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EC.721 Wheelchair Design in Developing Countries
Spring 2009

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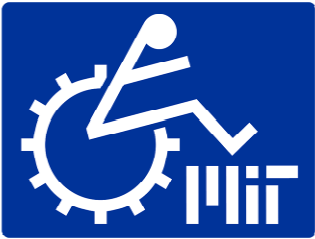


**WHEELCHAIR DESIGN IN
DEVELOPING COUNTRIES**

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

Amos Winter

PhD Candidate, MIT Dept. Mechanical Engineering



COURSE INFO

Lecturers: Amos Winter, PhD Candidate, Mechanical Engineering
Amy Smith, Senior Lecturer, Mechanical Engineering

Units: 2-2-5 (Lecture-Lab-Homework)

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

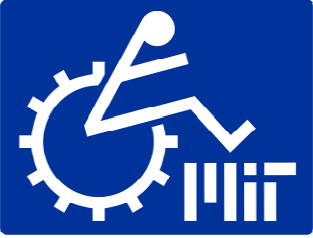
Project and Labs: Project teams and class presentation times chosen next Thursday. Lab groups will choose own meeting time.

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
- Team website: 20

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PROJECT

Team: 3 to 5 members with lab instructor

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

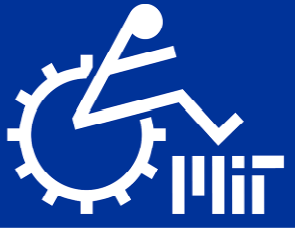
Courtesy of Whirlwind Wheelchair International. Used with permission.



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
- Weekly update emails to community partners and mentors

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RESOURCES

Monetary: \$4000 for prototyping (entire class budget)

Manufacturing:



Parts: African wheelchairs and bicycle components

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FELLOWSHIPS



- ~7 available
- Bring WDDC technology back to partner workshops
- Work in any or all 14 partner shops
- ~10 weeks duration
- Apply through PSC Fellowship process or other funding sources
- Develop your project proposal through SP.719

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WDDC SYLLABUS

Week #	Tuesday	Thursday	Assignments	Milestones
1 (2/2)	Introduction to wheelchairs in developing countries and review of potential projects	Wheelchair/Trike relay race around campus	Readings about wheelchair usage and distribution, Review projects	
2 (2/9)	2007 summer fellow presentations on last year's projects Alison Hynd speaking from the PSC about summer fellowships	Designing wheelchairs for the developing world and deterministic design process Choose project teams	Read 2.007 lecture notes on design process, define functional requirements of project, Reading from Nothing about us without us, watch videos of wheelchair workshops and PAWBA conference	
3 (2/16)	Monday schedule	Guest Speaker: Joost Bonsen Developmental Entrepreneurship	Reading from HBS case study "Note on Marketing Strategy"	
4 (2/23)	Abdullah and Daniel speaking to class	Abdullah and Daniel speaking to class	Reading from Independence through Mobility, 3/5-Encouraged to visit 2.007 lecture, 3/8-Encouraged to visit 2.007 lecture	Strategy presentations, time TBD
5 (3/2)	Guest speaker: Amy Smith and Amy Banzaert Appropriate technology, idea to product, successfully implementing technologies	Wheelchair role-play Results from Tanzanian Wheelchair Foundation Study	Readings about different appropriate and inappropriate technologies	
6 (3/9)	Wheelchair Biomechanics/Ergonomics and design for human use	Power output test up ramp in basement	Power calculations from class activity, reading from Positioning a Wheelchair, 3/1 - Encouraged to visit 2.007 lecture	
7 (3/16)	Manufacturing processes and strategies Watch video from local workshops in Africa and Vietnam. Watch economies of scale presentation from PAWBA conference.	Product design and critique of existing wheelchair designs	Reading from Mastering the Machine	Concept presentations, time TBD
8 (3/23)	Spring break	Spring break		
9 (3/30)	Material science/ mechanics of materials/welding with Mike Tarkanian	Material science/ mechanics of materials/welding with Mike Tarkanian	Reading from Mechanical principles of wheelchair design	
10 (4/6)	Watch "Murderball" in class Amos at conference	Finish "Murderball" and watch parts of "Emanuel's Gift" Amos at conference	Write short comment on the two movies, discuss portrayal of disability, mobility, public perception Project work	
11 (4/13)	Guest speaker: Ralf Hotchkiss Talking about his career and designing wheelchairs	Guest speaker: Ralf Hotchkiss Talking about his career and designing wheelchairs	Project work	Most critical module (MCM) presentations, time TBD
12 (4/20)	Guest Speaker: Prof. David Gordon Wilson Human-powered machines	Guest Speaker: Rory McCarthy Handcycle design and racing	Reading on wheelchair user image Project work	
13 (4/27)	Project work	Project work	Project work	
14 (5/4)	Project work	Project work	Project work	Poster and presentation for MIT Museum on Sat, 5/9
15 (5/11)	Project work	Project work	Project work	Final presentation of project with a working prototype, time TBD

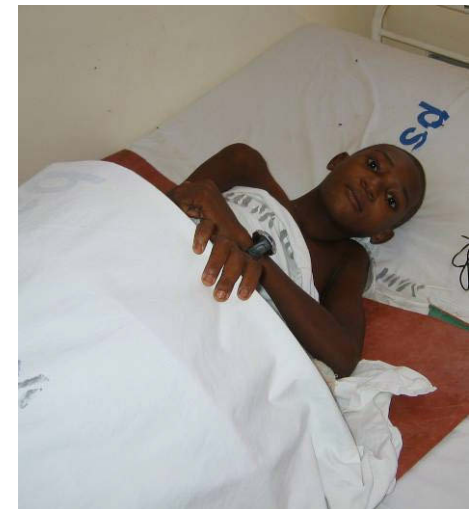
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MOTIVATION World's disabled

- 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)



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MOTIVATION Need for wheelchairs

- 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)

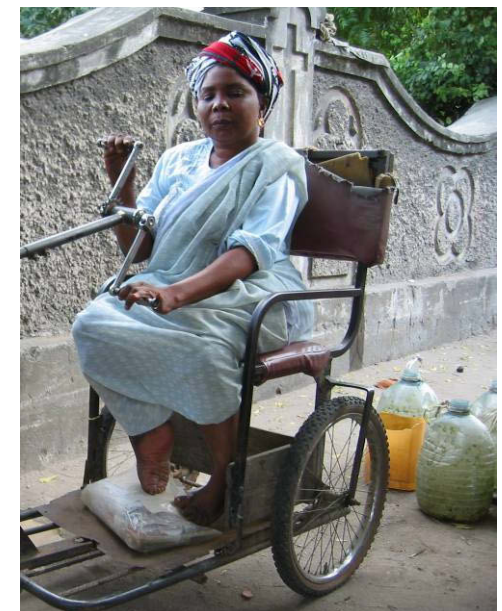
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MOTIVATION

Consequences due to lack of mobility

- **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)



(Statistics provided by Motivation UK)

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ROLE OF MIT IN DEVELOPING WHEELCHAIR TECHNOLOGY

What MIT can offer

- 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 every year
- Opportunities for cross-cultural, collaborative exchange of ideas
- World-wide recognition of MIT draws attention to wheelchair issues



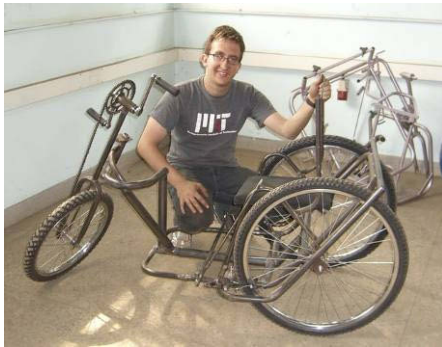
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BETTER TECHNOLOGY THROUGH COLLABORATION

Goal: By partnering with expert organizations, MIT can aid in making great improvements to mobility technology in developing countries

Innovation



MIT

- 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



Example: Mobility Care

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

Experience

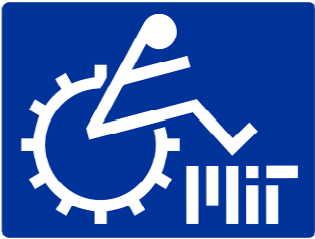


Courtesy of Whirlwind Wheelchair International. Used with permission.

Example: Whirlwind

- 30+ years designing wheelchairs
- Experts in wheelchair requirements for developing countries
- World-wide workshop network

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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



Map courtesy of CIA.

Parties interviewed



Wheelchair users

Wheelchair workshops



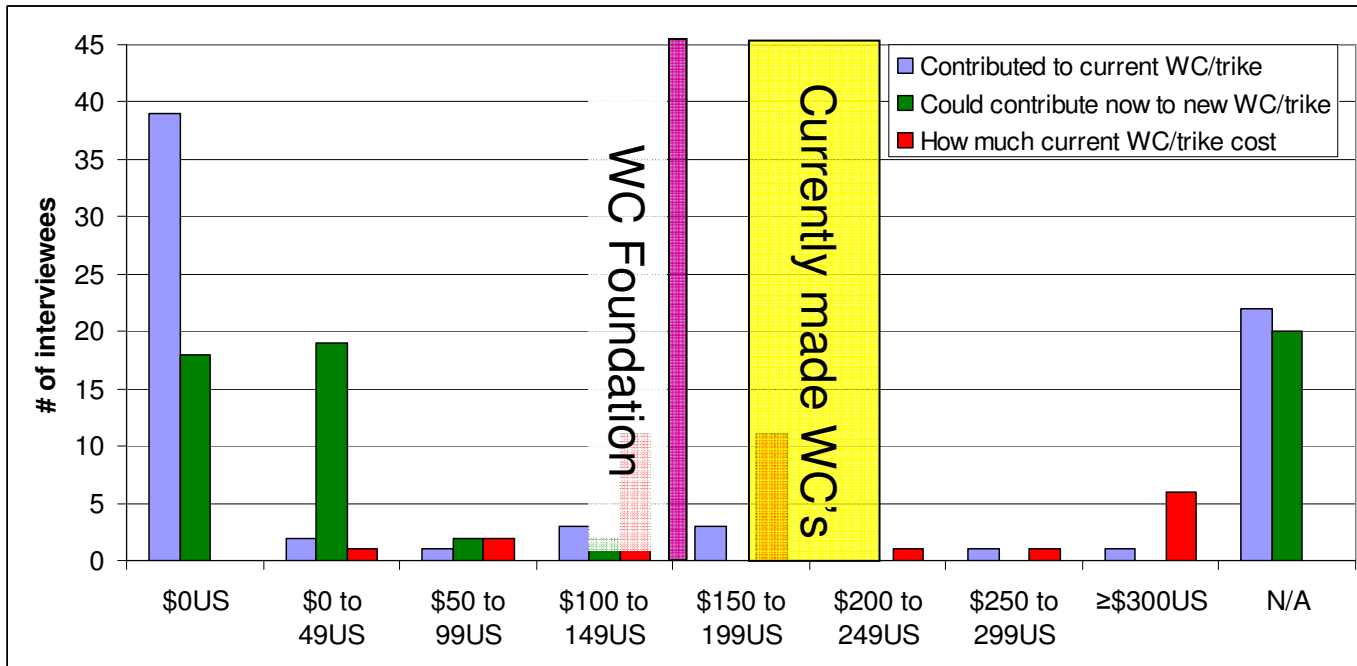
Wheelchair advocacy groups

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TZ WHEELCHAIR ASSESSMENT

Opportunities for purchasing and competing with imports



- \$100 to 150 price gap between what chairs cost and what people can afford
- Most people rely on donations to acquire a wheelchair

Largest donor in TZ

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

Image removed due to copyright restrictions. Photo of Wheelchair Foundation chair.

•Each WC foundation chair costs \$150US, \$50 to \$100 less than Tanzanian WCs but same price as TZ tricycles

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TZ WHEELCHAIR ASSESSMENT

Opportunities for improved distribution/procurement

- 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.

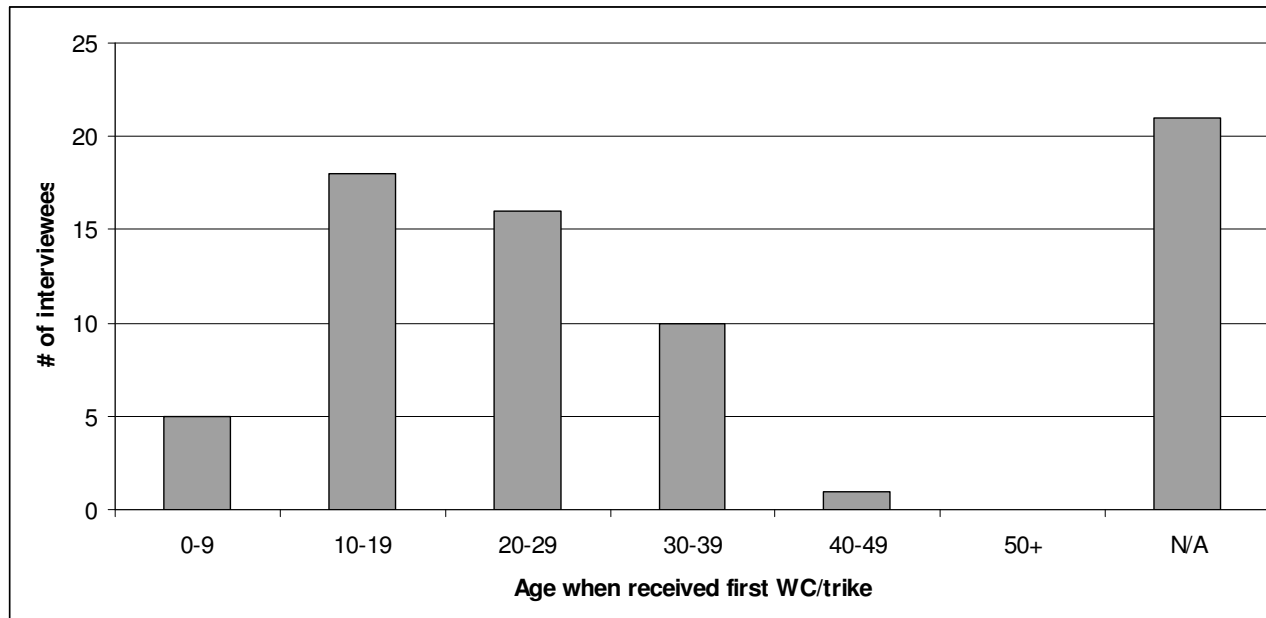
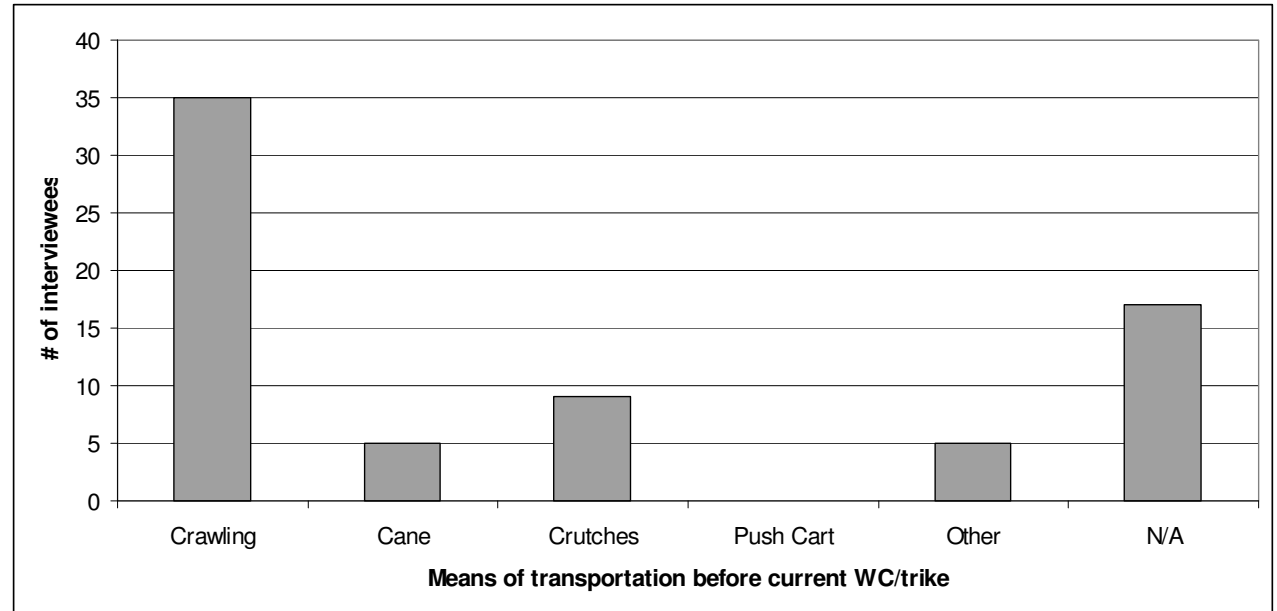


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TZ WHEELCHAIR ASSESSMENT

Opportunities to better serve user needs

- 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

Photo courtesy of Brother Rewd on Flickr.

Tanzanian-made trike



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TZ WHEELCHAIR ASSESSMENT

Opportunity to design mobility aids to better serve users

Common mobility aids available in East Africa

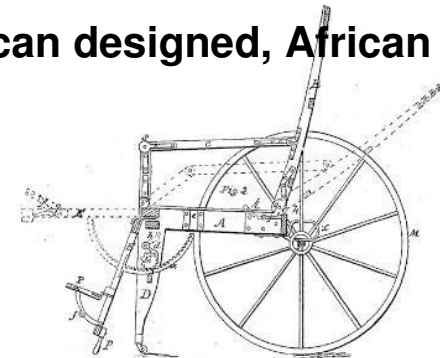


USA/Europe designed, African made

Photos removed due to copyright restrictions.
Chair by Free Wheelchair Mission, with plastic lawn chair as seat.

USA designed, foreign made

African designed, African made



**First USA wheelchair patent
A.P. Blunt, et. all., 1869**

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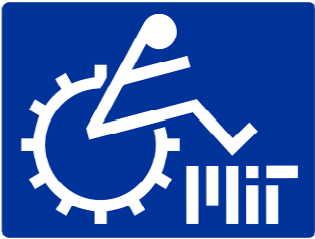
LEVERAGED FREEDOM CHAIR

A wheelchair designed specifically for developing countries



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Photos courtesy of MIT M-Lab.



WHEELCHAIR DESIGN IN DEVELOPING COUNTRIES

Established in 2007

Motivation: Engage many bright students in advancing wheelchair technology

Activities of students in the class:

- Use science and technology to improve the lives of others
- 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



Courtesy of Whirlwind Wheelchair International. Used with permission.

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PARTNER WORKSHOPS

How class projects were defined

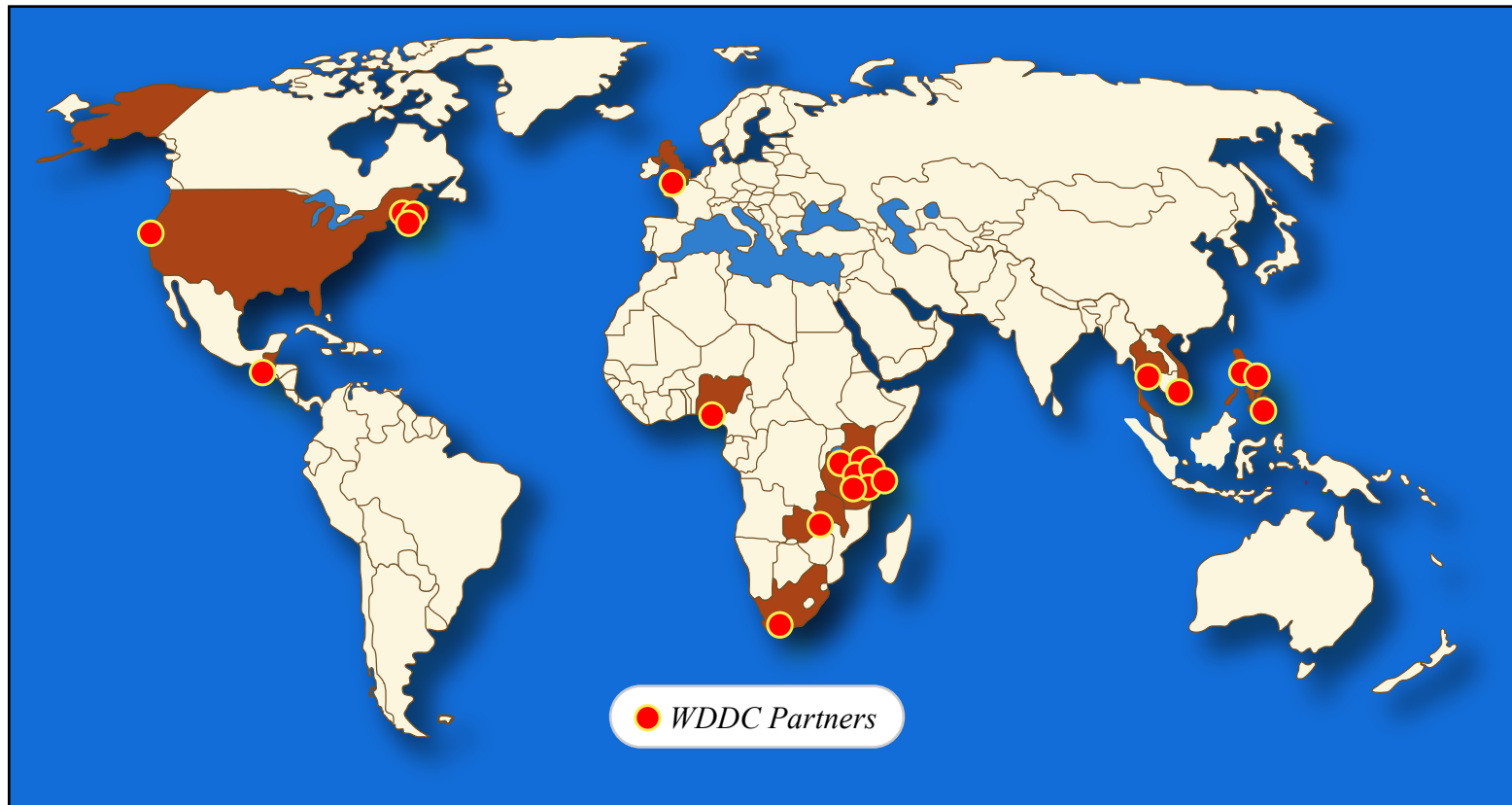
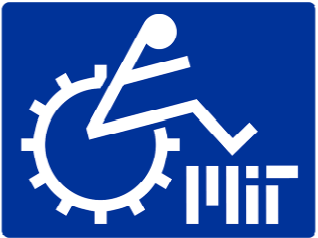


Figure by MIT OpenCourseWare.

10 countries in Africa, Southeast Asia, and Central America

14 partner workshops

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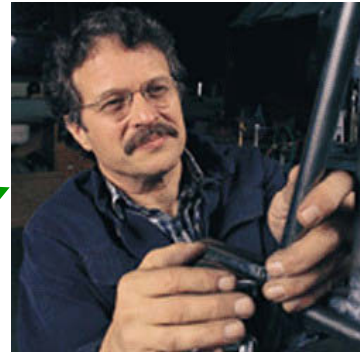
Class project cycle

Disseminate



Refine projects with workshops (Aug-Sept)

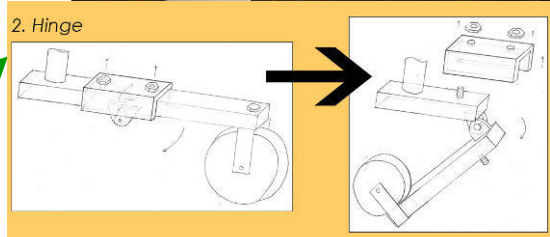
Collaborate



Wheelchair experts
Courtesy of Whirlwind Wheelchair International. Used with permission.



Students travel to workshops

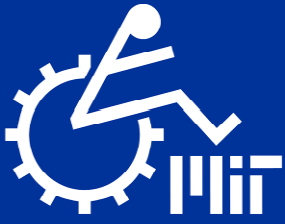


2. Develop ideas and prototype (Feb-May)

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3. Test and implement (June-July)



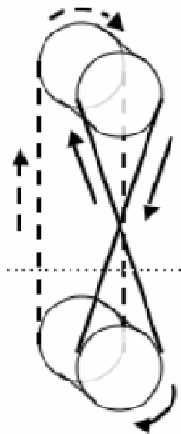
2007 CLASS PROJECTS

2-speed tricycle



How it works

- Pedal forwards: you drive normally
- Pedal backwards: normal chain ratchets at wheel and figure-8 chain drives forward



Marketing strategies for workshops



How to Make a Web Site at an Internet Cafe!

Learn the basic principles of good Web site design, and get started with making a Web site, with no previous experience required!

Welcome!

Having a Web site can allow you to distribute information across the globe without leaving your seat—giving you the ability to disseminate information from one side of the globe to the other.

Chapters

0. About this Guide
1. Welcome
2. Importance of...

COMMON PROBLEMS FROM IMPROPER WHEELCHAIRS

BACK SUPPORT
It is crucial to get a wheelchair that has been fitted to your size and provide adequate back support. Chairs that do not properly support the back and trunk back pain.

SHOULDER INJURIES
Improper positioning of the wheelchair wheels to your body and cause inflammation and pain in the muscles, and tendons. This will severely damage the shoulder or make it unstable. Again it is important to have a well fit chair that positions the shoulders over the axle.

CONTRACTURES
Keeping limbs immobile can cause a stiffness to develop in the joints and you will be unable to straighten the affected limb. To prevent this, make sure that your wheelchair is and fits your size and has proper support for the legs, trunk and feet.

PRESSURE SORES
Pressure sores are open wounds that develop near bony areas such as the feet and seat bones. In these areas where there is little mobility, pressure builds up and blood cannot flow. This causes tissue in the area to die. If left untreated this tissue becomes infected and may lead to death.

QUESTIONS TO ASK YOUR WHEELCHAIR MANUFACTURER

- ✓ Will the wheelchair be adjusted to fit my body?
- ✓ Is there a pressure relieving cushion?
- ✓ Can I receive any training to learn how to use the wheelchair?
- ✓ Are spare parts and repairs available and what are their costs?
- ✓ How durable is this chair?
- ✓ How long will it last?
- ✓ How are the models different?
- ✓ Tell the manufacturers what you will be using the chair for and ask them what will be an appropriate purchase for those needs.
- ✓ Don't be afraid to ask questions. The employees are there to serve you.

For more information speak to your doctor, and visit a local wheel chair workshop.

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Courtesy of Mario Bollini. Used with permission.

Courtesy of Shirley Fung. Used with permission.



2008 CLASS PROJECTS

Tricycle Attachment



The Learning Desk



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Photos courtesy of MIT M-Lab.