



WHEELCHAIR DESIGN IN DEVELOPING COUNTRIES

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

Amos Winter (awinter@mit.edu), PhD Candidate, ME Dept.
Mario Bollini (mbollini@mit.edu), Mechanical Engineer, Vecna



WHEELCHAIR DESIGN IN DEVELOPING COUNTRIES

Established in 2007

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**

mobility care Wheelchairs made in Africa for Africa



The alternative

MobilityCare wheelchairs are made of locally available materials. They are fitted with common bicycle tires that are available in any village. Each model can be tailor-made to suit the client's needs.



For disabled people here in Tanzania a wheelchair makes the difference between being stuck at home and having the freedom to get out. An opportunity to go to the market, to school, to work, and the chance to live a better life.

The problems in the past

In Africa most imported items that are not in conditions that get stuck in in-store yards at Soko or take the disrepair that a new tire or the metal repaired, and abandoned.

About MobilityCare

MobilityCare aims to work with educational health workers. Orthopedic departments can consult about the size of wheelchair needed. The home situation of a wheelchair applicant should be assessed before and after obtaining a wheelchair.

MobilityCare encourages its organizations to opt for durable, subsidizing local wheelchair purchase. Buying a locally wheelchair means an increased local capacity building.

MobilityCare also offers training helps technicians to start a production workshops. One this should lead to a regional service network.

Technicians who know how to use and how to make a wheelchair. They guarantee user-friendly products.





COURSE INFO

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



WDDC SYLLABUS



SP.784 WHEELCHAIR DESIGN IN DEVELOPING COUNTRIES



COURSE INFO

COURSE INFO

DESCRIPTION SYLLABUS SPONSORS



PROJECTS

DESCRIPTION:



LECTURES



ASSIGNMENTS



RESOURCES



PEOPLE

According to the [United States Agency for International Development](#), 20 million people in developing countries require wheelchairs, and the [United Nations Development Programme](#) estimates below 1% of their need is being met in Africa by local production. Wheelchair Design in Developing Countries (WDDC) gives students the chance to better the lives of others by improving wheelchairs and tricycles made in the developing world. Lectures will focus on understanding local factors, such as operating environments, social stigmas against the disabled, and manufacturing constraints, and then applying sound scientific/engineering knowledge to develop appropriate technical solutions. Multidisciplinary student teams will conduct term-long projects on topics such as hardware design, manufacturing optimization, biomechanics modelling, and business plan development. Theory will further be connected to real-world implementation during guest lectures by MIT faculty, Third-World community partners, and US wheelchair organizations.

In past years many SP.784 students have continued their projects abroad with community partners. This year SP.719 is being offered for students interested in applying for funding to continue SP.784 or other service projects abroad during the summer, IAP, or after graduation. The aim of the seminar is to guide students through the funding application process. Lectures will focus on elements of a good project, finding sources of funding, how to construct a project, and how to write a successful proposal. As a requirement of the seminar, each student will write a proposal and have it reviewed by MIT Public Service Center staff.

Course Syllabus



PROJECT

Team: 3 to 5 members with lab instructor

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



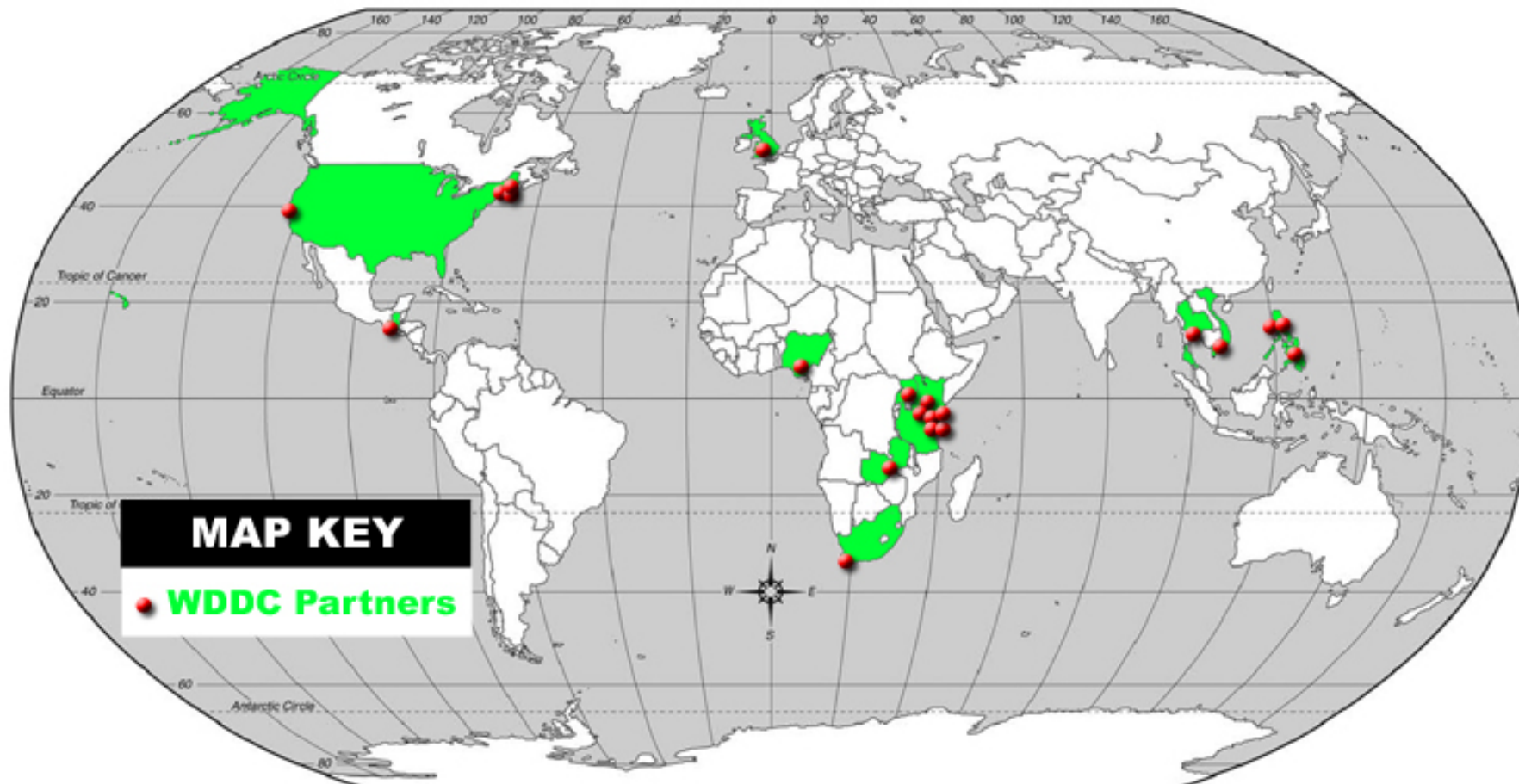
Deliverables:

- PowerPoint presentation for the Strategy, Concept, MCM, and Final prototype.
- Poster for The MIT Museum in May
- Prototypes: Physical solution to each team's 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



SP.784 WHEELCHAIR DESIGN IN DEVELOPING COUNTRIES

Class project cycle

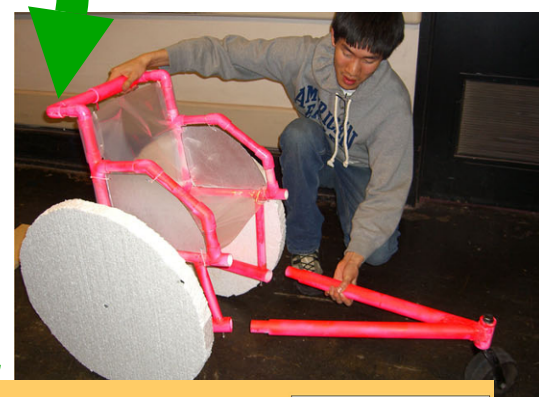
Disseminate

Collaborate

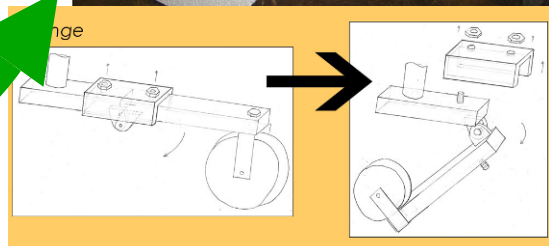
Wheelchair experts



1. Define projects with workshops (Aug-Sept)



Students travel to workshops



2. Develop ideas and prototype (Feb-May)



3. Test and implement (June-July)



RESOURCES

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

Manufacturing:



D-Lab



The Edgerton Center
Student Shop



Parts: African wheelchairs and bicycle components

Lab Space: M-Lab, basement of E34, part of D-Lab space



FELLOWSHIPS



- 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



PROJECT CONTINUATION AND AWARDS



M-Lab awards page

GLAMOUR IN THE MAGAZINE

SUBSCRIBE Get a FREE tote bag set!!

HOME fashion beauty sex, love & life **NEW!** weddings health & fitness +

Glamour / Magazine

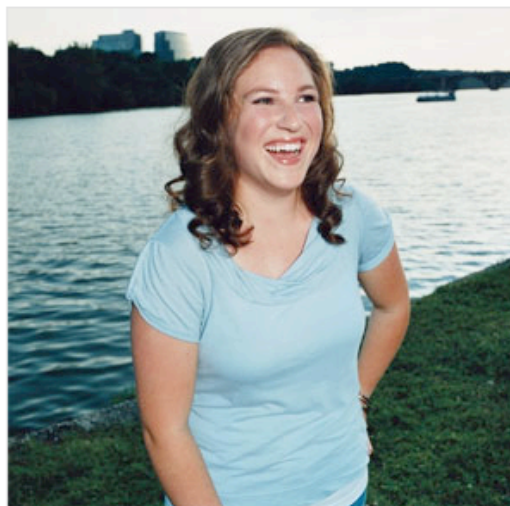
PRINT E-MAIL FEEDS SHARE YAHOO BUZZ

Glamour's 2009 Top 10 College Women

CONTINUED (PAGE 8 OF 12)

September 1, 2009

by Erin Zammett Ruddy



Scolnik in Washington, D.C., where she interned with the World Bank this summer

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."



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)





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)





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)





ROLE OF MIT IN DEVELOPING WHEELCHAIR TECH

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





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



Example: Whirlwind

- 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

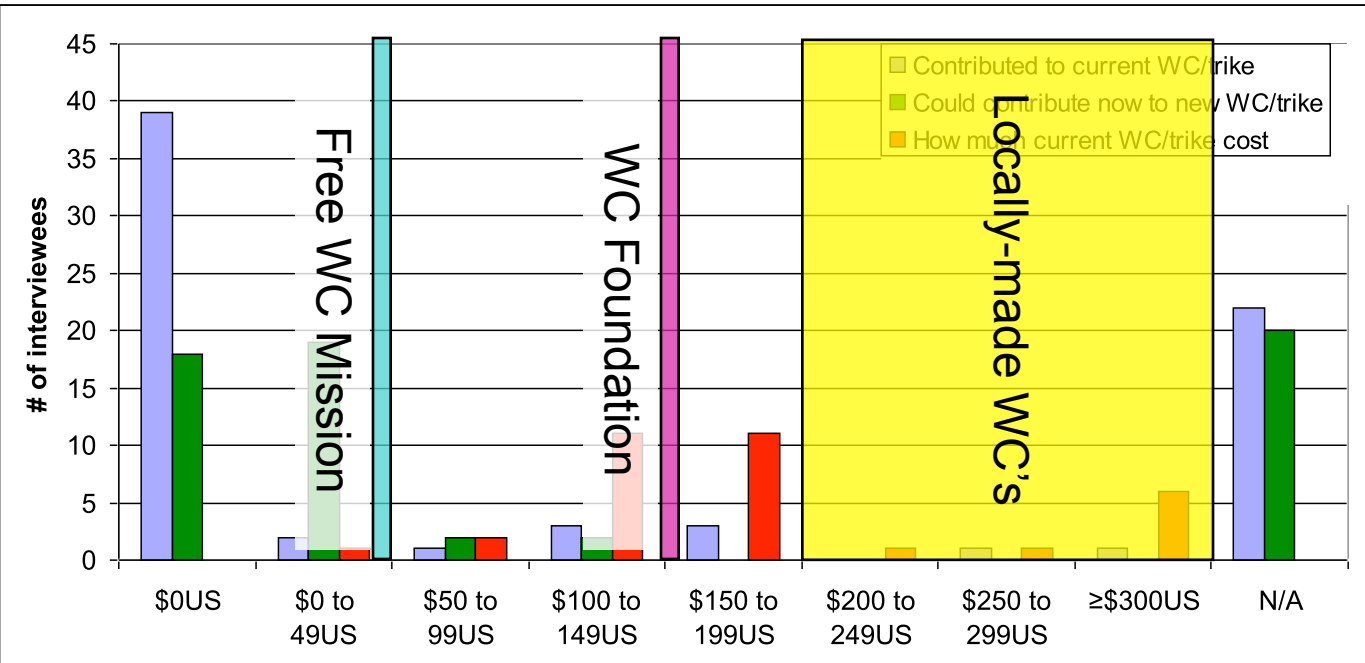


Wheelchair advocacy groups



TZ WHEELCHAIR ASSESSMENT

Opportunities for purchasing and competing with imports



- 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



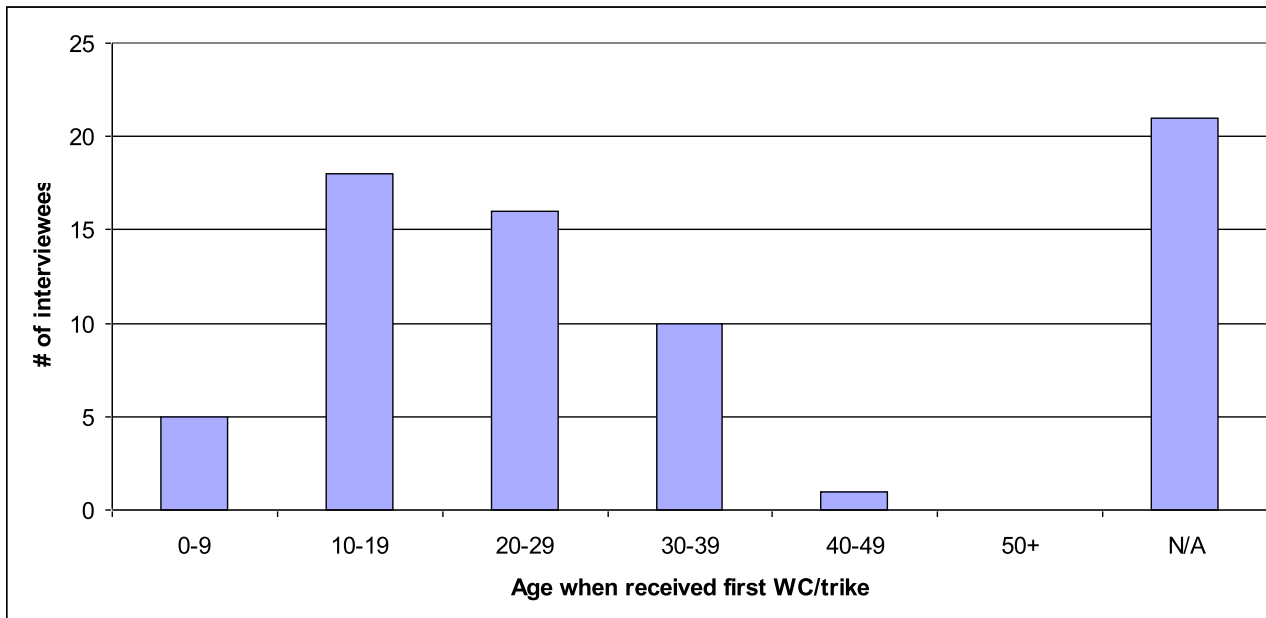
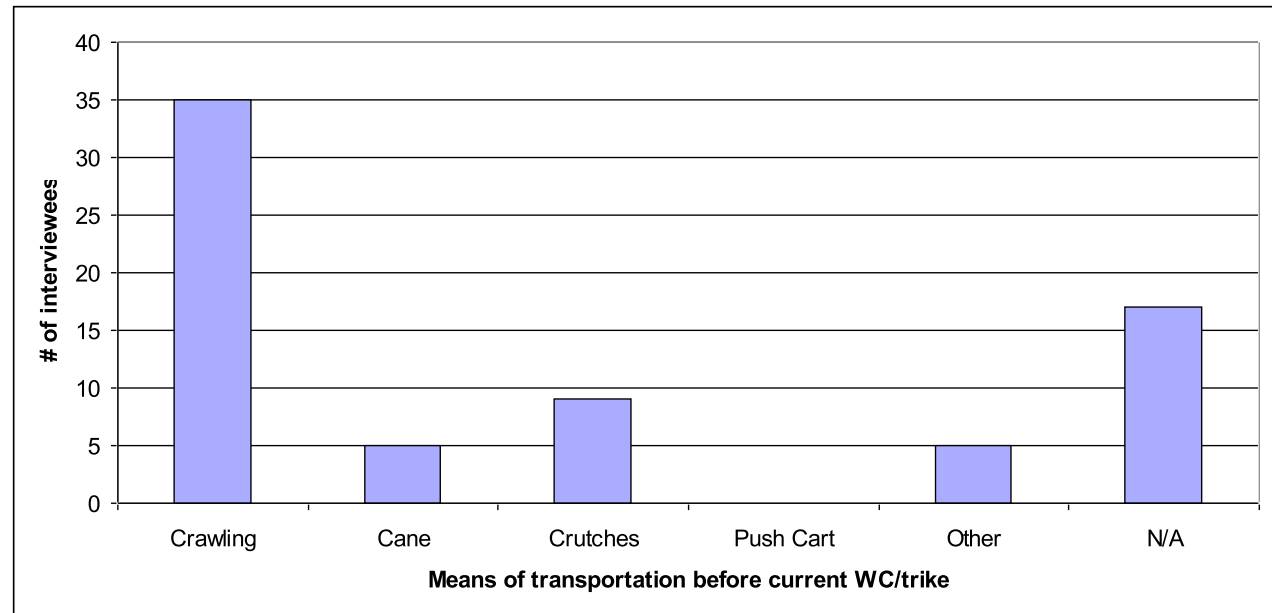
- Since 2000, WC Foundation has donated nearly 7,000 WCs in Tanzania
- Each WC foundation chair costs \$150US, \$50 to \$100 less than Tanzanian WCs but same price as TZ tricycles



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.

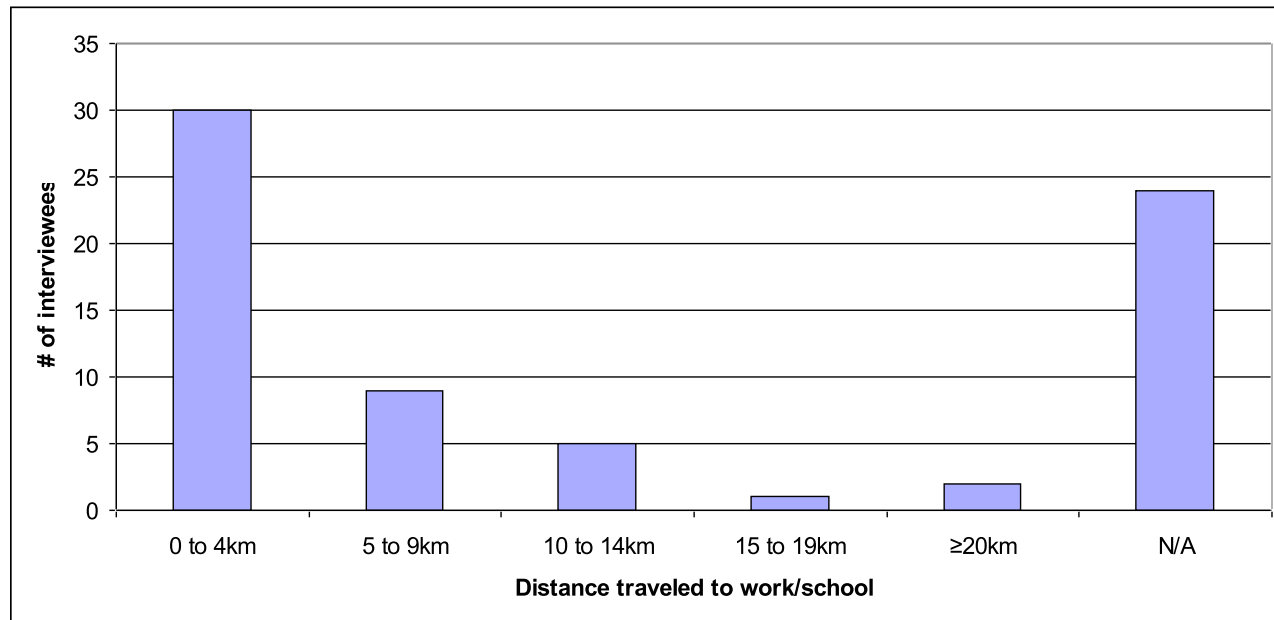




TZ WHEELCHAIR ASSESSMENT

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



Tanzanian-made trike



TZ WHEELCHAIR ASSESSMENT

Opportunity to design mobility aids to better serve users

Common mobility aids available in East Africa



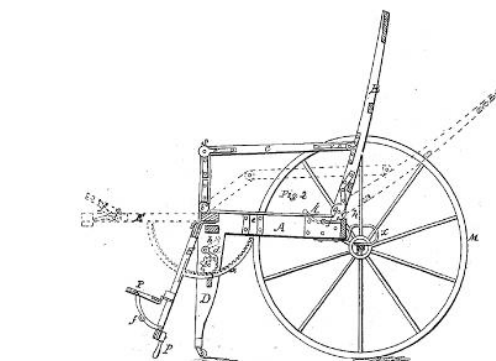
USA/Europe designed, African made



African designed, African made



USA designed, foreign made

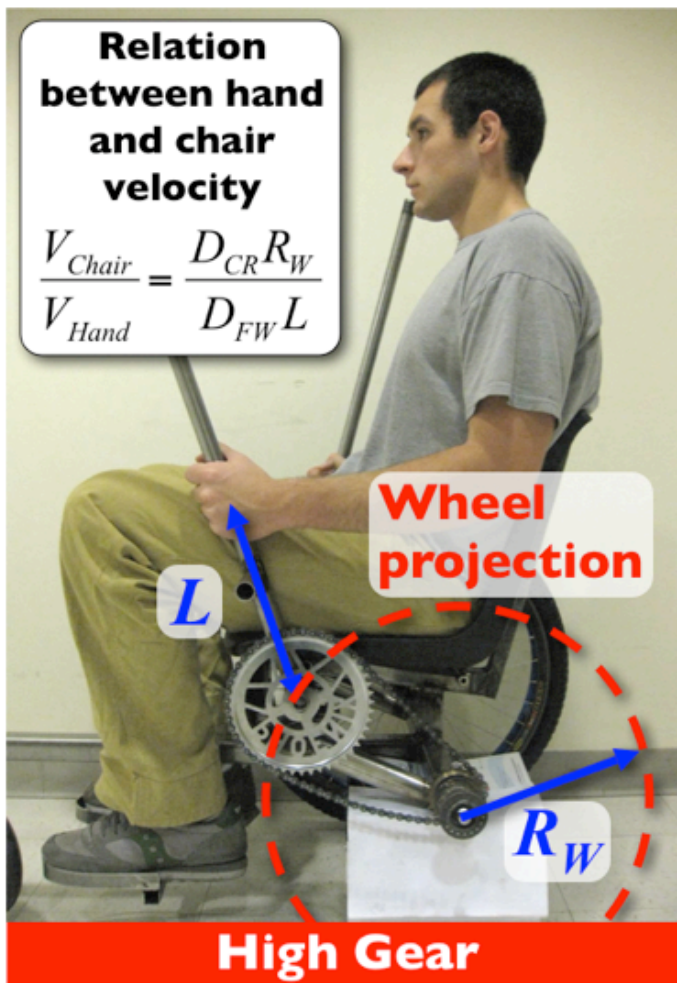
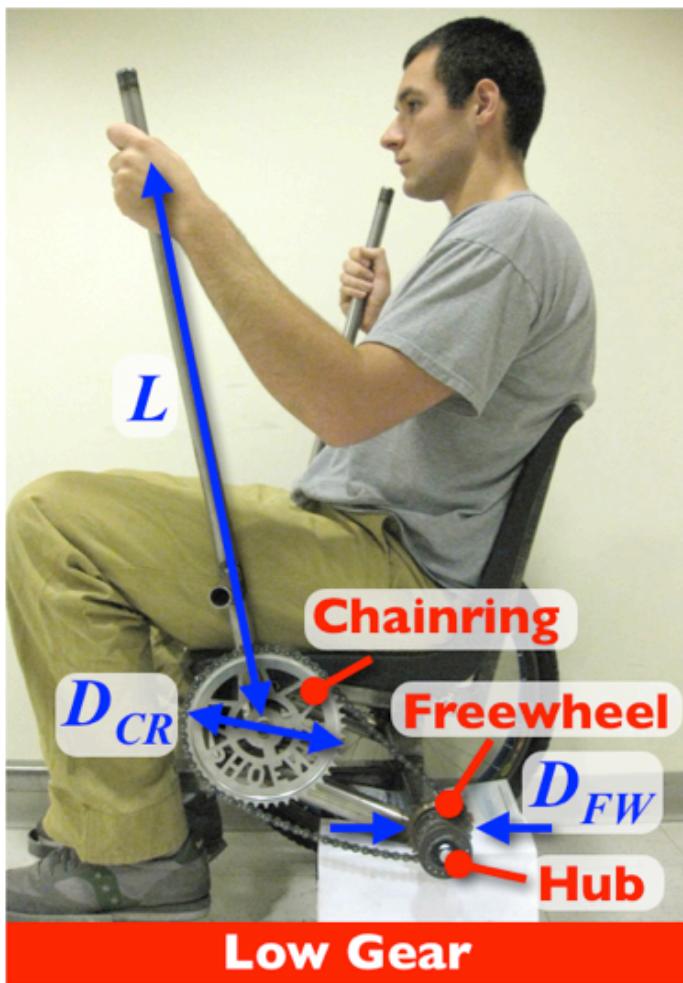


First USA wheelchair patent
A.P. Blunt, et. al., 1869



LEVERAGED FREEDOM CHAIR

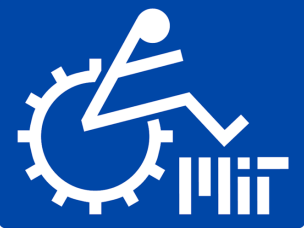
A wheelchair designed specifically for developing countries



Relation between hand and chair velocity

$$\frac{V_{Chair}}{V_{Hand}} = \frac{D_{CR} R_W}{D_{FW} L}$$

[Video](#)



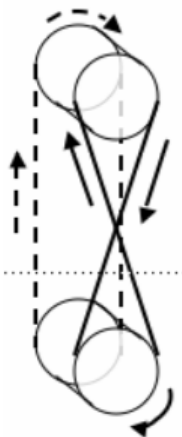
2007 CLASS PROJECTS

2-speed tricycle

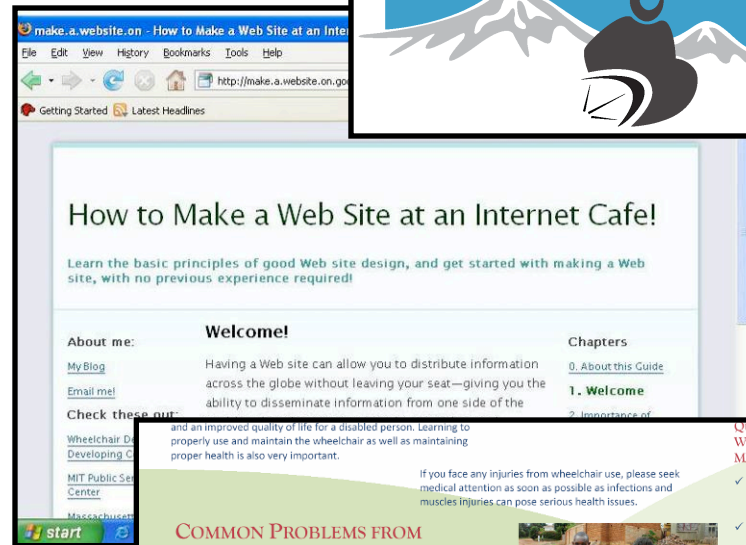
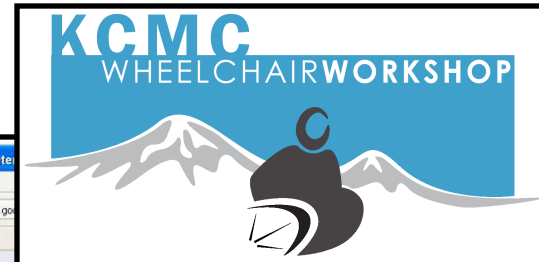


How it works

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



Marketing strategies for workshops



and an improved quality of life for a disabled person. Learning to properly use and maintain the wheelchair as well as maintaining proper health is also very important.

If you face any injuries from wheelchair use, please seek medical attention as soon as possible as infections and muscles injuries can pose serious health issues.

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 wheelchairs wheels to your body and cause inflammation and pain in the muscles and tendons. This will severely damage the shoulder or make it unstable. A gain 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.

To prevent pressure sores, it is important to periodically change body position and use a pressure relieving cushion in your wheelchair. Cushions can collapse and leave you vulnerable to sores so it is crucial to maintain the wheelchair's cushions. Well fitting chairs also help prevent pressure sore.

If you face any injuries from wheelchairs, please seek a medical attention as soon as possible to treat them. Infections and muscle injuries can pose serious health issues.

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

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.



2008 CLASS PROJECTS

Tricycle Attachment



The Learning Desk





2009 CLASS PROJECTS

Worldwide Mobility

Worldwide Mobility Empowering personal mobility worldwide

Worldwide Mobility seeks to empower individuals with disabilities through the dissemination of appropriate mobility aids in the developing world. We collaborate with foreign educational organizations to deliver quality mobility aids to people with disabilities, providing them with a means to social, educational, and economic opportunities.

<p>WM Website/Donor</p> <ul style="list-style-type: none"> Provide interactive area for donors to view workshop profiles. Allow purchase of locally made wheelchair (profile). Interface for workshops to upload profiles. Use crowdfunding for donations. Monitor site traffic. Blog, videos, media. 	<p>Paypal</p> <p>Conditions:</p> <ul style="list-style-type: none"> Create sub-administrator for each workshop. Fund Transfer: Funds immediately transfer to Paypal. Workshop transfer to bank account in U.S. Business plan. Direct transfer to domestic bank. Wikipedia/FAQ: 1,250+ 50,000 post transactions. Direct email to 100 U.S. application experts. 	<p>Bank Account</p> <p>Activity: International transfer from WM account to NGO account.</p> <ul style="list-style-type: none"> Use bank website or existing bank through SWIFT for Worldwide Interbank Financial. Sub-administrator (partner). Several issues for transfer of the funds. Use national money wire transfer through each office or bank for bank transactions. Fast transaction rates in transfer. 	<p>Regional NGO</p> <p>Receive donations through website directly from WM.</p> <ul style="list-style-type: none"> Monitor workshops and transfer donations to workshop. Upload user profiles through WM website account. Use local ATM. 	<p>Workshop</p> <p>Receive donation from local contact.</p> <ul style="list-style-type: none"> Direct care profiles. Assessment for the temporary disability of Kenya (AFDK). Received financial administration, billing. Alternative wheelchairs and mobility. AFDK Contact: Mr. Peter Mbugua (ask for photo, Reliable, Organized, Efficient).
--	---	--	---	---

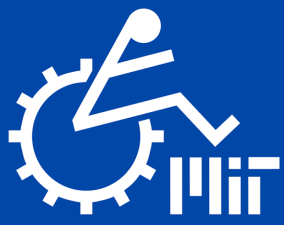
<p>Final Resolutions</p> <ul style="list-style-type: none"> Calibrate funding model. Define relationship between WM and AFDK. Make common with AFDK. Create customizable template for working with other partners. 	<p>Looking Ahead</p> <ul style="list-style-type: none"> Expansion. 700,000. Costing analysis. Open Bank account. Open Paypal. Managing Risk. Define Success criteria. 	<p>Team</p> <p>Danielle DeLatte, engineering, electronics and Administration</p> <p>Barbara McManis, engineering, Biology</p> <p>Axel Moran, engineering, Brain and Cognitive Sciences</p> <p>Lee Tascorin, junior, Mechanical Engineering</p> <p>Francis Hornsby, student</p> <p>Dakshini Sathya, member</p>
---	---	--

To read more about Danielle DeLatte's work on this project, check out her [blog](http://empoweringmobility.blogspot.com/)

Powertrike



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.





2010 PROPOSED PROJECTS

2. Indian handcycle post office

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

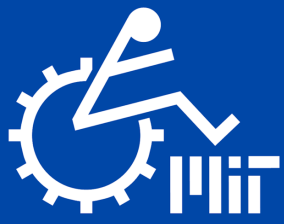
- Identify small business opportunities
- Develop business models for each wheelchair-based business
- Locate resources to allow people to buy own chairs
 - Micro loans
 - Pay-over-time plan from manufacturers
- Optimize usage of available materials and processes
- Work with mechanical engineers to prototype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



Ex) Mobility Care mobile phone credit seller chair



Ex) APDK retractable mobile phone tray



2010 PROPOSED PROJECTS

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





HOMEWORK

Due at beginning of next class

- 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

