Engagement in Practice to Expand Engineering Education: Collaborative Reflection on the Evolution of a Community of Practice

Ms. Sally Njoki Kimani, Tumaini Innovation Center

Sally N. Kimani has over 7 years experience working with at -risk and out-of-school youth in an alternative school called Tumaini Innovation Center. Currently, Sally is the Program Coordinator at Tumaini and is also an engineering educator at Tumaini. In addition to teaching technical and vocational classes, she also leads the community of practice of teachers in community-engaged research and teaches vocational students to use their skills in solving community challenges using the innovative tablet-based Engineering curriculum that has resulted in numerous projects, one being on designing a solar alert security system for low and middle income earners. Driven by her commitment to children's right and community development, Sally hopes to have a model for rehabilitation for street youth and families that equips them with livelihoods skills and restores the dignity of the youths to become acceptable members of the society.Sally holds a Bachelor's Degree in Economics from Moi University, Eldoret, focusing on system developments and models for the economy.Sally is a YALI RLC East Africa fellow and in 2022 was selected by Theirworld as a Global Youth Ambassador for education for marginalized populations.

Ms. Mary Wambui Muigai BSc. (Information Technology) – Ongoing, Tumaini Innovation Center

Mary W. Muigai is a dedicated and results-oriented Information and Communication Technology (ICT) professional with a strong foundation in software development, systems administration, and project coordination. Currently serving as a Project and ICT Officer at Tumaini Innovation Center in Eldoret, Kenya, Mary plays a key role in managing IT infrastructure, providing technical support, and overseeing the implementation of ICT projects that impact local communities. With a background that spans practical training at Amtec Technologies Ltd and volunteer experience at St. Luke's Orthopaedic and Trauma Hospital, she brings hands-on expertise in network setup, system troubleshooting, and ICT support. Mary is proficient in multiple programming languages and tools, including Java, C++, PHP, JavaScript, MySQL, Apache, and Microsoft SQL Server. Mary is pursuing a Bachelor of Science in Information Technology from the University of Eldoret and holds both a Diploma and Craft Certificate in ICT from RVTTI-Eldoret. Known for her strong work ethic, problem-solving abilities, and collaborative spirit, she is passionate about leveraging technology to drive positive change. Her interests extend beyond the workplace into volunteering, community engagement, and exploring tech innovations. She thrives in dynamic environments where technology meets real-world challenges.

Ms. Claudia Chebet Chemweno, Tumaini Innovation Center

Claudia Chebet Chemweno serves as a counselor and the Head of Work Readiness and Placement at Tumaini Innovation Center. Driven by a passion for integrating wellness into education, she aims to embed Social Emotional Learning (SEL) competencies into engineering education through a Community of Practice. Her goal is to enhance students' ability to navigate academic challenges and contribute to a more holistic and effective approach to engineering education.

Dr. Dhinesh Balaji Radhakrishnan, Purdue University at West Lafayette (PWL) (COE)

Dr. Dhinesh Radhakrishnan is a Research Scientist at Purdue University's School of Engineering Education. His research focuses on participatory and community-driven approaches to engineering education, particularly in displacement and marginalized contexts. He has led research and educational initiatives in Kenya, Uganda, Jordan, Zimbabwe, Senegal, and the U.S., co-developing the Localized Engineering in Displacement (LED) program. His doctoral dissertation explored how a Community of Practice (CoP) approach can engage informal educators in Kenya to co-design and teach community-centered engineering education. Currently, he co-leads a reciprocal innovation initiative that bridges CoPs across diverse countries and contexts. His work examines how local engineering knowledge is recognized, revitalized, and integrated into technical education and workforce development, fostering more inclusive and culturally responsive learning models.

Dr. Nrupaja Bhide, Purdue University at West Lafayette (PPI)

Nrupaja is a recent Ph.D. graduate from School of Engineering Education at Purdue University. She is interested in exploring how local knowledge can be centered in STEM curricula.

Prof. Jennifer Deboer, Purdue University at West Lafayette (PWL) (COE)

Jennifer DeBoer is currently Assistant Professor of Engineering Education at Purdue University. Her research focuses on international education systems, individual and social development, technology use and STEM learning, and educational environments for

(Engagement in practice): Collaborative Reflection on Evolution of an Engineering Community of Practice

Abstract

Community-engaged practices must prioritize reciprocity [1] in university-community engagement, by centering the wants and needs of the community, as identified by the community themself. In this paper, we highlight the development and evolution of a Community of Practice, emphasizing the role of community members as experts in assessing their own community needs and developing solutions to mitigate challenges through co-designing an engineering curriculum.

Research and academic articles have traditionally been prioritized by academic researchers from the Global North for their expertise in partnerships with local communities in the Global South to address specific challenges [2]. However, in this paper we highlight the reciprocal impact [3]. We examine both the community's growth but also that of university researchers from high-income countries (USA). Through collaborative reflection, [4] we (teachers, community workers, staff, engineering education researchers) discuss the journey and offer lessons learned from this unique, cross-cultural engagement. These findings emphasize the importance of creating equitable partnerships between communities and universities to support sustainable and inclusive educational practices.

Background

Communities of Practice (CoP) are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis.[5, p.4]The journey towards developing the Engineering CoP at Tumaini Innovation Center, a Community-Based Organization in Western Kenya, started in 2017 when the institution together with the international partners, Purdue University sought to design a collaborative engineering learning program that could equip the young marginalized trainees at the organization to be able to address the challenges (e.g., electricity, water quality, security) faced in their own communities.

Tumaini Innovation Center(Tumaini) as a technical training institute, engages the vulnerable youth (in particular, street youth, youth who live/work in the streets [6]) in an educational model that breaks down the barriers faced by "street youth" and other vulnerable youth in a changing society. The center leverages their inherent resourcefulness, resilience and independence, and equips them with the knowledge and skills they need to have successful and productive careers in their community. The program's mission is to empower them with hope, knowledge, skills, opportunities and resources necessary for them to earn a positive livelihood off the streets. These livelihood opportunities include learning vocational skills like motor vehicle mechanics, electrical engineering, metalwork and fabrication, solar power installation, and entrepreneurship skills, enabling them to access employment, start a business, reunite with their families, and live communally and/or independently.

In 2015, a partnership for collaboration between Tumaini and Purdue University was formed. The collaboration resulted in the development of a localised engineering course where students are taught engineering skills focused on solving problems that exist in the local communities.

Our approach to preparing teachers to facilitate localised engineering was via an engineering CoP that was initiated in 2017, with only three volunteering teachers at the time with no STEM background and an engineering education graduate student. The goal was initially to design the classes and teach Engineering Design Process (EDP), STEM fundamentals relevant to a problem area, and professional competencies such as communication, and teamwork.

At the start of the localised engineering program, teachers were assisted in establishing the CoP to foster their

development using three sequential interventions. These were reflective practice, action research, and mentorship to build the capacity of untrained teachers. Teachers and researchers mutually engaged in a community through joint enterprise on a shared domain of interest to develop a shared repertoire essential to their practice. Since then, the CoP has grown and now comprises eleven "core" members, six being the technical instructors for the trade courses taught at the vocational school. The CoPs goals have expanded and the core curriculum has has transitioned from the focus on Engineering Design Process to a Localised Engineering Education (LEE) which not only focuses on solving problems using locally available resources but has also begun to integrate local knowledge into the curriculum through Culturally Sustaining and Revitalizing Pedagogy principles.

Community engagement for our context is the direct involvement of the CoP members, the school staff and students, academic researchers and the local community in decision-making and implementation of policies and projects.

The CoP has evolved over the past eight years, shifting from just focusing on teaching engineering and solving problems to developing engineers and researchers as well. In this paper, members of the CoP (both university researchers and community teachers) reflect collectively to answer three key questions:

1) *How has the CoP shaped the teachers to be engineers?*
2) *How has engineering influenced our community engagement practice? and*
3) *How has our experience in the CoP has resulted in the development/growth of both community and academic researchers?*

Reflection prompts were generated by the CoP team and were shared among the teachers, staff, and researchers. The CoP team members then individually documented their reflections in a journal format and the reflections were analyzed by the first (one of the founding members of the CoP and an engineering teacher) and second authors (CoP members and technical trainer). A total of nine members of the Community of Practice journaled their reflections.

For this brief, the analysis involved first categorizing documented reflections relevant to each research question, followed by organizing them to identify emerging themes. The study was conducted in compliance within an existing ethics and research review approval of Purdue University and the research review policy of the Tumaini Innovation Center. Preliminary findings are outlined below, with each entry capturing one central takeaway from the participant (Authors) reflections.

Findings (Preliminary)

1. ***The role of CoP in shaping teachers to be engineers.***

> **"**... I never thought of myself even becoming an engineer. Engineering in my mind, was a complex field that only a selected few were called to do. It involved machines, chemicals and construction for the most part of it and I was not interested at all. … When the CoP was initiated, I learnt that Engineering was as simple as solving problems and that we are all engineers in one way or another. …**" (**Sally Kimani)

With the Tumaini faculty coming from different career backgrounds all with the common goal of becoming engineers, the CoP needed to accommodate different points of view and adopt specific engineering nurturing practices to enable the growth of every member.

The CoP started with the engineering research team from Purdue being the mentors, imparting engineering knowledge to the Tumaini CoP members. In a weekly check-in system with engineer researchers through journals and sharing of class experiences, the teachers were able to get feedback that could improve their understanding of engineering knowledge and teaching practices. This quickly evolved to preparation of class materials together and

co-teaching as methods of assessing and improving the teaching of the engineering curriculum.The CoP allowed room for the teachers to learn what entails being an engineer and boosted the confidence of the teachers in their engineering practice.

2. Influence of engineering on community engagement practice.

> **"**The CoP has been instrumental in enhancing my mentoring abilities by providing a collaborative and supportive framework. I've been able to, encourage participatory approaches that give voice to local communities and their needs e.g. in The Solar Alert; we the community of practice and students went to the neighborhood and asked the neighbors what challenges that they are going through and majority mentioned that the major challenges that they are facing are that their chicken is stolen from the chicken hatch. That's when we developed the solar alert system which is an Embedded system that texts or calls the homeowners when there is an intrusion in their homes.**"** (Mary Muigai)

With the CoP being created with the central purpose of teaching engineering design process to the teachers at Tumaini and to be eventually shared with the students in solving community challenges, there was a need for this knowledge to be applied in creating solutions to address the challenges faced by the community.

Engineering as defined in our classes, is designing solutions to problems using locally available knowledge, skills and resources. In the Solar alert system the CoP (Teachers and engineer researchers) guided the students, helped the students to identify a problem in their community and together with the community members developed a solution to address the problem; the Solar alert system. The Solar alert system is currently a finished product ready for sale and a few units have already been bought by the community members.

3. The role of CoP in developing academic researchers at Tumaini

> "… I have learnt to value relationships in community engagement, but with the understanding that all relationships are not equal. But valuing unequal relationships has helped me develop the skills to strengthen relationships within and beyond work. …**"** Nrupaja Bhide

Valuing local expertise ensures project goals and outcomes that are impactful to the beneficiaries takes precedence. Whether its service learning where student researchers collaborate with the CoP or its experienced researchers, working in collaboration with the community experts (the CoP) ensures that everyone is working in solidarity for the benefit of the community.

Maximum benefit is realized when everyone's contribution is considered. This can only be achieved where fostering relationships between the researchers and the CoP is considered much of a priority just as the project being pursued. Having a good relationship with the researchers and the CoP, both in and out of work, allowed CoP members to openly express their reservations about the engineering curriculum. These concerns were then addressed in subsequent versions of curriculum development and teaching. They could also give feedback on the areas of improvement with ease. The researchers who had also developed a trustworthy relationship with the teachers took their considerations and feedback and allowed room for change in the process of the engineering curriculum development valuing the teachers as the community experts.

> ***"…*** The CoP also helped me unlearn that engineering is not about technical aspects and that it's a multi-dimensional endeavor not only social, ethical and cultural as I was gaining that perspective from my PhD course, but also deeply emotional, particularly the emotional Joy. …**"** Dhinesh Radhakrishnan

Decentering hierarchical relationships and instead building the relationships with each other as peers as a priority allowed the researchers to be one with the community, learning from each other's culture and individual

personalities to build better working relationships. Sharing stories and laughter within the CoP created a space where everyone felt equal and comfortable with each other to share their insights and work together not only in regard to developing the Localised Engineering Education curriculum but also in other research work.

Project Design and Execution

At the start of teaching the engineering curriculum the course, formerly called, Engineering Design Process, the focus was on teaching the modern engineering practices in the field. With the shift to Localized Engineering Education (LEE), the focus of the curriculum has been revived to integrate the global engineering trends and the local knowledge that traditional engineering does not formally recognize in a bid to make engineering more relatable and approachable to the community. While the central aim of LEE continues to be that the students can identify local problems and develop viable prototypes that address the problem, the content and delivery of it has become culturally and ethically relevant through the evolution of the CoP. With changes the teachers also took the center stage in developing the curriculum topic by topic to match with these goals.

The keys stages that LEE currently focuses on are:

1. Identifying local needs that students design solutions based on real-world problems identified through active engagement with local communities and their knowledge systems.
2. Developing viable engineering solutions that emphasize on context-appropriate innovations that integrate both technical expertise and traditional/local insights for long-term sustainability.
3. Utilization of the local resources. Leveraging locally available materials and indigenous knowledge to build cost-effective, culturally appropriate solutions.
4. Community partnerships: CoP work collaboratively with the local government to provide our trainees to co-create learning experiences rooted in shared knowledge and mentorship.
5. Interdisciplinary Teams: CoP encourages trainees from different engineering disciplines to work together fostering a holistic approach to problem solving.
6. Hands-on experiences by implementing PBL (project based learning) methodology where our students learn by actively engaging in real-world and meaningful projects
7. Sustainable practices
8. Ethical considerations. Respect for local culture, values, and knowledge is embedded in all stages of the engineering process.
9. Feedback loops

The project design phase begins with problem identification, where community needs, local industries, and infrastructural gaps are assessed by students. Input from local stakeholders—such as community leaders, students, and government agencies plays a critical role in shaping the engineering content. The curriculum is then customised by the CoP to reflect these local realities, focusing on practical, hands-on learning that utilises locally available materials and resources to develop viable engineering solutions. Engineering problems addressed in projects often align with local societal challenges, such as access to clean water, solar energy, etc.

Execution focuses on delivering the program through participatory and experiential learning methods. Instructors guide students through real-world engineering challenges, encouraging innovation and entrepreneurship. Collaboration between students, CoP teachers, and community members ensures that projects not only provide technical education but also foster societal reintegration, especially for marginalised groups. Throughout execution, continuous feedback loops and assessments are incorporated to ensure adaptability and sustainability.

This approach bridges the gap between theory and practice, ultimately contributing to socio-economic development and long-term engineering solutions by use of local knowledge and locally available materials.

Transferability

This program is conducted with students and teachers from the Community Based organization in partnership with international researchers. The strategies employed may be particularly relevant to other youth-focused educational programs in similar socio-economic contexts in other parts of sub-Saharan Africa where similar barriers to education and innovation exist.

Lessons Learned Through Successes and Failures

The integration of local knowledge in teaching has greatly contributed to the content delivery being simplified for the students hence in engaging students more as they bring in their own cultural and lived experiences. Through this the content becomes relatable and students are able to see themselves as engineers because they are able to reflect back and see how our ancestors were engineers in their own way and how their engineering practices are still relevant to date.

Co-teaching has improved teaching effectiveness in course delivery through the peer reviews among instructors on how the class was conducted and content delivered. Additionally curriculum development in LEE has thrived since it has become more flexible and iterative, shaped by continuous community feedback and student input. The CoP teachers have improved their content delivery in class simply because of being involved in the development of the curriculum through the CoP. By doing so they have owned the curriculum and become better at understanding how to translate it to the ways their students can understand. The reflective practice by the CoP teachers has contributed widely to the refining of the LEE curriculum and is key to effectively teaching LEE.

Conclusions and Next Steps

Efforts are underway to collect data through continuous assessment tests on the new curriculum for continuous improvement and hopefully get the curriculum approved by TVET for accreditation. Additionally, we are currently exploring the integration of social and emotional well-being into the LEE curriculum to provide a more holistic learning approach and experience for our learners.

For continuity of the community of practice, mentorship for the new teachers to guide them and support them is crucial. For this to happen, the older members of the CoP are matched with the new teachers as co-teachers to enable a smooth transition of the new teachers into the CoP. Getting funding for capacity building and professional development support for the instructors, is a priority and continues to be one of the key challenges in our work, aimed at improving on both their engineering knowledge and skills hence improving the content delivery in class.

References

[1] D. A. Delaine *et al.*, "A systematic literature review of reciprocity in engineering service‐learning/community engagement," *J. Eng. Educ.*, 2023, doi: 10.1002/jee.20561.

[2] P. Lumb, "Strategic International Partnerships: Global North and Global South Discourses," *Comp. Int. Educ. Éducation Comparée Int.*, vol. 51, no. 2, pp. 110–126, 2023, doi: 10.5206/cie-eci.v51i2.15155.

[3] B. I. Omodan, "Building reciprocal relationships through decolonial practices in academic research," *Cogent Soc. Sci.*, Dec. 2025, Accessed: Feb. 21, 2025. [Online]. Available: https://www.tandfonline.com/doi/abs/10.1080/23311886.2024.2443558

[4] A. F. McKenna, B. Yalvac, and G. J. Light, "The Role of Collaborative Reflection on Shaping Engineering Faculty Teaching Approaches," *J. Eng. Educ.*, vol. 98, no. 1, pp. 17–26, 2009, doi: 10.1002/j.2168-9830.2009.tb01002.x.

[5] E. Wenger, *Communities of practice: Learning, meaning, and identity*. Cambridge university press, 1998.

[6] J. Ennew, "Difficult circumstances: Some reflections on 'street children in Africa," *Child. Youth Environ.*, vol. 13, no. 1, pp. 128–146, 2003.