WHEELCHAIR DESIGN IN DEVELOPING COUNTRIES

http://web.mit.edu/sp.784/www

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Motivation: Engage many bright students in advancing wheelchair technology

Activities of students in the class:

• Learn the technical, social, and economic factors preventing appropriate wheelchair technology from being implemented

• Study engineering, business, and biomechanics theory in context of wheelchairs

• Work in teams, collaborating with developing country partners and wheelchair specialists, to design and prototype wheelchair technology

• Interact with faculty, professional, and community partners during guest lecturers

• Participate in summer fellowships in developing countries to implement class projects

• Learn how you can use science/technology to make a positive impact on the world
Lecturers: Amos Winter, PhD Candidate, Mechanical Engineering  
Mario Bollini, Mechanical Engineer, Vecna  
Amy Smith, Senior Lecturer, Mechanical Engineering

Units: 2-2-5 (Lecture-Lab-Homework), counts towards course 2A international development focus

Lecture: Required, can miss two, but not more without instructor permission. Attendance taken starting second week of class.

Project and Labs: Project teams and class presentation times chosen next Thursday. Lab groups will choose own meeting time.

Homework: Project and team website primary components of homework. Additionally there will be readings and short assignments.

Grading: Final course grades will be assigned A-F.

- Class participation/homework: 10
- Strategy presentation: 15
- Concept presentation: 15
- Most Critical Module (MCM) Presentation: 15
- Final presentation and prototype: 25
Course Syllabus
**Team:** 3 to 5 members with lab instructor

**Collaboration:** Partnership between MIT students, US and European experts, and wheelchair manufacturers

**Deliverables:**
- PowerPoint presentation for the Strategy, Concept, MCM, and Final prototype.
- Poster for The MIT Museum in May
- Prototypes: Physical solution to each teams’ MCM for MCM presentation. Proof-of-concept prototype for final presentation
- Website chronicling project development. Pages dedicated to major milestones. Website completed by summer fellows
PARTNER WORKSHOPS
How class projects were defined

10 countries in Africa, Southeast Asia, and Central America
14 partner workshops
1. Define projects with workshops (Aug-Sept)

2. Develop ideas and prototype (Feb-May)

2. Develop ideas and prototype (Feb-May)

3. Test and implement (June-July)

Disseminate

Collaborate

Wheelchair experts

Students travel to workshops
**Monetary**: ~$4000 for prototyping (entire class budget)

**Manufacturing**: 

**Parts**: African wheelchairs and bicycle components

**Lab Space**: M-Lab, basement of E34, part of D-Lab space
Over 20 people have traveled during the past three years

Bring WDDC technology back to partner workshops

Work in any or all 14+ partner shops

~4 to 10 weeks duration

Apply through PSC, IROP, Kelly Douglas
Glamour’s 2009 Top 10 College Women

September 1, 2009
by Erin Zammet Ruddy

The Inventor
Tish Scolnik, 21, Massachusetts Institute of Technology
Her dream: To see disabled people in developing countries given the same opportunities as able-bodied people.

How she’s making it happen: Working abroad in Tanzania, the mechanical engineering major was overwhelmed by how handicapped people lived. She once met a disabled student who had to crawl across campus because he didn’t have a wheelchair. So she created a design for a three-wheel folding chair, complete with work space, storage, an umbrella—and a spot for an ad on back. Back on campus, she helped found the Mobility Lab to get students involved (and won a 2009 Truman Scholarship). Words to live by: “Haba na haba hujaza kibaba,” a Swahili proverb that can translate to ‘little by little fills the pot.’” Her Dos & Don’ts: “Do smile at people you pass on the street. Don’t order a salad when you really want a cheeseburger.”

M-Lab awards page
The World Bank and other authorities estimate that there are as many as **600 million persons with disabilities around the world**, making them one of the largest minority groups of unserved, marginalised people. (UNESCO Bangkok)

About 600 million people in the world experience disabilities of various types. **80% of the world's disabled people live in low-income countries**; the majority of them are poor and do not have access to basic services including rehabilitation facilities. (World Health Organization)

Between **20 and 50 million people globally are estimated to be injured or disabled in road traffic accidents each year**. (World Health Organization, 2004)

Close to **ten million severely or moderately disabled people are added each year** to the total global figure – or about 25,000 every day. (Helander, 1999)

**70% of disabled people in developing countries are estimated to live in rural areas** (Groce, 1999)

(Statistics provided by Motivation UK)
The WHO and Pan American Health Organisation (PAHO), estimate that only **1-3% of people with disabilities in the South who require rehab services have access to them.** (Helander, 1999)

Most people who sustain a **spinal cord injury in the South die within two years**, compared to a normal life expectancy in the North. (Werner, 1998)

Conservative estimates put the number of people with disabilities in developing countries at close to half a billion. Of these, an **estimated 20 million require wheelchairs to be mobile.** (United States Agency for International Development, 2003)

An estimated **95% of people who need a wheelchair don’t have one.** (Werner, 1998)

**Below 1% of the need for wheelchairs in Africa is being met through local production.** (United Nations Development Project, 2002)

(Statistics provided by Motivation UK)
Disability is both a cause and a consequence of poverty. Eliminating world poverty is unlikely to be achieved unless the rights and needs of people with disabilities is taken into account. (UK Department of International Development)

In Tanzania, households with disabled members are 20% more likely to be living in poverty. (UK Department of International Development, 2005)

“98% of children with disabilities in developing countries do not attend school.” Earlier studies by UNESCAP and UNICEF show that this deplorable condition also applies to the Asia-Pacific region, where only around 2% of children with disabilities – one in every fifty children – have access to education of any sort. (UNESCO Bangkok)

Worldwide, only 2% of disabled children get any schooling. (Action on Disability and Development, 2006)

Men, women and children who are discriminated against often end up excluded from society, the economy and political participation. They are more likely to be poor. (UK Department of International Development, 2005)

Women and girls with disabilities face double discrimination based on disability and gender. As a group, they fare far worse than nondisabled women or disabled men on most indicators of financial, educational and vocational success.” (Mobility International USA, 2002)
• Enthusiastic, creative students who are excellent engineers and work for FREE

• Resources, facilities, manpower to pursue high risk/high payoff projects that workshops or NGOs may not otherwise be able to develop

• A fresh perspective on wheelchair problems; new students ever year

• Opportunities for cross-cultural, collaborative exchange of ideas

• World-wide recognition of MIT draws attention to wheelchair issues
Goal: By partnering with expert organizations, MIT can aid in making great improvements to mobility technology in developing countries.

**Innovation**

- Next generation of great technical minds
- Excellent facilities/resources
- Strength of MIT reputation
- Specialize in sound engineering and innovation
- Students work for free

**Local knowledge**

- Best understanding of community
- Working directly with wheelchair users
- Knowledge of local factors: parts/materials, labor skill, cultural stigmas, terrain

**Experience**

- 30+ years designing wheelchairs
- Experts in wheelchair requirements for developing countries
- World-wide workshop network
PERSONAL MOTIVATION TO IMPROVE WC TECHNOLOGY
Summer 2005: Assessment of WC technology in Tanzania

Supervision organizations
• Tanzanian Training Center for Orthopedic Technologists, Moshi, TZ
• Whirlwind Wheelchair International, San Francisco, USA

Interview locations

Parties interviewed
Wheelchair users
Wheelchair workshops
Wheelchair advocacy groups
• Up to $350 price gap between what chairs cost and what people can afford

• Most people rely on donations to acquire a wheelchair

Largest donor in TZ

Wheelchair Foundation

“Serving the World”

• Since 2000, WC Foundation has donated nearly 7,000 WCs in Tanzania

• Each WC foundation chair costs $150US, $50 to $100 less than Tanzanian WCs but same price as TZ tricycles
• 65% crawled on the ground before current mobility aid
• Mean age when acquired first mobility aid is 21
• In TZ, 2,000 people have a wheelchair, 30,000 to 50,000 need one.
- 36% interviewees traveling more than 5km per day
- Largest fraction of interviewees (37%) using a tricycle
- Tricycles much more common (75% of sales at APDK, Kenya)

Tanzanian public bus

Tanzanian-made trike

TZ WHEELCHAIR ASSESSMENT
Opportunities to better serve user needs
TZ WHEELCHAIR ASSESSMENT
Opportunity to design mobility aids to better serve users

Common mobility aids available in East Africa

USA/Europe designed, African made

African designed, African made

USA designed, foreign made

First USA wheelchair patent
A.P. Blunt, et. all., 1869
LEVERAGED FREEDOM CHAIR
A wheelchair designed specifically for developing countries

Video
How it works

• Pedal forwards: you drive normally

• Pedal backwards: normal chain ratchets at wheel and figure-8 chain drives forward
2008 CLASS PROJECTS

Tricycle Attachment

The Learning Desk
To read more about Danielle DeLatte’s work on this project, check out her blog:

http://empoweringmobility.blogspot.com/

Check out the powertrike video at:

http://www.youtube.com/watch?v=4GNJWxXvQIs
2010 PROPOSED PROJECTS
1. Continuation of the powertrike project

Objectives:

- Create a product that can be sold in East Africa for ~$500 to $1000
- Explore importing product or locally producing

Project details:

- User needs to be able to easily transfer on and off trike
- Need to be able to start tricycle when stationary (e.g. with a starter motor)
- Product needs to be locally-repairable, if not also locally-manufacturable.
Objective: Design a mobile post office for Indian tricycles

Project details

• Low cost (<$50)
• Does not adversely affect tricycle performance
• Wet weather protection
• Compartments to carry stamps, money, letters
• Locally-manufacturable by tricycle makers
2010 PROPOSED PROJECTS
3. Small businesses run from wheelchairs

**Objective:** Identify ways disabled people can buy their own mobility aid and use it to generate an income.

**Project details**
- Identify small business opportunities
- Develop business models for each wheelchair-based business
- Locate resources to allow people to buy own chairs
  - Micro loans
  - Pay-over-time plan from manufacturers
- Optimize usage of available materials and processes
- Work with mechanical engineers to prototype add-ons to wheelchairs to facilitate business
4. LFC continued development and production tooling

Objective: Prepare LFC for next trial and begin to design production tooling

Project details

- Required LFC revisions
  - Reduce width
  - Lighten frame
  - Lower seat 4” and move rear wheels back 2”
  - Improve caster geometry
  - Improve brake placement and adjustability

- Production tooling required to improve repeatability and speed in manufacturing
• Rank the projects in order of preference
  – Project teams formed next Tuesday 2/9

• Readings (posted on course website)
  – International Society of Prosthetics and Orthotics (ISPO): “Wheelchair” article
  – Whirlwind Wheelchair International: “Proposal to develop standards for wheelchair provision services” article
  – A. Winter: “Assessment of wheelchair technology in Tanzania”
NEXT CLASS
Wheelchair relay race

Start
8-205

Turnaround in
E25

Finish
1-005