Engineering Design and Education:
Outside the Classroom and Outside the Country

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Insitu
A Center of Excellence for Socially Engaged Design

Global Sustainability / Health Challenges Requires…

Mobility

Water

Energy

Development

…Socially Engaged Design

The integration of social and societal contexts into design processes.

University of Michigan
Promoting Connection with New Contexts

1. 6th among U.S. schools sending students abroad (Open Doors 2012-2013)
2. Co-curricular experiences = fastest growing segment of education abroad
    - Project-based learning
    - Volunteer/service
    - Internships
    - Clinical experience

Why would faculty, or indeed a university, support co-curricular experiences?

BLUElab: Co-Curricular Organization Example

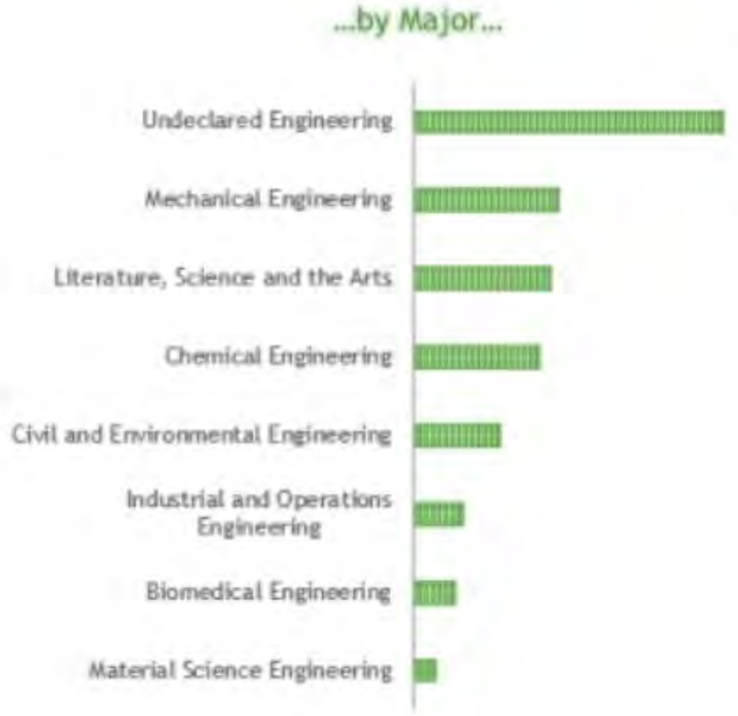
- 295 Student Members
- Serve society and the environment through the practice of **sustainable design**
- Provides resources and organization for students to help them engage with communities at **home and abroad** to address **environmental and social challenges**
  - Design-build-test-implementation cycles
  - Engage in social responsibility
  - Develop as servant leaders

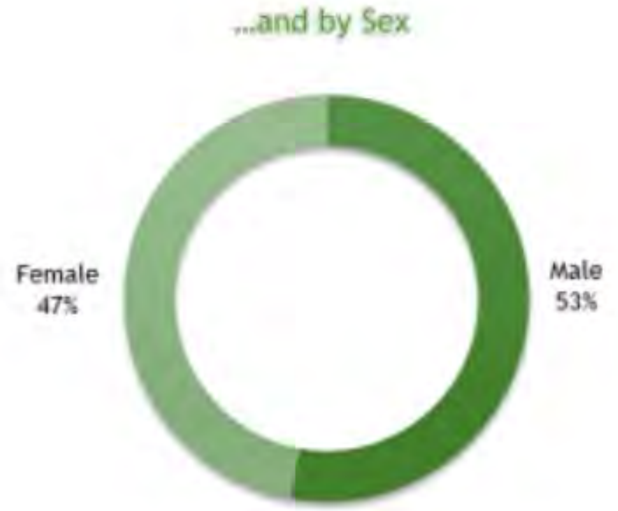
Who We Are

We take pride in fostering a well-rounded community of students from various disciplines across campus. This ensures that our projects have the qualitative skills necessary to complete needs-based assessments of our communities and implement educational programs, while having the technical capabilities to design and build our technologies. As a result, our members learn to collaborate and share their unique perspectives, reflecting a real-world working environment.

Core Leadership Team has been 90% female over the past 4 years

Total Membership: 295





BLUElab: Isn‘t this just Engineers without Borders?

- The organization is student governed and all projects are *generated* and executed by students.
- Students decide the projects to be worked on, and they raise money, establish project standards, acquire necessary professional review, build community relationships, and promote self-sufficiency of the solutions they generate.
  - *If the students fall, there is no net*.
- Students are “beyond engineering”.
  - Stronger focus on community needs finding, co-design, and eventual self-sustaining “business plans”. AY15 President is not an engineer!
- Students perceive this not as service to an outside organization but a part of their education that they help to create.

Faculty perspective:
BLUElab Teaches Non-Traditional But Critical Engineering Skills

- Traditionally, engineering students have been taught to solve problems.
- Today students must not *just* to solve problems, but define problems & implement solutions.
  - *This is particularly true in the field of sustainability!*
  - These opportunities *cannot* be achieved as well in a scalable course setting.
- Co-curricular projects provide a *scalable model* and that *prioritizes safety* and *high quality* impact.

Faculty perspective:
What course-related challenges are solved by co-curricular projects?

1. **Time**. The semester is short.
2. **Pace**. Community co-design can be slow (in a good way!) but courses can't wait.
3. **Continuity**. If instructors maintain relationships, students don't really own the work.
4. **Money**. Tuition can't cover international travel. Should students have to pay more for some classes?
5. **Learning Objectives**. Courses require a syllabus and learning objectives. Can the learning really be known in advance when the problems aren't even known?
6. **Team Dynamics**. In a course, students must be put on teams – in a co-curricular situation, teams form themselves.

The Difference:
Forcing Context Considerations by Creating Contrast

Domestic Co-Curricular Design Projects

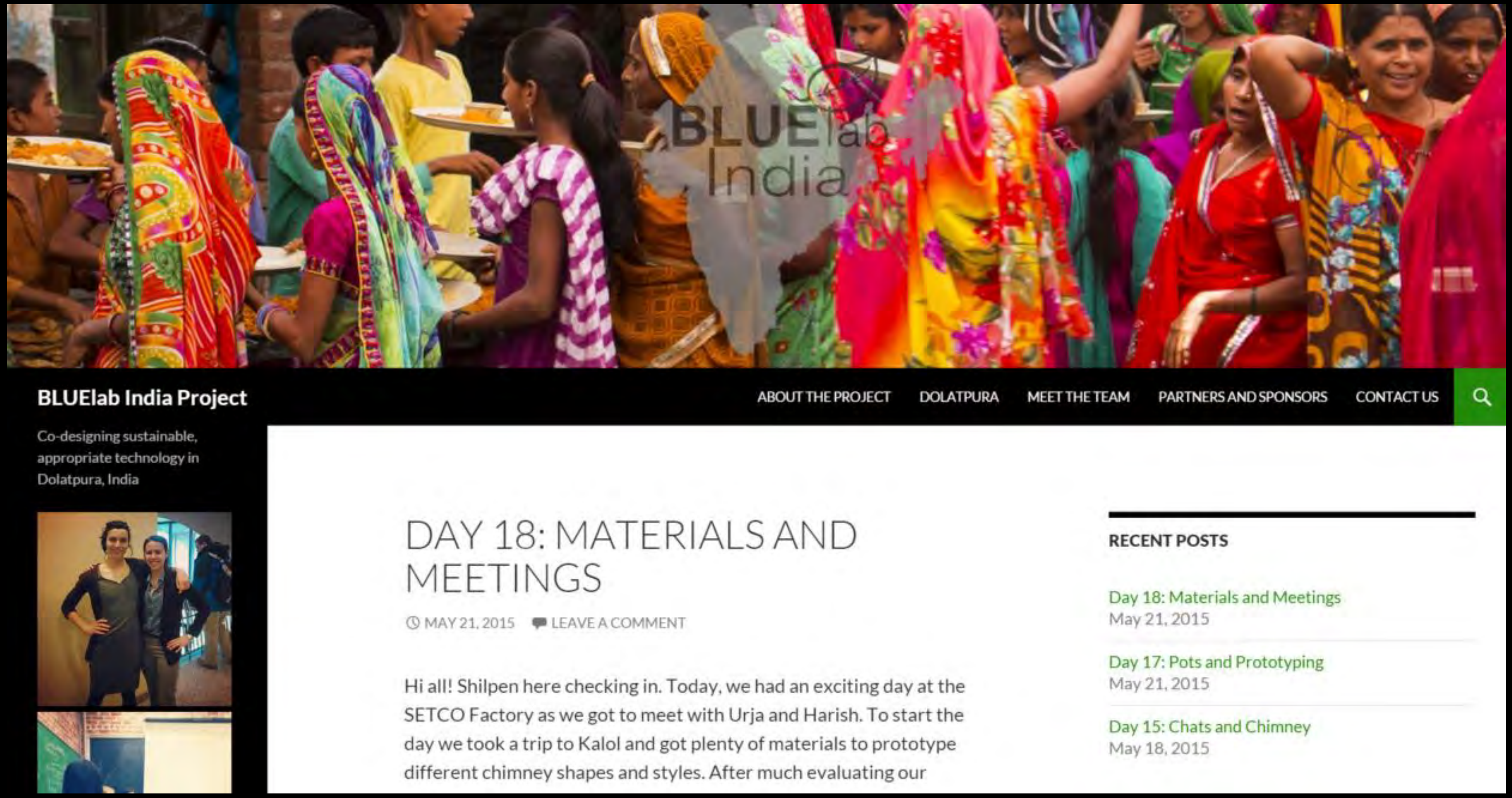
vs.

International Co-Curricular Design Projects

A Testimonial From the Future: Kaylla Cantilina

11pm May 21, Dolatpura India

“Most our friends have (corporate) internships ... They are missing out! We are directly engaging with real people, living in real communities, and doing real work. Universities and companies have cultures of their own and we've been exposed to it before; they are filters that prevent students from being engaged with real culture on the ground.   Talking to villagers through a translator and forging relationships with folks who have a completely different way of life is a life-changing experience.”



Lack of Curricular Opportunity for Experiential Learning

Global Health Design Program: Curricular Example

- Undergraduate project-based learning related to real-world health problems
- Co-creative user- and context-centered design processes
- Project scoping through clinical immersion and experiential learning
- Appreciation of the cultural influences on an engineering problem and the implications of technology introduction to a community
- Consideration of a wide range of unique constraints, such as low cost, use of local materials, adoption by unskilled users, and cultural beliefs
- Community-based demonstration and subsequent refinement of prototypes
- Intercultural and clinical competencies

Courtesy of R. Malkin

Program features

- Multidisciplinary student teams
  - 3-4 engineering students
  - ≥1 non-engineering student(s)
- Pre-departure training
  - Design primer coursework
  - Cornerstone coursework
  - Basic patient history and physical examination skills workshop
  - Clinical observations
  - Thematic directed self-study
  - Vicarious trauma training

Program features, cont.

- Two month clinical immersion
  - Morning meetings
  - Observations
  - Interviews and focus group discussions
  - Problem co-identification and co-creation with the community the device intends to serve
- Homestays
- Needs assessment and generation of user requirements and engineering specifications
- 1-2 semesters of design
  - Field site validation of prototype

Maternal Health

- Portable pelvic examination table
- Reconfigurable labor & delivery bed
- Preeclampsia detection device
- Autologous blood transfusion device
- Assistive delivery device
- Post-partum hemorrhage device

Infant Health

- Clinical device for infant male circumcision
- Blood exchange transfusion device
- Respiratory rate monitor
- Pneumonia diagnostic device
- Breast pump

Minimally Invasive Surgery

- Gall bladder removal device
- Low-cost, low environmental impact tissue resection device
- Low-cost force-feedback training grasper

Other

- Folding tricycle attachment for standard wheelchairs
- Patient-powered CPAP
- Cervical cancer screening simulator
- Tool for traditional adult male circumcision

Student experiences

"The immersion experience really helped me to understand the intricacies of the clinical environment we were designing for. There were many subtleties to how the hospital operated that I did not think would be relevant to our designs at the time, but ended up playing a large role in the design decisions made by our team. I strongly believe that we were able to design a more appropriate device for the clinical environment due to our experience observing there."

- Caitlin Winget, student participant

Student experiences cont.

“Understanding the subtle cultural difficulties in the setting of intended use is close to impossible without the full immersion into that setting. Without knowing the true difficulties and how they are managed, other teams who we have had contact with have difficulty meeting the demands of their end users.

Other student design teams struggle to fully understand the user requirements and find it hard to achieve them with a completed prototype based off literature before initiating contact with the end user.”

- Gillian Henker, student participant

Best Practices

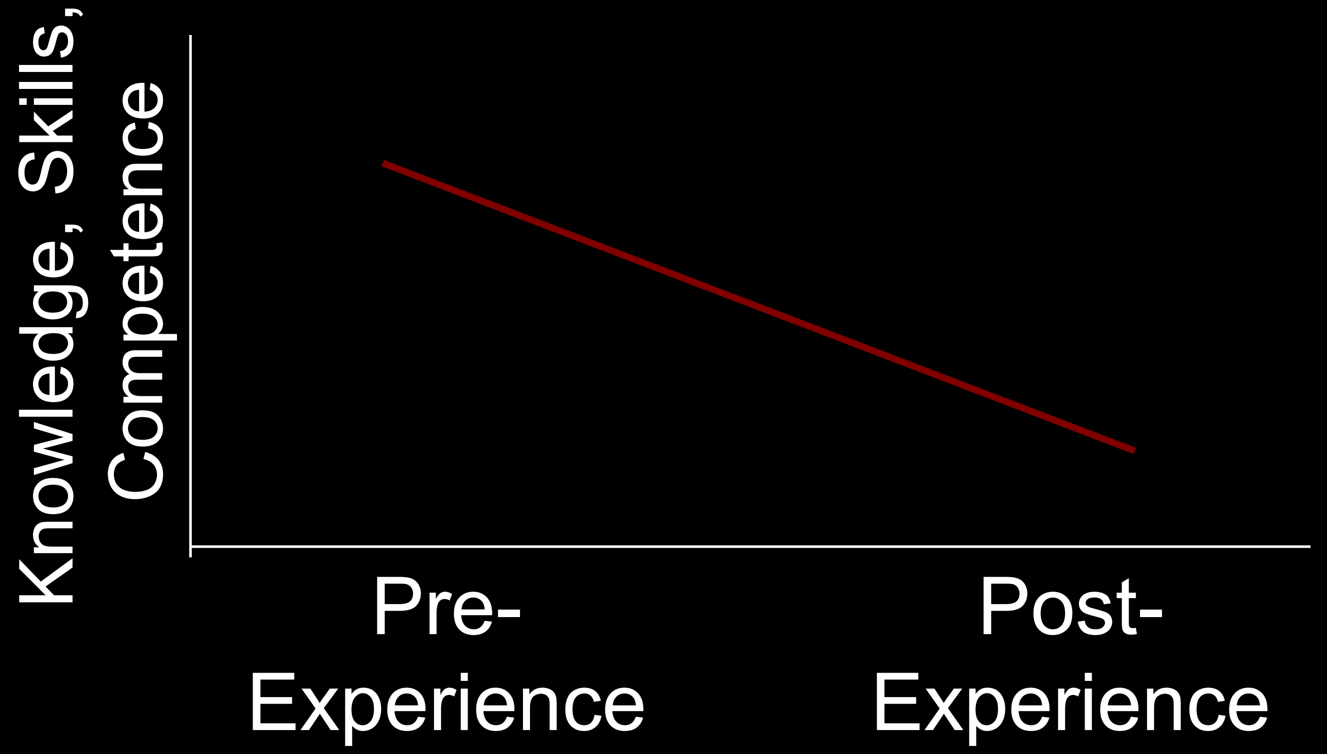
- Field site partnerships
  - Partner with teaching hospitals
  - Build upon existing university relationships
  - Establish long-term collaborations centered on reciprocity
  - Limit teams per field site
  - Conduct joint immersion experiences with in-country engineering students
- UM partnerships
  - Global Intercultural Experiences for Undergraduates
  - African Studies Center
  - International Programs in Engineering
  - Center for Entrepreneurship
- Cohort themes
- UM clinical mentor(s)
- Student leadership
  - Self-directed study
  - Peer-to-peer training
- Homestays
- Minimum six week immersion experience
- Semi-weekly deliverables and telecons
- Professional outcomes
- Classroom as an extension of research laboratory
- Scholarship with potential for short-term societal impact vs. service
- Assessment and evaluation

Challenges

- How to create classroom-based exercises that translate to work conducted independently in the field
  - Design ethnography
  - Needs assessment
  - Needs filtration
  - User requirements elicitation
  - Decision making
- How to scale
- How translate project outputs beyond the classroom
  - Publication of conference and journal papers
  - Intellectual property
  - Start-up companies and social ventures
  - Deployment in resource-limited settings
- How to best to measure (not quantify) success

Becoming a Global Engineer: A Rich Area for Research

- Students claim to know less after they engage in global experiences
- Self-reported quantitative data
  - Accuracy issues
  - Lacking depth

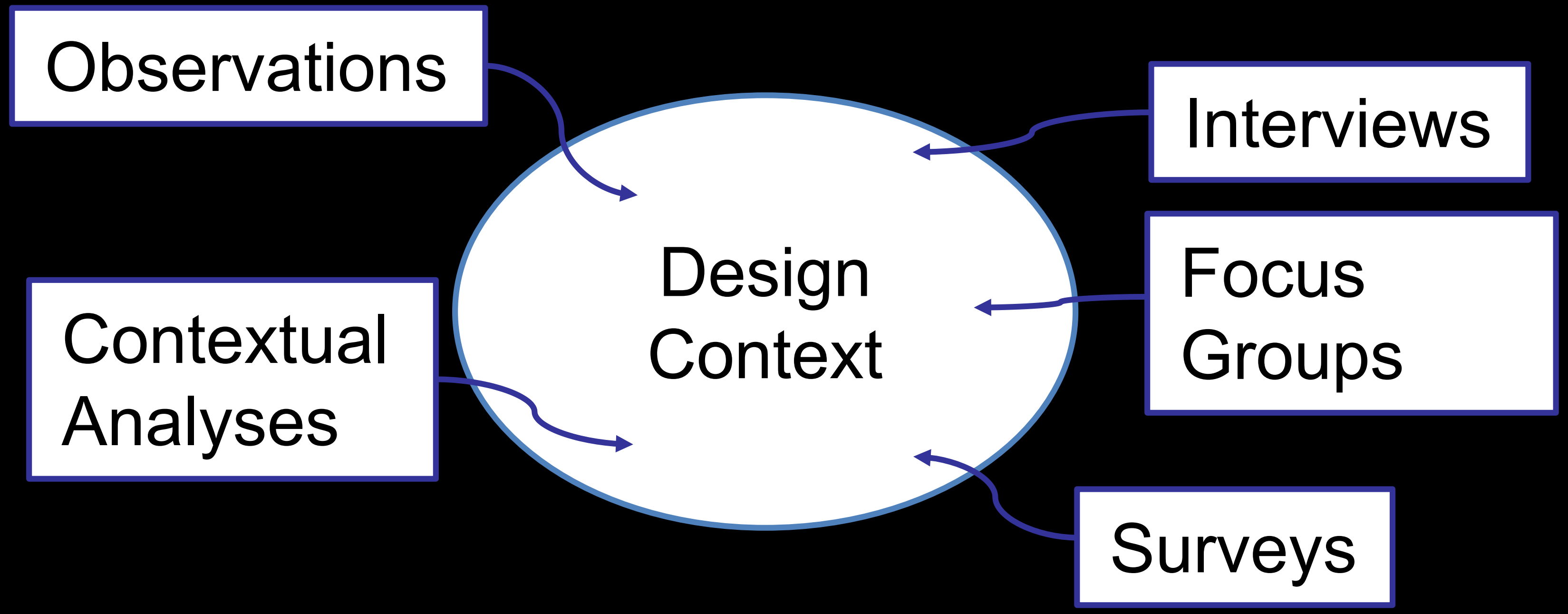


- Questions of Interest:
  - What does it mean to become a global engineer?
  - What are the learning and developmental processes of moving from novice to more informed to expert?
  - What pedagogy and experiences support learning and development?

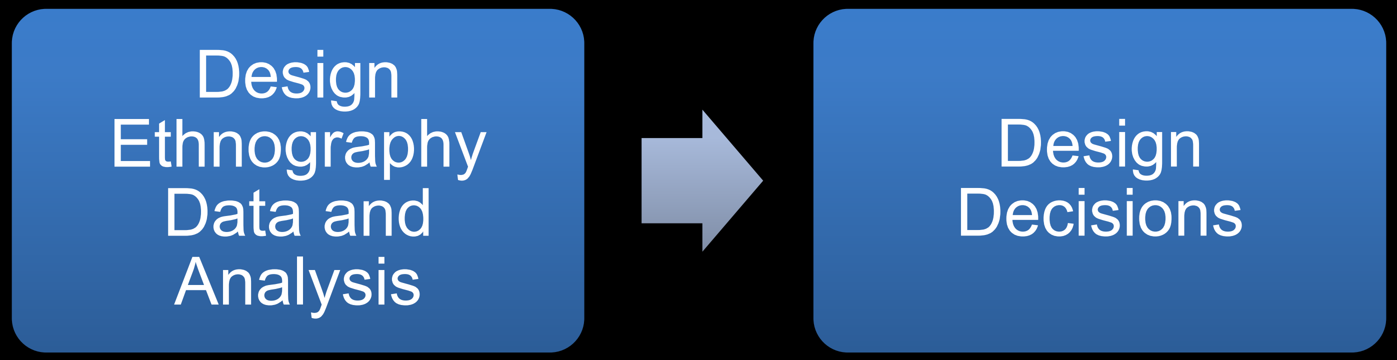
Design Ethnography

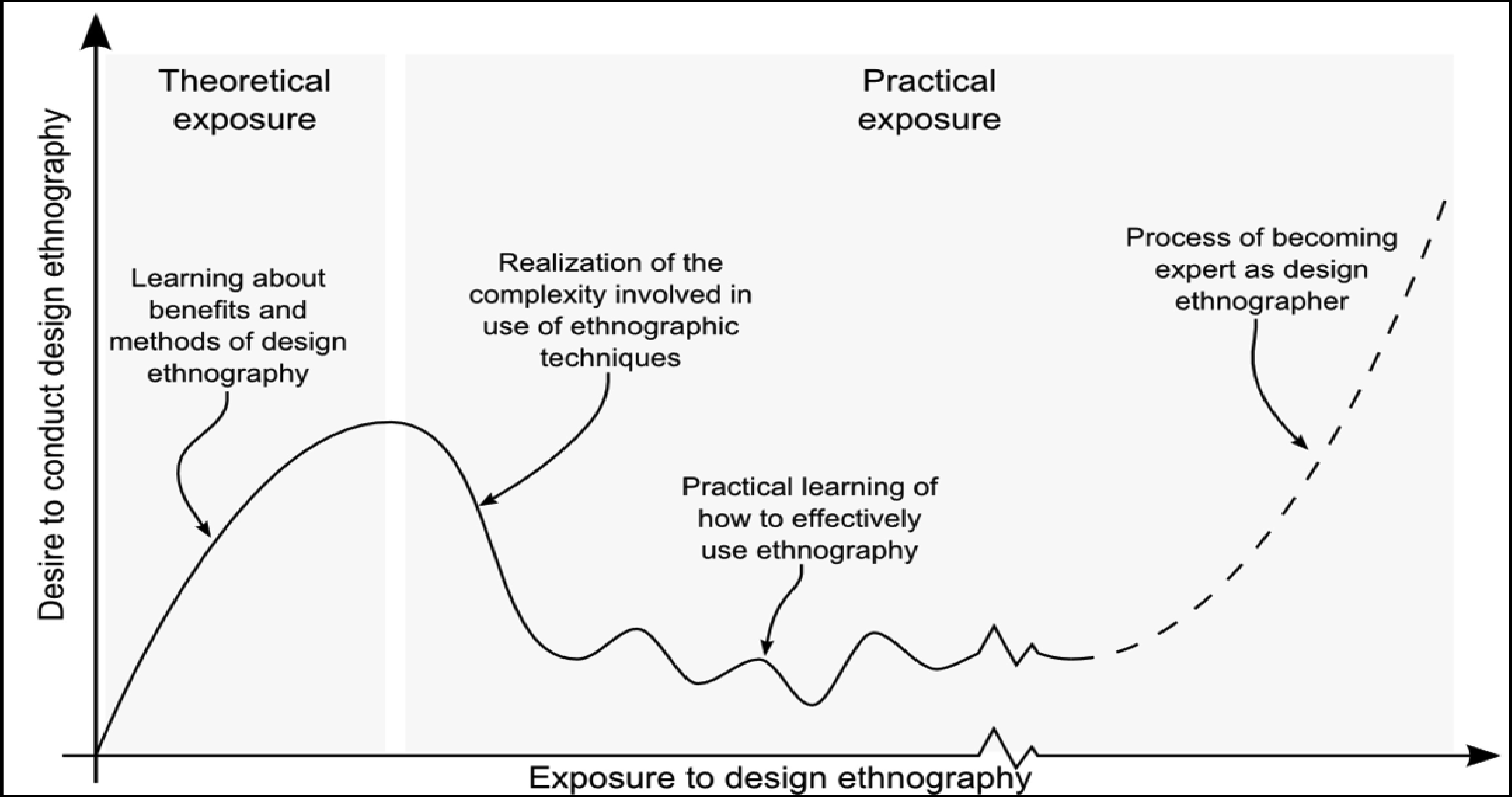
Design ethnography seeks to understand “the broad patterns of everyday life that are important and relevant specifically for the conception, design, and development of new products and services”
(Salvador, Bell, & Anderson, 1999)

<u>Data Collection and Analysis</u>



<u>Data Translation to Design Decisions</u>




Theoretical exposure
Practical exposure
Desire to conduct design ethnography
Learning about benefits and methods of design ethnography
Realization of the complexity involved in use of ethnographic techniques
Practical learning of how to effectively use ethnography
Process of becoming expert as design ethnographer
Exposure to design ethnography

Identifying Pedagogical Obstacles through Longitudinal Studies

Most teams recognized value of human elements in design and some teams leveraged experts for some decisions:	‘‘[The expert] taught us about the dragger tubes. We had no idea they even existed. We figured out online research is kind of hard for some knowledge…” ‘‘It was a lot more helpful to actually talk to people who are specialists in the field… once we started talking to [the manufacturing engineers]… they were able to answer a lot of questions we just couldn’t find online.”
Teams struggled to synthesize multiple perspectives to make design decisions:	‘‘Because what does accuracy mean? Different people will interpret it different ways.’’ “Sometimes doctors would say that cost is super important and other times [cost] would end up one of the [least important requirements]…”
Teams did not know how to take advantage of stakeholder knowledge:	‘‘They didn’t even know what our solution would look like. [Doctor] said, ‘well I guess if it is some handheld device, maybe a 50% increase [in size over the current solution]’…they were just kind of guessing…might not have been a good thing for us to aim for, in hindsight…’’

Mohedas, I., Daly, S., & Sienko, K. (2014). Students as design ethnographers: A case study of student capstone design teams. International Journal of Engineering Education, 30(4), 888-900.

Culturally-Contextualized Design

What are processes for creating culturally relevant, user-centered engineering design solutions? What characteristics distinguish expertise in culturally-contextualized design work?
How can we measure student progress?

Novice	“I was slightly freaked out [walking into the group] just because I wasn’t used to having so much culture. I'm not really from a cultural family. It was just like everyone is from all of these places and I'm from a [State]. I felt really, I don’t know, uncultured in a way when I came in.”
Aware	“I think having a good knowledge of other people's culture helps you relate and understand…If you can empathize with people you can better understand them and better relate to them. If you can relate to somebody, you can solve the problem. I definitely think it's important, but I don't know how to describe why.”
Informed	“When you have a design, before you even get to the design, there's a lot of work that goes into it. I think if you are designing for any other culture, first you really need to do research, and you need to learn about their daily lives. You need to learn about what factors affect their daily lives. Maybe it's government or economics or gender roles or anything. I think that kind of getting it down to the human level is really important, and then from there just trying to always keep that culture in your mind as you are designing. It's really hard, but don't design it for yourself. Design it for them.”

Novice → Aware → Informed → Expert

Human-Centered	Collaborative	Intentional	Open to Flexibility & Ambiguity	Invested & Committed
The desire to understand the cultural context of stakeholders in order to identify their needs and thoughtfully carry on the design process.	The capacity to work and interact with stakeholders who have different perspectives during the design process.	The motive to participate and engage with the goals and objectives of the design, and the purpose to complete the design experience.	The propensity to engage in unfamiliar interactions and leverage differing perspectives.	The personal commitment to social justice and the sustainability of the design and processes.

Sánchez-Parkinson, L., Daly, S., Holloway, J., Conger, A., Sienko, K., & Meadows, L. (2015). Engineering Case Studies Supporting a New Framework for Culturally Contextualized Design. Proceedings of the American Society for Engineering Education Annual Conference and Exposition, Seattle, WA.

Research allows us to identify practices, translate practices for student learning, and measure impact

Identification

What strategies are used across expertise levels—from novice (beginner) to more informed to expert? How are these strategies connected to outcomes?

Translation

How can best practices be shared (pedagogy, experiences)?

Measuring Impact

What is the impact of the translation on outcomes and engineering development?

What skills do engineering students learn through these experiences?

The Engineer of 2020

- Communication & teamwork skills
- Creativity
- Practical ingenuity
- High ethical standards
- Analytical skills
- Flexibility
- Lifelong learners
- Leadership
- Professionalism
- Business & management skills

We require deeper, engaged learning experiences that prepare UM engineers to leverage their education to make a difference to transform the world

Global Engineering Design Skills

- Contextual awareness
- Creating within context
- Info gathering
- Qualitative data collection
  - Observations
  - Interviewing
- Engaging with stakeholders
- Qualitative data analysis
- Translation of qualitative themes to quantitative engineering specifications

What pedagogical practices facilitate deep learning of these skills?

Field-based Demonstrations of Skills, Real-time Feedback, and Reflection are Key to Development

What structures can support engineering student learning of global engineering skills?

INSITU

A Center of Excellence for Socially Engaged Design

TO RESEARCH…

Evidence-based best practices to include end-users and societal issues in design processes, and to understand all the human elements of the design process.

TO EDUCATE ALL UM DESIGNERS…

With skills to evaluate user preference and technology context across economic, environmental, and societal dimensions

TO PREPARE STUDENTS TO LAUNCH CAREERS…

Where they will continue this transformational approach to engineering and address global challenges through service to industry, government, academics, and NGOs.

INSITU: Realizing the Vision

- Build a research center to understand the best practices of socially engaged design.
- Create on-demand content and hands-on skills training modules to disseminate the best practices of socially engaged design to all UM engineers and designers.
- Create UG, Master's, Ph.D., and professional education programs – including integration to all existing CoE programs.
- Connect students to real design projects that interact with and impact communities.
- Build the Socially Engaged Design Center physical space with integrated consultation.
- Develop new industrial, NGO, and governmental partnerships to support all of the above.

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