

Design that Matters: Connecting Engineering Students with Underserved Communities

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Design that Matters

1. Introduction

In this paper, we give an overview of the collaborative design process that we have built to address unmet needs in underserved communities while at the same time educating engineering students about their capacity to create positive social change. The process description is motivated by a specific example—the design of a tool for adult literacy education in developing countries. We give an overview of some initial program results from the academic perspective. Finally, we outline our approach towards the further development of this service.

2. An Overview of Design that Matters

Design that Matters (DtM), a nonprofit organization hosted at MIT, helps underserved communities realize an improved quality of life by creating products and services that meet needs identified by the communities themselves. DtM acts as bridge to bring problems identified by nongovernmental organizations (NGOs) and the communities into the classroom for university engineering students to tackle in their capstone design courses. DtM serves as the “institutional memory”, capturing the ideas resulting from each capstone course to allow successive teams of students to build on each other’s work. Finally, DtM works with NGOs, corporate partners and local entrepreneurs to ensure that promising student innovations result in products and services for communities in need.

Since its launch in 2000, DtM has reached over 400 engineering students—roughly half of them women and minorities, and many of whom have realigned their life trajectories to include work in underserved communities. In 2002, DtM completed a proof-of-concept implementation in MIT's mechanical engineering capstone design course with Prof. Woodie Flowers. DtM is now expanding within MIT and to other schools in the US and UK.

2.1. DtM Project Areas

Design that Matters works to address the needs of underserved communities in developing countries as well as indigenous groups, the disabled and the elderly. DtM student teams have tackled such challenges as an improved IV drip for cholera treatment¹, a non-electric incubator for premature infants in rural areas², a children's talking toy for Native American language preservation, "smart canes" for the blind, hand-powered electricity generation for rural computing and communication tools for handicapped children.

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In selecting problems to address, DtM relies on the following basic selection criteria:

- **Need:** the design challenge meets a real need, something that seriously affects the lives of thousands or even millions of people.
- **Scope:** we can provide sufficient information and enough focus to make the problem accessible to students in a single semester. This may involve breaking a large problem up into smaller component problems.
- **Contacts:** there exist community/stakeholder representatives, NGO contacts and domain experts who can answer questions and are willing and able to put the student innovations to immediate use.
- **Status:** there are no existing, satisfactory solutions to this problem, nor do any appear to be in development.

In addition DtM looks for opportunities in the area of “intermediate technology,” finding solutions that bridge the gap between the kinds of computerized, mechanized products available in industrialized countries and the basic technology found in rural regions of developing countries. Similarly, conservation of natural resources is a goal of all DtM projects. DtM specifically targets design challenges that assist communities to exploit local resources in a sustainable fashion.

2.2. DtM Design Challenge Portfolios

DtM packages problems identified by our clients into curriculum materials called Design Challenge Portfolios for university students in engineering, science, policy and business to work on in their courses. We transfer the resulting student innovations back to our partners in NGOs and industry to develop as new products and services that will have an immediate impact on the lives of communities in need.

DtM Design Challenge Portfolio:
Cholera Treatment Devices

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Portfolio Overview

Design Challenge Summary
 Improve the current system of IV drip flow monitoring and control.



IV drip treatment of cholera victims at a refugee camp in Mozambique.
 [Medecins Sans Frontieres/Doctors Without Borders]

Project Motivation

Cholera is an acute intestinal infection which, if not treated, can quickly lead to severe dehydration and death. Rehydration through the intravenous (IV) drip infusion of saline is the only technique available for the treatment of severe cholera. In a cholera epidemic, where many patients need to be treated as quickly as possible, it is critical that setting up IV equipment and initiating treatment occurs as rapidly as possible.

Cholera epidemics in refugee camps or resulting from natural disasters can lead to a situation where the number of patients exceeds the capacity of the trained medical staff on site. In this situation, as shown in the photo above, local people often wind up treating each other. This creates a need for IV drip devices that are intuitive to set up and operate, for people who have little or no medical training and who may even be illiterate.

Design Challenge Portfolios include the following information:

- **Background materials:** a history of the problem, an overview of the country and region where the design challenge is found, and details about local culture relevant to the design.
- **Well-posed design problems:** a list of specific design problems related to the challenge, accompanied by a catalog of design specifications and any available sketches, technical diagrams, photos, and audiovisual material that would assist students and faculty in understanding the challenge.
- **Prior art:** a survey of designs currently applied to this challenge, including the work of previous student teams, with a review of their advantages and limitations.
- **Portfolio Jury:** a panel of 3-5 experts associated with each design challenge portfolio, consisting of stakeholder and NGO representatives, university faculty and industry sponsors, who will help to review and revise the design challenge portfolio content and assist with design validation and overall project evaluation.
- **DtM Collaborative Design Network:** a network of contacts and domain experts among local community groups, NGOs, universities, innovators, entrepreneurs and industries—individuals and groups having direct experience with the design challenge in the particular region and/or a stake in the development of related products or service. These individuals will be able to answer student questions about cultural considerations, local resources, manufacturing constraints and financing and distribution models.

These design challenge portfolios are designed to move a concept to commercialization within three years of its introduction. During this time, the portfolios evolve in depth and detail and include design problems from every stage of the product development lifecycle. In engineering and industrial design, the design problems will focus on prototype development based on design

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criteria supplied by the community and local NGOs. For students in manufacturing engineering, the design problems will focus on product design based on existing prototypes, given local material constraints and manufacturing capabilities. For business students, problems will focus on market analysis, financing models, and the development of business plans based on the product and the local community.

DtM project mentors create and maintain our design challenge portfolios, and develop our collaborative network. The project mentor keeps the design challenge portfolio up to date by incorporating new resources and the progress made by student teams. The project mentor coordinates the communication between student design teams and the collaborative design network, connecting groups, relaying questions and broadcasting changes in the design specifications or problem parameters. Finally, the project mentor connects promising student prototypes and methods with the stakeholders, NGO and industries that can make the most use of them. In this way, we can guarantee that communities as well as the students benefit from this exchange of ideas.

Visit http://www.designthatmatters.org/proto_portfolio to view a selection of prototype design challenge portfolios.

2.3. Product Design Process

DtM act as a project manager for design process, recruiting schools and classes with the necessary technical skills for the project and then supporting a process for brainstorming and prototyping. DtM relies on or is developing various aids to facilitate this process:

2.3.1. Design Reviews and Jury Reviews

Design Reviews provide student teams with critical feedback on their designs during the course of a semester. Jury Reviews, which happen at the end of a semester, identify the most promising contributions made to a project in that semester. This helps ensure the most promising ideas are carried forward to the next generation of student teams that pick up work on a project. Design reviewers and jurors include stakeholders, communities, local entrepreneurs and industry.

2.3.2. Design Competitions and Field Studies

The value of the competitions is to motivate DtM students to carefully document their work so that the next generation of students to work on the problem can pick up where the previous generation finished. Field studies provide a mechanism for community feedback on promising prototypes in development.

Design that Matters currently encourages students to enter their designs in such competitions as the MIT IDEAS Competition, the MIT \$50K Entrepreneurship Competition and the Saatchi & Saatchi Innovation in Communication Award. DtM led its first field study to West Africa in July 2003.

3. The Kinkajou Microfilm Projector

Over the last 18 months, we have applied our collaborative design process to the development of a robust, low-cost projector system for use in adult literacy courses in developing countries.

One in five adults worldwide does not know how to read. In rural regions of West Africa, up to 75% of the population is illiterate. According to Barbara Garner of the World Education Organization, "It's the lack of resources"—specifically access to books and lighting—rather than the lack of interest in education that contributes to these numbers. After validating this with the community, Design that Matters translated this need into a detailed problem description for engineering and business students to address in their university courses and research. The objective has been to design and build a rugged, lightweight, low-power projection system, which uses a microfilm cassette to store up to 10,000 images at a fraction of the cost of paper books, and employs a state-of-the-art optics system to project an image large enough for the entire classroom to read.



Night-time women's literacy course in rural Guinea



DtM Student Team at MIT with prototype projection system



DtM Microfilm Projection System in use in Bamako, Mali

The design concept was developed in Spring 2002 by a team of undergraduate students taking a DtM-lead seminar at the MIT Media Lab. In Fall 2002, a second undergraduate team in an MIT Mechanical Engineering senior capstone design course picked up the project, developing the first working prototype. In Spring 2003, students from the course continued the development of the projector through senior thesis projects³⁻⁷, culminating in a six-week field test in West Africa the following summer. In Fall 2003, development of the projector moved to the University of Cambridge in England, where students in the Sustainable Development program researched opportunities for local production of content, and Worcester Polytechnic Institute, where electrical engineering students are tackling the redesign of a robust battery-charger circuit and a more efficient LED driver circuit⁸. In 2004, DtM will work with students at MIT and the University of Cambridge to tackle problems related to systems integration and design-for-manufacture.

DtM is now working with World Education to organize an extended pilot study of the device this fall, as a prelude to large-scale deployment among World Ed's literacy programs in Mali and Guinea in 2004. Visit <http://www.designthatmatters.org/k2> for an extended overview of this project.

4. Initial Program Results and Next Steps

From an academic standpoint, we have found DtM design challenge portfolios to be a useful tool in introducing engineering students to such concepts as intellectual property, stakeholder analysis, product roadmapping and market evaluation—as well as raising their awareness of their capacity to create change in underserved communities.

In the next six months, we will be expanding our pilot study to include 5-10 new universities in the New England and San Francisco Bay Area, as well as in England. We will conduct a critical review of our existing inventory of design challenge portfolios, with the goal of developing 10 fully-developed challenges for the 2004-2005 academic year.

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Neil Cantor is co-director of Design that Matters. He received his MBA from the MIT Sloan School of Management. Prior to Sloan, Neil worked at two startups, managing media outreach and doing business development. He also worked five years for Dow Jones Newswires, where he rose from reporter to desk editor and finally newsroom editor. He did his undergraduate work at Cornell University, majoring in political science.