Tumaini-Tech Project: Enabling Out-of-School Youth to Engineer Community Solutions

Development Challenge & Rationale Kenya, as with a number of rapidly growing African economies, has a youth bubble and untapped potential. Engineering education is seen as a key vehicle for individual and societal economic growth\(^1\), but providing engineering skills to the increasing numbers of out-of-school street youth is a "roadblock" challenge in development.

We strive to co-create a program that enables former “street youth” in Eldoret, Kenya to learn engineering skills and problem solving processes and then apply these tools to local development challenges in their community. We organize and supplement existing open educational resources (OERs), employ co-generation of the program along with the students and local leaders, deploy a novel tablet platform, and enable students to manage local problems. Our sustainable plan is to enable local expertise and expand youth capacity with relevant problem contexts, for example, solar energy, electrical systems, and water plumbing and filtration. We partner with the Tumaini Innovation Center (TIC), a residential school for former "street youth", with the intent to scale to other underserved youth.

Project Structure The project comprises four components: (a) a flipped classroom structure, (b) content on introductory engineering, (c) hands-on application of engineering skills, and (d) educational research.

1. Create an interactive, flipped classroom structure that combines existing open content: We have developed and are piloting an interactive Android interface that serves as an engaging digital textbook for out-of-class learning. The flipped classroom structure includes synchronous and asynchronous activities, as in-person individual and group work, and collaborative activities with visiting mentors from Moi University\(^2\). In addition to the affordances of blended learning\(^3\), students will also gain information and communication technology (ICT) skills and coding practice that can transfer to other contexts.

2. Develop a foundational curriculum for basic engineering knowledge, skills, and attitudes: We have developed content on the mobile platform for students to interact with introductory engineering topics, including knowledge and practice with mathematical modeling, estimation, the design process, communication and teamwork, and others. Using best practices and existing research in engineering education, we identified the following broad learning objectives:
   - STEM (science, technology, engineering, and math) fundamentals
   - Professional competence (communication, inter- and intra-personal communication, teamwork)
   - Problem-solving, mathematical modeling, and problem-solving processes
   - Design and design process

3. Develop a curriculum and activities applied to an “authentic problem,” solar energy generation: We have developed content to teach approaches to design, applied science, and practical considerations of engineering around the topic of green energy (solar), which addresses an immediate demand for the Tumaini Innovation Center and the local community. The curriculum therefore includes technical skills as well as more broadly transferable engineering skills and approaches (e.g., prototyping, optimization, measurement; Fig 1) to ensure future job flexibility.

4. Study the student and teacher experience and determine effectiveness and scalability: Understanding whether and how the new structure and curricula are working is critical to inform next steps to improve these tools. Using Dr. DeBoer's experience investigating blended learning tools in a variety of contexts\(^4\),\(^5\), we study the user experience, the relationship between tool use and learning outcomes and potential differential effects for individual students (e.g., are effects different for female students?). We utilize participatory action research (PAR) to engage the students as researchers.

---

\(^1\) See, for example, the call for Education for All and academic work such as [www.tinyurl.com/HanushekWoessmanJEL](http://www.tinyurl.com/HanushekWoessmanJEL)

\(^2\) [https://mu.ac.ke/](https://mu.ac.ke/)


\(^5\) [http://eric.ed.gov/?id=EJ817429](http://eric.ed.gov/?id=EJ817429)
themselves, driving research question and focus areas themselves, as well as novel quantitative models that capture students’ engagement with digital tools. We employ a contextualized and co-developed approach to curriculum development that ensures relevance and utilization of existing open educational resources for this course (Fig 2).

**Our Team** combines a leading Purdue research lab, a unique learning space—the Tumaini Innovation Center, and engaged student leaders from Moi University.

Jennifer DeBoer and her research group provide expertise on the use of flipped classrooms and locally-centered curricula. Her research agenda focuses on the ways in which technology can facilitate formal and informal learning opportunities and access to engineering and technology knowledge and skills for diverse students in low-resource settings. This dovetails with her National Science Foundation CAREER award work, which looks at four uses of blended curricula around the world and the ways in which diverse students use such materials to learn introductory engineering concepts. Dr. DeBoer began her international career conducting research with the Hole-in-the-Wall project in India. The lead graduate student, Dhinesh Radhakrishnan, is a doctoral student in Purdue’s engineering education department, the first PhD program of its kind.

**Tumaini**

The Tumaini Innovation Center is a comprehensive service delivery center for street youth in Eldoret, Kenya. Since 2010, Tumaini has worked with thousands of street youth to prepare and support their reintegration into the traditional Kenyan education system. Early efforts supporting students’ reintegration into the traditional Kenyan education system led to the development of the residential Tumaini Innovation Center. The Tumaini Innovation Center director, Samuel Kimani, teachers, and students are the lead partners on this project, and they provide contextualized direction, testing, and feedback on the project outcomes. Tumaini teachers are supported directly through a corresponding instructor guide. The Tumaini director and students and Dr. DeBoer’s research group conduct weekly Skype calls to coordinate their work.

The School of Engineering at Moi University, led by Dean Simuyu Sitati, has been engaged and visionary in partnering on this project. Undergraduate student leaders serve as mentors and role models by periodically facilitating engineering activities with Tumaini. They serve as the local university partner and provide additional experience, resources, and training (Fig 3).

Quanser, a Canadian mechatronics company, is the project’s technology partner. Qdex, a product of Quanser, is used to transform conventional static training documents into highly interactive, concept-rich resources that fully exploit the convenience, power, and usability of modern smart mobile devices. This partner has provided initial tablets to test the platform and develop novel capacities in the complex space of this project.

**Viability and Scalability** Our project will demonstrate two major scalable goals: (a) the application of a low-cost, student- and teacher-enabling platform for delivering engaging and accessible content and individualized assessments, and (b) the creation and application of a vocational engineering curriculum as a vehicle for immediate employment and transferable skills. The low-cost platform has potential to scale to other education providers. It has unique adaptability, low cost, and empowerment of the user to create his or her own content. The applied curriculum will also have high potential for economic impact and long-term sustainability, given its immediate job potential as well as adaptability for the long term.

Integrating engineering and entrepreneurial skills together provide an avenue for students’ enablement, engagement, and workforce participation. Employability and income generation opportunities will be facilitated by verified certification from the three partner institutions (Purdue, Moi, TIC) and additional credits for the specific modules students achieve. The program
provides transferable ICT, technical, and STEM skills, adaptable engineering experience, and community impact.

Figure 2 Model of Curriculum Co-development

**Future Work** Future development includes tests of scalability of the learning platform to other content areas in the formal Kenyan curriculum (e.g., science, math, social studies); scale up to conflict zones (through Dr. DeBoer’s collaboration with UNHCR), and integration of other authentic problem contexts in additional modules, including connection to other engineering and agricultural projects at Purdue.

**Timeline** Each project step has generated a viable, scalable product (a tested educational platform, curricular structure, authentic problem context, and scholarly insight). The first two modules are being piloted in May – July and September – November of 2016 and will be evaluated thereafter. The 6-month benchmark comprises the training and support of the teachers and deployment and evaluation of the first modules, with 14 Tumaini students impacted and their own solar energy installation completed. A 1-year benchmark will include design and application of a water pump, with 20 Tumaini students impacted. A further 3-year time horizon includes scale up to potentially 200 students. Success of the intervention will be measured based on students’ improved understanding of key concepts, increased performance on standardized skill- and knowledge-based tests, and, ultimately, attainment of sustainable sources of income for graduating street youth.

Our goal is to break down educational barriers faced by street youth, leverage their resourcefulness, resilience, and independence, and equip them with the knowledge and skills they need to not only get off the streets but to have successful and productive careers in their community.