D-LAB HEALTH
SP 725
Jose Gomez-Marquez
Course Guide

- Overview
- Grading
- Trip
- Projects
Course Goals

- Learn about the distinctive medical challenges of the developing world
- Learn to identify medical improvisations in the field
- Learn hands-on prototyping and medical design skills
- Learn how to address safety, regulatory, and ethical challenges in device design
Class Attendance Expectations

- Lectures (PowerPoint) will be posted on web-site after the fact
- You must attend lectures- PowerPoint bullets don’t contain
  - Background
  - Discussion
  - Q and A
  - Context
Nature of the Course

- Lectures
- Material Discussion
- Hands-on work
- Teamwork
- Grading
  - Class participation and attendance 20%
  - Homework assignments 15%
  - Lab notebooks and assignments 25%
  - Presentations and design reviews 25%
  - Final design/prototype 15%
Focus of our class are devices. The following are not the purpose:

- To teach you CAD tools
  - Though rapid prototyping tools are available
- Formal Methods -Semi-quantitative, qualitative Analysis-
- Product optimization algorithms
- To study deeply the causes of poverty
- To learn advanced clinical methods for developing world medicine
- To learn how to design health systems
Resources

- Stellar
- D-Lab Site
- Office Hours
- Mentors
- D-Lab
- Edgerton Center
The Context...
D-Lab Philosophy

The Three Revolutions of Development
Appropriate Technology

Mohammed Bah Abba with the “pot in pot” earthenware cooling system.

Treadle pump
Courtesy of Alfinio Flores.
Used with permission.

Charcoal from agricultural scrap
Courtesy of Amy Smith.
Used with permission.
Participatory Development

- Working with communities to identify problems
- Stakeholder analysis

Courtesy of Amy Smith. Used with permission.
Co-creation

Courtesy of Roger Sipitakiat. Used with permission.

D-LAB
The Design Process

Problem → Solution

Idea Generation → Concept Evaluation → Detail Design → Fabrication → Testing & Evaluation

Courtesy of Amy Smith. Used with permission.
Consultation vs Co-Creation

Community Involvement

Problem

Solution

Community Involvement

Idea Generation

Concept Evaluation

Detail Design

Testing & Evaluation

Fabrication

Courtesy of Amy Smith. Used with permission.
Guiding Principles for D-Lab

- Identify functional requirements
- Encourage participatory development
- Value indigenous knowledge
- Promote local innovation
- Strive for sustainability
What makes D-Lab D-Lab?

- Real projects for real people
- Participation and co-creation
- Opportunities for continuation
What is Global Health?

“The health problems, issues, and concerns that transcend national boundaries, may be influenced by circumstances or experiences in other countries, and are best addressed by cooperative actions and solutions.”

Institute of Medicine of the National Academies
Photos of health facilities around the world (hospitals, clinics, etc.) removed due to copyright restrictions.

Photos of disaster response medicine removed due to copyright restrictions.
The Burden of Disease

Disability Adjusted Life Years

The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability.
## The Burden of Disease

### Mortality

<table>
<thead>
<tr>
<th>Rank</th>
<th>Condition</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ischaemic heart disease</td>
<td>12.2</td>
</tr>
<tr>
<td>2.</td>
<td>Cerebrovascular disease</td>
<td>9.7</td>
</tr>
<tr>
<td>3.</td>
<td>Lower respiratory infections</td>
<td>7.1</td>
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<tr>
<td>4.</td>
<td>COPD</td>
<td>5.1</td>
</tr>
<tr>
<td>5.</td>
<td>Diarrhoeal diseases</td>
<td>3.7</td>
</tr>
<tr>
<td>6.</td>
<td>HIV/AIDS</td>
<td>3.5</td>
</tr>
<tr>
<td>7.</td>
<td>Tuberculosis</td>
<td>2.5</td>
</tr>
<tr>
<td>8.</td>
<td>Trachea, bronchus, lung cancers</td>
<td>2.3</td>
</tr>
<tr>
<td>9.</td>
<td>Road traffic accidents</td>
<td>2.2</td>
</tr>
<tr>
<td>10.</td>
<td>Prematurity, low birth weight</td>
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### DALYs

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<th>Rank</th>
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</thead>
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<tr>
<td>1.</td>
<td>Lower respiratory infections</td>
<td>6.2</td>
</tr>
<tr>
<td>2.</td>
<td>Diarrhoeal diseases</td>
<td>4.8</td>
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<tr>
<td>3.</td>
<td>Depression</td>
<td>4.3</td>
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<tr>
<td>4.</td>
<td>Ischaemic heart disease</td>
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<tr>
<td>7.</td>
<td>Prematurity, low birth weight</td>
<td>2.9</td>
</tr>
<tr>
<td>8.</td>
<td>Birth asphyxia, birth trauma</td>
<td>2.7</td>
</tr>
<tr>
<td>9.</td>
<td>Road traffic accidents</td>
<td>2.7</td>
</tr>
<tr>
<td>10.</td>
<td>Neonatal infections and other</td>
<td>2.7</td>
</tr>
</tbody>
</table>
Health Expenditures

Public health spending, 2004 data. © Copyright 2006 SASI Group (University of Sheffield) and Mark Newman (University of Michigan). Used with permission. For high res images, see: [http://www.worldmapper.org/map_list.html](http://www.worldmapper.org/map_list.html).
Global Health Inequality

Between 1986 and 2001, global funding for health research rose from US$30 billion to US$106 billion, but progress towards new health tools for the poor remains insignificant.

Of 1,393 new medicines approved between 1975 and 1999, only 1% (16 drugs) was developed for tropical diseases and tuberculosis.

Source: MSF
80-90% of all medical technology in the developing world is hand-me-down equipment.

80% of it fails within the first 6 months.

Operating room in Sudan. Courtesy of Teseum on Flickr.
Dual-Use Opportunities

- Dual technologies
  - Those that can be useful in developed markets, such as America, and with design parameters that can be implemented in the developing world.

- Medicines
  - Two-market pricing mechanisms

- Vaccines
  - R&D funding for disaster response to provide public health benefits

- Devices
  - DoD
  - Disaster response
  - Dedicated market opportunities
Technology Case Study

- The Jet Injector

Source: US CDC
Technology Case Study

- The Jet Injector

Images removed due to copyright restrictions.
Two newspaper clippings.


Image removed due to copyright restrictions. Photo of MEDIVAX vaccine injector.
The D-Lab Health Design Cycle

*Elements for Device Design Success*

- Select the Appropriate Device Attributes
- Invent using Design Toolkit Strategies
- Global Health Innovation Compass
Global Health Innovation Compass

<table>
<thead>
<tr>
<th>Program Goal X Level of Pushing the Status Quo</th>
<th>Net Resources Expended (Time &amp; Money – Resulting Impact)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inexpensive/Not Very Appropriate</strong></td>
<td></td>
</tr>
<tr>
<td>![Glucose meter](upper left &amp; right)</td>
<td>![Cellphone and hospital](by MIT OpenCourseWare)</td>
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- Farmer (lower left) courtesy of Lon@Queta on Flickr.
- Vaccination clinic (bottom center) courtesy of cambodia4kids.org on Flickr.
- Drawings of cellphone and hospital by MIT OpenCourseWare.
Attributes for Medical Devices

Essential:
- SAFE
- Accurate
- Robust
- Longevity
- Cheap
- Reliable
- Reusable/Disposable

Enhancing:
- Mobile
- Connected
- Smart
- Plug n’ Play

Long-Term:
- Local Mfg
- Local Innovation
How do we get there?
Design Strategies

- Hybridization
- Vintage Technologies + Smart Design/Tech = New Solutions
- Taking the improvisation and engineering solutions
- Bottom up observation
- Be trendsetting, not trendy
- Context shifting
- Distributed Systems
- Crowdsourcing
Hybridization

CellScope (UC Berkeley)

Image credits: CellScope photo courtesy of Daniel Fletcher. Microscope photo courtesy of Biology Big Brother on Flickr. Cell phone drawing by MIT OpenCourseWare.
Improvisation → Design

Photos of commercial asthma inhaler removed due to copyright restrictions. See, for example, Philips Respironics OptiChamber(R), http://optichamberholdingchamber.respironics.com/

Image by MIT OpenCourseWare.

D-LAB HEALTH
Grayson Rosenberger with his “Bubble Wrap® Cosmetic Covering Shell for Artificial Legs in Developing Countries.”
Context Shifting

Photo removed due to copyright restrictions. Playpumps International water pump in action:
http://www.flickr.com/photos/playpumps/3236397277/
Context Shifting

Photo courtesy of jillig on Flickr.
Leveraging Distributed Systems

Photo of a telemedicine system removed due to copyright restrictions. A community health worker captures images and symptoms using a cell phone, transfers the data to a server, where a doctor logs in using the internet to provide consultation and prescribe treatment.
Crowdsourcing

Photos from Open Prosthetics Project (public domain license)
http://openprosthetics.org
Homework

- Chart out technology X
- Asthma
  - [insert devices, options, treatment staff]
- Cardiac care
  - [insert devices, options, treatment staff]
The Stage & the Actors

Policy & Aid
- WHO
- UNICEF
- Multilateral aid agencies
- MSF
- Red Cross

Solution Side
- PATH
- FIND
- Rice, Duke,
- MIT
- CIMIT
- MedMondiale
- IAVI*
- OneWorld Health*
The Stage & the Actors

Funders
- GAVI
- Gates
- Rockefeller
- Who else?

Regulators
- MOH
- FDA
- CE

- Industry
- Social Entrepreneurs