DESIGNING UNIVERSITY LAB SPACE: RECOMMENDATIONS FOR DEVELOPMENT ENGINEERING PROGRAMS

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Published **December 2021**

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Executive Summary

The field of Engineering for Global Development (EGD) has been evolving and growing in U.S.-based universities. Many EGD-related programs provide physical lab spaces that allow for team-based, multidisciplinary, experiential learning opportunities that engage students at multiple points in their academic careers. These EGD-related lab spaces often cater to a variety of technical, environmental, and socially focused research and implementation projects. In partnership with the Ohio State University, the purpose of this research collaboration was to categorize and provide recommendations for new and developing EGD-related lab spaces within university settings. To understand the current landscape, Fellows conducted desk research of 23 universities with EGD-related programs. To supplement, Fellows conducted semi-structured interviews with individuals representing 11 universities.

Across the universities investigated, labs have a wide variety of organization and funding (e.g., state, grants, industry partners). Students' involvement in the labs varies, including how students are recruited and what training, tools, and resources are available. Programs face challenges related to university structure, project sourcing, and resource constraints. Meanwhile, success factors include industry support, passionate faculty, and clear communication of the space's value-addition to a department or university. Based on these findings, Fellows identified recommendations for creating and sustaining EGD-related lab spaces, including ways to get students involved in sustainable development innovation, and how to address and alleviate challenges. Rather than providing a strict set of guidelines for future programs to follow, this report is meant to serve as a record of lessons-learned from existing EGD-related programs.

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Engineering for Global Development Lab Spaces

The aim of this report is to provide recommendations for new and developing Engineering for Global Development Lab spaces. Existing programs and leaders in this space were researched and interviewed to create the recommendations within this report. Although Engineering for Global Development is a growing field that many universities are beginning to establish programming in, there are programs that have been around for nearly 20 years. This report is intended to highlight lab spaces that currently exist and to give insight into those that want to grow or expand opportunities into a physical space. These lab spaces and programs are essential to the evolution of engineering education to prepare students to understand the social and cultural intersections of engineering and the field's impact.

For the purposes of this report, Engineering for Global Development (EGD) is meant to be a broad term that includes humanitarian engineering, engineering for social good, global engineering and other similar names that focus on applying engineering problem solving in complex settings and situations. Lab spaces is also a broad term that includes any formal research spaces, projects, organizations, programs, or courses that utilize a physical space in an academic setting to work in the engineering for global development space. The research that was conducted included these broad definitions of “EGD” and “labs” to create a holistic view of the field and to provide insights into the current trends and opportunities within this field.

Research Methods

Engineering for Change fellows partnered with The Ohio State University to research and determine recommendations to create and sustain a global development innovation lab. This was done by first determining a list of universities in North America who have similar programs or labs that can be learned from. Twenty-four universities were identified as well as 30 labs and programs. Each program was researched using online sources; mainly the schools’ websites. The research was guided by a list of topics and questions, ranging from purpose of the lab to tools and technology used to partnerships the lab utilizes. Next, interviews were conducted with identified program faculty, staff, or researchers. A total of eleven interviews were conducted. The main limitation of this research is the capacity of the researchers to interview every program within this space.

University	**Lab/Program Name**	**Interviewee**	**Interviewee title**
Arizona State Univ.	Laboratory for Energy and Power Solutions (LEAPS)	Nathan Johnson	Director
Colorado School of Mines	Engineering, Design and Society	Juan Lucena	Director
Colorado Univ.-Boulder	Mortenson Center in Global Engineering	Laura MacDonald	Managing Director
George Fox Univ.	Servant Engineering Program	Gary Spivey	Head of Center
Lehigh Univ.	Creative Inquiry and Mountaintop Initiative	Khanjan Mehta	Vice Provost
Mass. Institute of Tech.	Global Engineering and Research (GEAR) Lab	Elizabeth Brownell	Program Manager
Michigan Tech. Univ.	D80: Prosperity by Design	David Watkins	Director
Univ. of Michigan	Design Science	Grace Burleson	Graduate Student
Univ. of Nebraska	Daugherty Water for Food Global Institute (DWFI)	Peter McCornick	Executive Director
Univ. of California-Davis	Center for Information Technology Research in the Interest of Society (CITRIS)	Nate Metzler	Program Manager
Villanova Univ.	Center for Humanitarian Engineering and International Development	Brandon Simons	Graduate Student

Universities researched but not interviewed:

- University of Toronto, Centre for Global Engineering, Water and Energy Research Lab (WERL)
- Brigham Young University, Design Exploration
- Drexel University, Peaceteach Lab
- Lipscomb University, The Peugeot Center for Engineering Service in Developing Communities
- Oregon State University, Humanitarian Engineering Program
- Penn State University, THRED Group
- Purdue State University, Innovation for International Development Lab
- Santa Clara University, Frugal Innovation Hub
- SMU Lyle School of Engineering, Hunter and Stephanie Hunt Institute for Engineering and Humanity
- Stanford Institute of Design, d.school
- University of California at Berkeley, Development Impact Lab, BEST Lab
- University of Dayton, ETHOS Program
- University of Washington, ICTDLab
- Duke University
- University of San Diego
- James Madison University
- University of South Florida
- Appalachian State University

Creation of Lab and Growth

Getting Started

The EGD-related labs and programs we investigated described unique origins. Consistently, there was a theme of a passionate faculty member bringing together a group of researchers and students to form the new lab or program. All interviewees described filling a gap that existed at their institution - meaning, there lacked a space or opportunity to provide students with EGD-related experiences. For example, George Fox University created their program as part of the curriculum to get students involved since students did not have the time outside of classes to get into sustainable development projects. Some programs added on or expanded existing programs, for example, at the Colorado School of Mines, the professor added onto their existing disabilities lab, with the goal to create affordability, community development, and cultural acceptance.

Many labs were started with support from their departments and partnerships, often with help from interested students. At Arizona State University, a professor and students came together to start the lab to develop energy and power solutions for off-grid contexts, and spent 2-3 years building their team and relationships with partners. The program at Michigan Tech was created by students and civil & environmental engineering faculty and started as smaller programs and clubs, such as Engineers Without Borders.

Large grants were the catalyst for many programs. Colorado University at Boulder was granted a five million dollar endowment to create the lab and program, focusing on providing students with hands-on design, research, and implementation experience. University of California at Davis' program was started by a group of professors and students after receiving a state-funded grant, with the goal to use technology to address challenging societal problems. Many programs received support from industry, for example, tpresident of the University of Nebraska partnered with a CEO to establish their EGD-related program, with an emphasis in the water and agriculture sectors.

Lab Leadership

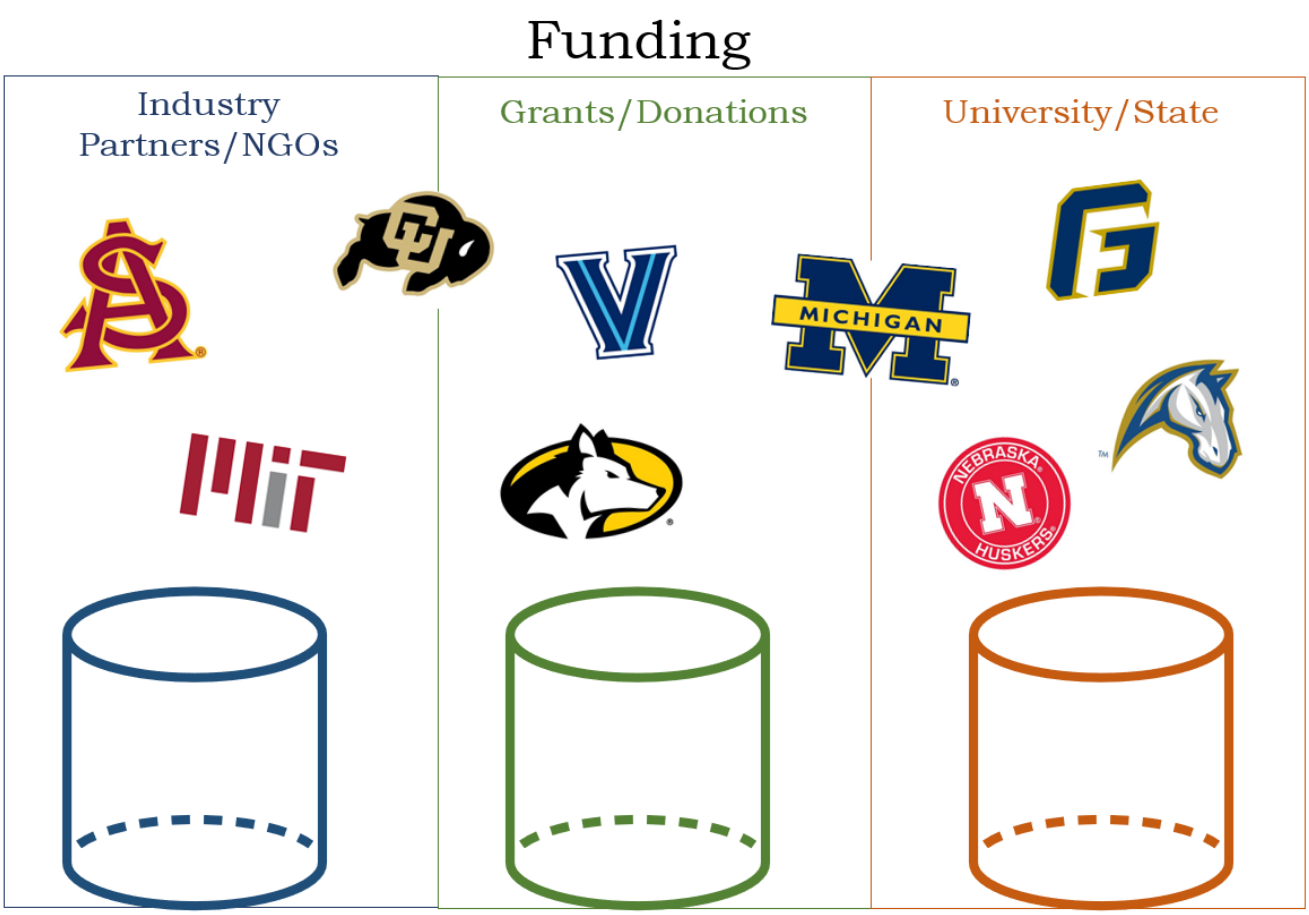
Most labs and programs include a collaborative leadership team with multiple support roles. Many larger programs have directors, assistant directors, and/or program managers to run class projects, student experiences, and general lab maintenance. For example, Villanova University's program has a director and an assistant director with team leads supporting the various projects. Other universities utilized structures with individuals leading their specific projects. For example, the University of Nebraska's program has a team of executive directors, Arizona State University's lab has a 30-person team, and Lehigh University's program divides management responsibilities across projects. Some interviewees described unofficial roles held by students, for example student-led training, equipment management, data management, and scheduling management.

Economic Sustainability of Labs

The majority of the interviewees described receiving funding from outside sources, such as industry partners, grants and donors, with the primary source being industry partners. Industry partners were often created through networking at conferences, existing personal relationships, community engagement, or by identifying companies working within similar fields. Interviewees described that a critical aspect of maintaining partnerships is to have mutually beneficial agreements, in which both the university and the company benefit. Much of the financial support in EGD-related programs is due to clear communication of the value of the research and work. Many interviewees described keeping regular and clear documentation of outcomes and achievements. Clearly documenting the program's activities is instrumental when applying for grants and reaching out to potential partners. Additionally, since these programs are housed in larger university departments, administrators often require clear evidence of impact and achievements.

Many interviewees also described receiving financial assistance from individual donors, particularly university alumni. Many alumni donors aim to help provide experiences for current university students, and donations often fund student experiences (e.g., travel to field visits or conferences) and program operations.

Furthermore, a few of the labs received their funding from the university or government. For example, the program at George Fox University is almost completely funded by the university, primarily because their program is a requirement in the engineering curriculum. Both the University of Nebraska and UC-Davis receive funding from the state for their programs. The University of Nebraska received support from the state because many of their projects deal with water and agriculture, a priority identified by the State of Nebraska. Overall, the majority of the labs interviewed are economically sustained from outside sources, however a few are supported by university and state funding.

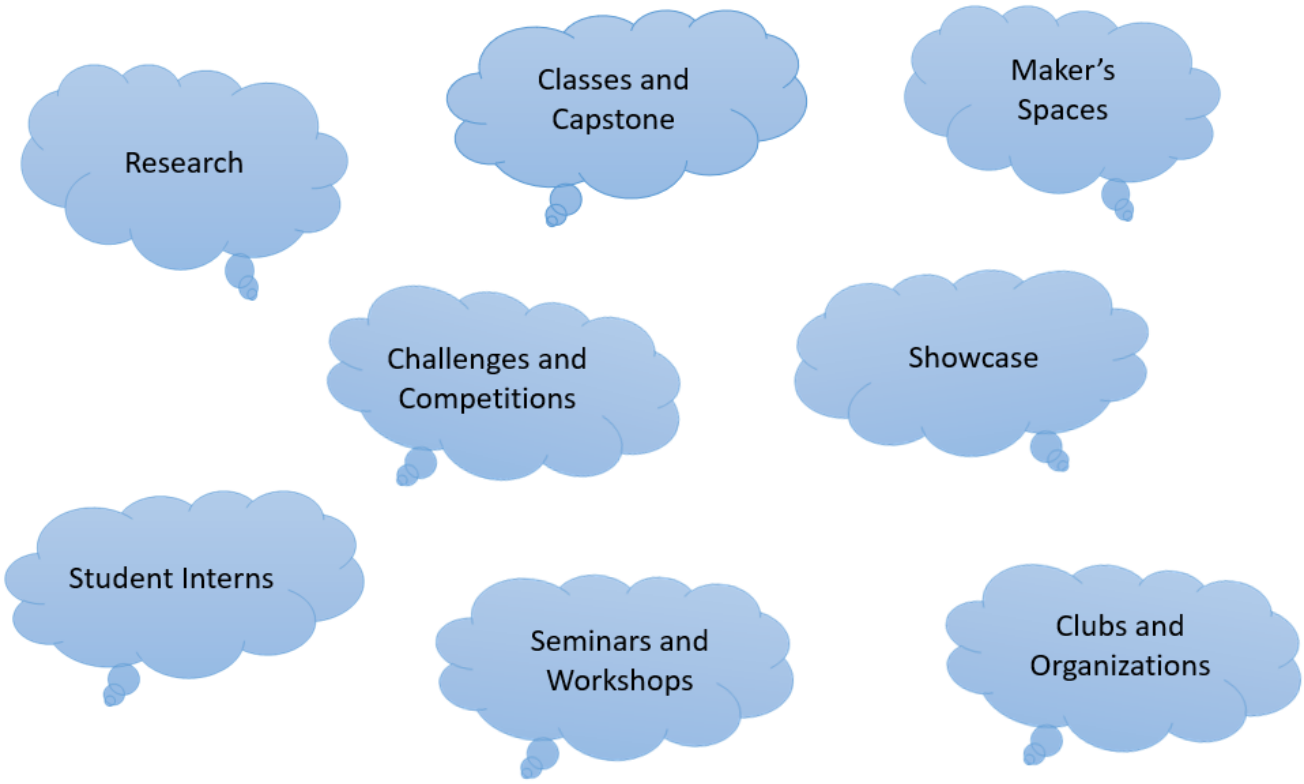


Student Intersection

Student Engagement

The goal of all the labs and programs is to provide students with experiences in EGD-related design and research. Across the labs investigated, students can be involved in a variety of ways. One common theme was the engagement of graduate students working to help run the labs and conduct research, while also having undergraduates working on projects and research. George Fox University made their program part of the curriculum, so every student gets involved through courses and capstone projects. UC Davis has a development team challenge, as well as other competitions to engage students from across the engineering program, and host an annual engineering showcase where students can share their projects and results. Arizona State University and the University of Nebraska both hire students as interns and continue doing work over the summers. A majority of these universities have courses related to EGD, host seminars, facilitate clubs and organizations for students to join (e.g., BlueLab and MHealth at the University of Michigan), and have multiple lab spaces across the university for students to use. Some of these spaces have included makerspace resources, such as 3D printing, laser cutting, and other hands-on building materials that students can use for projects.

Students Involvement



Each program has a unique method for recruitment and retention of students to their programs and initiatives. The program at Colorado School of Mines has an annual showcase for capstone students, allowing them to share their results, engage with future capstone students and build connections and rapport for the program. The program at UC Davis works to align projects with current student interest, aiming to capture the attention of a variety of student interests. The program at the University of Nebraska presents to students in related courses, and professors establish relationships with interested students. A few of the universities interviewed had internship opportunities for students over the summer. The most common trend observed was that effort was made to raise awareness in regards to the various opportunities available to students so the burden of finding projects or opportunities was not solely on the interested students.

Each lab space had a unique process for onboarding and training students to use the space. At George Fox University, the program facilitates weekly meetings with advisors to keep up with projects and information. The University of Nebraska has gatherings a few times a year for the students to make connections and get to know fellow researchers. Many of the labs also offer some sort of one-on-one training with supervisors and other lab members, resulting in better connections and a more personalized experience, which can help strengthen the lab team, and overall, the lab. Many programs also utilize the university's required ethics and lab management training, to provide students with that knowledge before participating in research.

Lab Contents

Tools

The specific tools that each lab utilized were dependent on the research and projects. Having basic tool sets and materials readily available for students was a common aspect that led to successful projects. The integration of high precision and prototyping tools is becoming more and more common within these lab spaces, providing students with resources such as 3D printers and small CNC machines to prototype unique components.

Figure: 3D Printers and other machines at Colorado University Boulder's Mortenson Center for Global Engineering

Product Evaluation

A gap that was identified within this initiative was that none of the labs conduct product evaluation. A number of labs ordered particular products to use on their projects, but we were not able to identify a group that specifically validated the performance of products in this space. The need for a uniformed product evaluation space is clearly demonstrated.

Challenges

Diversity, Inclusion, and Equity

Projects in EGD and related fields often aim to address needs of historically underserved communities. Involving these partners closely is important to create culturally acceptable and impactful solutions. Our interviewees recommended that programs engage in long-term, meaningful, and respectful community partnerships so that

their voices and opinions are considered throughout projects. However, there are a variety of challenges that are present with respect to fostering inclusive and equitable educational programs. The higher education system as a whole creates challenges for a wide variety of people to be involved. Programs are designed for English speakers, people who excel at test taking and have had access to resources and experiences in the past. Programs are also often expensive and time-intensive. At the graduate level, in particular, it can be difficult to include a wide range of people due to the barriers that were in place leading up to that point. Emphasis should be placed on creating and fostering opportunities for individuals from a variety of backgrounds to learn and grow through these programs.

Progamatic Structure

Nearly all of the programs that were studied for this report were not housed in a single department. The programs are often a group of faculty across different disciplines and departments who come together to work on EGD-related projects. As a result, we did not identify a consistent structure for EGD-related programs, rather it appears that the structure is dependent on existing institutional structures and the available personnel and funding. Furthermore, interviewees from programs that are more established at an institution (i.e., more formally recognized and supported within the university space) described the benefits of having that rapport within departments, leading to more student interest, funding, and access to resources.

Project Sourcing, Management, and Beneficial Relationships

Many of the interviewees reported challenges with identifying projects for students to engage with. There are many opportunities and complex global challenges to solve, but finding ones that work within the constraints of the academic space can be a challenge. Projects need to have value for the partners, but also be manageable for students to complete. Many interviewees described the importance of acknowledging that students are often novices, and projects must be designed such that they gain valuable experiences, but also so that they contribute in an appropriate and respectful manner with the partner and faculty/staff actively engaged. They are also often constrained by the budgets of the university program and community partners. Aligning projects with the timelines of academia and the partners is another challenge. Balancing the needs of the many stakeholders involved will always be a challenge of these projects. Universities can help support this work with departments of outreach or service learning with dedicated staff for working on these challenges.

Limits of the Space

There are many sectors and specializations within EGD-related fields. Interviewees described that it can be a challenge to attempt to cater to too many specializations. Rather, it was recommended that labs identify a couple areas of focus and to support projects in these areas. Moreover, it is also important that labs have established rules for how the lab will operate. Some projects may need a quiet space to meet with project partners and other projects may need to use machines and be noisy. Using a scheduling spreadsheet or agreeing on rules for the space can ensure teams are able to complete their work.

Resource Constraints

Another commonality between many of the labs was the lack of professional bandwidth to grow and expand the programs. Most were led by a few individuals who devoted their time to contribute to EGD, in addition to other more traditional areas of research. The programs were limited by how many projects a faculty member could lead and manage. If there was more support from the university to faculty in this space then programs could

flourish and expand beyond current limitations. Multiple interviewees reported that the current tenure-track career path is often not conducive to supporting EGD-related work, since faculty are often incentivized to focus on activities in traditional academic disciplines more than interdisciplinary programs. There are often professors who are interested in becoming involved in this EGD-related work, but they do not have the means to do so because of strained schedules and responsibilities, largely due to tenure-track requirements.

Opportunities

Curriculum Intersection

Few of the programs that were included in the study had university support. An important part of being successful in EGD is conveying the value of the work to others. EGD-related programs and labs can convey their value to the university by creating intersections with the engineering curriculum. The space is a valuable area that students can learn about ethics, history, and social sciences along with technical engineering courses. If academic programs began to offer courses that met students curriculum requirements they would have greater value from the university perspective. More students could become involved in the work and as the program grew there would be a stronger reason for the university to support engineering for global development work.

Uses for the Space

Over the last twenty years, the EGD field has been growing. Many more universities are offering programming in the space. There are more faculty and students than ever trying to contribute to the space. Having a communal lab space that is available for project teams to access will greatly enable them to further their work. Something as simple as having a place to store projects on campus can have a large impact on projects. Historically, this kind of work is limited to operating out of someone's garage with whatever tools people can come up with. Establishing labs and programs to prepare people to contribute to engineering for global development is essential to grow these programs in the future.

Future Work

An area of work that was not included in this study was nonacademic labs who are working in this space. This area was included in the initial scope of the project, but was removed because of time constraints. The majority of EGD labs are in academic spaces, but including non academic spaces would create a larger system understanding of the work being completed in this space. Future research in this area would lead to an understanding of the role of non academic work in contributing to this space. Specifically, there is an interest in understanding labs that test and verify the performance of technologies in the engineering for global development space.

Themes of Success

Industry Partners

Most programs that were included in this study had received a large corporate donation to start the lab. These came from a variety of ways including alumni, friends, networking, and requesting donations. The largest and most established labs in the space all had this in common. Communicating the value of EGD research and

learning opportunities to industry partners is therefore recommended. The lab's purpose may be contributing to EGD, but the lab likely has intersections with local industries as well. For example, an EGD lab with a research emphasis in the water sector could partner with local water companies who would gain value from the access to university resources and students. New labs could start by working on development problems that immediately affect the university and local area. It is easier to communicate the value of these projects with partners in the same field, and can be an opportunity for networking. This principle also relates to other forms of support and funding - federal grants, university partnerships, and alumni donors, for example.

Passionate Faculty

Every program included in the study had a passionate faculty member or small group that led the effort. Most of the leadership models were a traditional hierarchy with a director and assistant directors. There were also a couple programs with one strong leader and a lab that had a fluid leadership structure. Regardless of the leadership structure, an established professor led the way for the program to become established. When expanding the program, it is essential to find similarly passionate and dedicated faculty. Due to the limitations of university tenure structure it will take dedicated faculty to make engineering for global development work possible.

Communication

An important part of the work in these programs is communicating the results and value of these programs to a variety of stakeholders. EGD programs are being formed at more universities, but many are still striving towards formal recognition. One way that programs can help earn recognition is by communicating the value of the lab frequently to various stakeholders. For example, programs should maintain an updated presence online, especially as a way to attract student interest and rapport. Moreover, an important part of communication is accurate documentation of activities and outcomes. All work completed in these labs should be clearly documented to report back to funders and share results with stakeholders. Another way to communicate the work conducted in these programs is through community outreach, e.g., research fairs or "open house" events, where students and faculty can showcase the work they have accomplished. This can serve as a recruiting event for other students and also highlight the value of the work completed by these programs.

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