Implementing Co-Creative Engineering Design at International Field Sites to Address Global Health Challenges

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Global Skill Set for Engineering Students

- Engineers will increasingly work in a diverse domestic and global workplace or will work on complex problems with global impact.
- Industry increasingly seeks students with cultural competency.
- Pressing problems in resource-limited settings (e.g., clean water, energy, global health) likewise call for engineering solutions that carefully consider local cultures.
- At the University of Michigan, we have developed a program in which undergraduate students learn engineering design through co-creation of medical device technologies with local stakeholders at international field sites.
Curricular Innovations

- Undergraduate project-based learning related to real-world problems
- Co-creative design process featuring human-centered design
- Project scoping through clinical immersion and experiential learning
  - Identification of stakeholder needs
  - Negotiation of problem definition with stakeholders
  - Generation of need statements
- Appreciation of the cultural influences on an engineering problem and the implications of technology introduction to a community
- Consideration of a wide range of unique constraints, such as low cost, use of local materials, adoption by unskilled users, and cultural beliefs
- Community-based demonstration and subsequent refinement of prototypes
- Intercultural and clinical competencies
Context for project-based learning

- Developing countries hold 84% of the world’s population and bear 93% of the worldwide burden of disease
- Over 95% of the medical devices in the developing world are imported
- Only 50% of these devices are currently operational
Piloting the program
Field site: Ghana
Program Features

- Multidisciplinary student teams
  - 3-4 engineering students
  - ≥1 non-engineering student(s)

- Pre-departure training
  - Design primer coursework
  - Cornerstone coursework
  - Basic patient history and physical examination skills workshop
  - Clinical observations
  - Thematic directed self-study
  - Vicarious trauma training
Program Features (continued)

- 1-2 month clinical immersion
  - Morning meetings
  - Observations
  - Interviews and focus group discussions
  - Problem co-identification and co-creation with the community the device intends to serve

- Homestays

- Needs assessment and generation of user requirements and engineering specifications

- 1-2 semesters of design
  - Field site validation of prototype
Maternal Health
• Reconfigurable labor & delivery bed
• Portable pelvic examination table
• Threshold-based blood pressure detection
• Autologous blood transfusion device
• Breast cancer detection device
• Assistive delivery device

HIV/AIDS
• Tool for traditional adult male circumcision
• Task-sharing clinical adult male circumcision device
• Clinical device for infant male circumcision

Minimally Invasive Surgery
• Gall bladder removal device
• Low-cost, low environmental impact tissue resection device
• Low-cost force-feedback training grasper

Other
• Blood exchange transfusion device
• Respiratory monitor
• Folding tricycle attachment for standard wheelchairs
• Patient-powered CPAP
• Surgical thoracotomy simulator
• Surface water pump
Example: Autologous Blood Transfusion

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Caitlin Winget
Best Practices

- **Field site partnerships**
  - Partner with teaching hospitals
  - Build upon existing university relationships
  - Establish long-term collaborations centered on reciprocity
  - Engage in service learning
  - Limit teams per field site
  - Conduct joint immersion experiences with in-country engineering students

- **UM partnerships**
  - Global Intercultural Experiences for Undergraduates
  - African Studies Center
  - International Programs in Engineering
  - Center for Entrepreneurship

- **Cohort themes**
  - Maternal health → Ghana
  - MIS → China

- **UM clinical mentor(s)**

- **Student leadership**
  - Self-directed study
  - Field site preparation
  - Peer-to-peer training
  - Peer evaluation

- **Homestays**
  - Minimum 6-8 wk immersion experience

- **Semi-weekly deliverables and telecons**

- **Assessment and evaluation**
Challenges

- How to effectively train engineering students to conduct comprehensive needs assessments and identify jobs-to-be-done
- How to create classroom-based exercises that translate to work conducted independently in the field
- How to teach down-selection of problems in light of numerous challenges observed during immersion experiences
- How to teach students a process for generating a rank-ordered list of user requirements after they collect numerous required design features from diverse and numerous stakeholders (e.g., 100s of comments ➔ 10 requirements)
- How to scale up the programs
- How to take design project outputs beyond the classroom:
  - Publication of conference and journal papers
  - Intellectual property
  - Start-up companies and social ventures
  - Deployment in resource-limited settings
- How to best quantify success
Further Outcomes

- Field site requests for our student teams
- Impact on Ghanaian institutions
- Industry sponsorship
- Conference and journal publications
- Awards
- Grants
- Early stage start-up companies
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