engagement.

This case highlights why engineering education must move beyond technical competence alone to meaningfully address contemporary development challenges. Global sustainable development demands recognition of the multiple epistemologies that coexist within a socio-technical system.

Conclusion

This study highlights important implications for sustainability-focused engineering education. First, it underscores the need for engineering education to move beyond assumptions of resource abundance, and the one-size-fits-all approach to problem-solving. By revealing the gaps in how situated dimensions are currently unaddressed in engineering curricula, this work underscores the importance of educational approaches that integrate contextual awareness. This paper highlights the necessity of educational methodologies that incorporate systems thinking through practical application rather than abstract concepts. Community-engaged learning environments, as illustrated in the Kasisa project, enable students to engage directly with socio-technical complexity and develop more context-responsive engineering practices. Additionally, they help students unlearn the assumptions of resource abundance and embrace the ideas of being resourceful and learning about local resource utilization.

The findings also demonstrate that community-based engineering projects serve as critical sites of epistemic learning. that is, learning that shifts not only what students know, but how they come to know it, including which sources, methods, and forms of knowledge they recognize as valid. In Kasisa, the participatory design process prompted engineering students to move beyond privileging technical and disciplinary knowledge toward recognizing community expertise, embodied practices, and locally situated understanding as legitimate and essential forms of knowing. Engineering students learned adaptive-problem solving skills through interaction with the real-world constraints In Kasisa, participatory design process enabled engineers to learn how social norms, local practices, material conditions, affordability and maintenance capabilities shaped the sanitation system. Community-engaged engineering not only contributed to systems thinking skills, but it also served as a mode for students to value local knowledge and community expertise.

Finally, this study makes a theoretical contribution by positioning jugaad as an interpretive lens for examining how engineering students navigate real-world challenges by engaging with systems holistically and collaboratively. The findings also suggest that jugaad holds potential as a pedagogical framework for structuring community-engaged engineering education, though further research is needed to explore how it might be operationalized. It supports an understanding of systemic factors, encourages problem-solving beyond liner models, and develops decentralized context-sensitive design approach. Together, these insights suggest that there is significant value in community-engaged projects for students to learn systems thinking skills to address challenges in real-world settings.

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