Low-Cost Digital Technology as a Platform for an Innovative Engineering Skills Curriculum

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Engineering Education

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• Work with digital tools in development (HITW, OLPC, MOOCs)
• Education training
• Secondary school teaching experience, eight years of experience with street youth in Eldoret
• Student leadership work
• Experience and expertise in solar energy
Outline

Development Challenge
Out-of-school youth in Kenya

Tumaini Tech-Project Process
Project steps, curriculum development, and theoretical foundation

Partnerships
Core partners and external supports

Challenges
Technological challenges, human challenges

Initial Results and Impact
Qualitative data and anecdotal stakeholder sharing

Scalability, Sustainability, and Discussion
Near- and long-term directions
“Street Children”

- Children *of* the street – Children who live on the streets, even sleeping there at night (Ennew, 1996)
- Children *on* the street – Children who only work on the streets by day and return to a home base at night – (Unicef, 2001)
- Major push factors for children ending up on streets
  - Hunger
  - Abuse at home
  - Post-election violence
  - High cost of education
    (Steffen, 2012)

Image source: [www.tumainicenter.org](http://www.tumainicenter.org)
Tumaini Innovation Center

“Tumaini in Kiswahili means hope. The Tumaini Children’s Drop In Center is dedicated to empowering and serving street children in Eldoret, Kenya”.

The Tumaini Innovation Center seeks to improve the lives of street children and youths in Eldoret, Kenya by empowering them with hope, knowledge, skills, opportunities and resources necessary for them to find their healthy alternative to street life.

Image source: www.tumainicenter.org
Setting

Tumaini Innovation Center

- Residential School
- 14 Children
- Age range: 12 – 17
- Started with 10 and currently hosts 14 children
- Diverse educational backgrounds (ranging from no prior education to primary level education)

Image source: www.tumainicenter.org
Challenges and Opportunities

- Equity and access
  - Educational
    - Marginalized population unsuccessful in reintegrating into traditional education
  - Learning materials
  - Teaching aids
- Labor Market
  - Permanent space off the streets through gainful employment
Phase 0 - Project Initiation  
- Need finding and initial data gathering  
- Identifying technology partner & developing partnership  
- Project Planning (project phases and timeline development)

Phase 1 – Curriculum design and content development
- Feedback from Tumaini Innovation Center
- Technology Integration
- Feedback from Tumaini Innovation Center and Researchers

Phase 2 – Alpha test (Field test and data collection)
- Beta-test (Ongoing)

Phase 3 - Deployment
Curriculum development

- Backward design model (Wiggins & McTighe, 2005)
- Curricular priorities based on apprenticeship of
  - Head (intellectual development)
  - Hand (skill development)
  - Heart (development of habits, mind, values, and attitudes) (Carnegie Preparation for the Professions Program)
- Experiential learning – “learning through reflection on doing”

**John Dewey:**
Learning from one cycle stimulates the beginning of another leading to a process that reconstructs our knowledge and skills in light of new experiences.

**David Kolb:**
Learning involves the acquisition of abstract concepts that can be applied flexibly in a range of situations.
Curriculum Co-development Process

Learning Objective Co-development

Summative Assessment
- Contextualized, authentic problem
- Hands-on application

Formative Assessment

Stakeholder direct development

OERs

Iterative feedback

Teaching and Learning Activities

Students

Teachers and Director

Engineering Ed Researchers

User/Community goals

Best practices
Empirical research

Identification Evaluation

Context

Iterative feedback

OERs

Identification Evaluation
Example: Measurement Activity

**Objective:** Water cycle can be understood through empirical evidence. Measurement is an engineering activity.

**Hands-on:** Students are measuring the parameters of a fish pond and using the tablet as a recording tool.

Students from Group 1, Kariuki and Hezron, are measuring the length of the fish pond 1. Kevin is recording the measurement.

Students from Group 2, Willy and Benga, are measuring the length of the fish pond 2. Joshua is recording the measurement.
Technology – Tablets and qdex

- Quanser – Global leader in control systems for engineering education
- qdex - mobile device platform
- Develop highly interactive, concept-rich sources that fully exploit the convenience, power, and usability of modern smart devices
- Tablets – multi-purpose (reading, writing, recording, listening, and watching) educational tool
- Access to learning materials

Image source: www.qdexapps.com
Course – Semester 1

- Co-development with students, teachers and director
- Locally identified engineering problem and scope (authentic problem context)
- Semester 1
  - Problem Setting: Lack of reliable energy source to access water to the farm at Tumaini
  - Solution – Design and construct a solar powered water pump for Tumaini
- Continuous feedback from students and teachers
Partnership Relations

- Tumaini Innovation Center
- DeBoer Lab
- Moi University
- Quanser
- I2D
- Purdue School of Engineering Education
- I2D Projects – Cross-pollination

Connections:
- Tumaini Innovation Center to Moi University
- Moi University to DeBoer Lab
- DeBoer Lab to Quanser
- Quanser to Purdue School of Engineering Education
- Purdue School of Engineering Education to Tumaini Innovation Center
- Tumaini Innovation Center to DeBoer Lab
- DeBoer Lab to I2D Projects – Cross-pollination
- I2D Projects – Cross-pollination to Moi University
- Moi University to Tumaini Innovation Center
Technology integration

Modules – Lessons programmed into the platform. Qdex requires XML programming in a computer editor software.

Multiple formats of delivery provide multiple modes of learning (Mayer & Ross, 2002) – Text, images, video, GIF’s, simulation.

Interactive features – Formative assessments are provided with question and answers.

Tool for flipped classroom model are built in. These include videos and activities for homework.

Homework
Watch this two videos and write a small paragraph (20-25 lines) on what you learned from each video.
Technology Integration

- Tablet used as a lab notebook (Google docs)
- Tablet used as a recording tool (Camera)
- Tablet used as a design tool (Markers app)
- Tablet used as a classroom tool (qdex)
Challenges encountered

• Technological challenges
  – Limited bandwidth internet at the Tumaini Innovation Center
  – Continuous request for updates for android OS and other apps
  – Frequent charging needs for tablets
  – Platform constraints limiting integration with android apps

• Human Challenges
  – Students - Challenge of distraction with tablets during class hours
  – Teachers - Self-imposed limits to exploring the technology, inhibiting the use of the technology’s affordances
Initial results

- **Data**: semi-structured interviews with four students (conducted in Kiswahili and English), think-aloud use case
- **Analysis**: two rounds of thematic analysis and feedback (Patton, 2005)
- **Emergent themes**:
  - Frustration with infrastructure and platform constraints
  - Meta-cognitive awareness of learning process, perception of learning
  - Emotional awareness of learning support structures
  - Perceived value of course for learning, future goals
  - End user direction (both feedback for revision of existing structure/content and articulation of additional structure/content)
Impact

• Initial anecdotal impact (May)
• Students’ stated aspirations
  – Engineering as a future job opportunity
• Students’ self-reported activities
  – Activities at center
  – Activities at home
• Director and teachers’ instructional approach
  – Experiential, inquiry-based
  – Student-centered → student-led
Video
Extent of scalability/sustainability

- **Scalability**
  - Context-based
    - Can be relevant to other authentic problems
    - However, needs individualization to be context-specific
  - Simple platform, simple coding (xml)
  - Platform currently in use in university engineering coursework
  - Demand for such a solution given large number of out-of-school youth in Kenya (UNICEF & Republic of Kenya, 2014)

- **Sustainability**
  - Incubator for student-run businesses
  - Community consultants
Conclusion and Discussion

- Technology is not the solution → the teaching environment and all other components are the solution
- Capacity building, beyond vocational training → adaptive expertise for future job market opportunities
- Scale – how do we tackle the scale question here?
- Data use and being thoughtful about “information”
References