

To: Prof. Cohen  
From: Kelsey Lantz and Kristin Tuttle  
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Subject: Updated Capstone Project Memo

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## RESEARCH QUESTION

What is an effective way to teach students about engineering for development?

## INTRODUCTION

The EGRS capstone project is an important component of the seminar that embodies our understanding of the major in a tangible manner. For the project, we developed the curriculum for a course called *Development Engineering*. This is an important topic because engineers face very different challenges when trying to reproduce solutions in developing communities that operate under a very different set of social contexts and assumptions.

We developed a curriculum for a 3-week short course designed for the new Innovation, Design, Entrepreneurship, Activism, and Leadership (IDEAL) center. The 3-week format was chosen so *Development Engineering* could be used as an interim course, which is the length of the current Lafayette interim courses. This course addresses the importance of engineering for development, and illustrates examples of different initiatives across time and space and their varying degrees of success. For example, the students will be asked to deconstruct a case-study that explores the failure of the implementation of the El Cajon Dam in Honduras, which did not address the needs or capabilities of the community. In addition to studying the failure of engineering development projects, students will also evaluate a case-study that describes the continued success of a fish farm built in Mali.

This project is relevant to contemporary academia because development projects are becoming more widely criticized by scholars and engineering professionals for their failures on a global platform. More and more journal articles have been published that outline past failures and identify possible solutions. The engineers of tomorrow need to be well equipped and prepared to handle the challenges presented by executing a project in a developing community.

## METHOD

We worked with Professor David Stifel from the Economics department. As the professor of *Development Economics*, he has vast experience taking principles from a traditional academic discipline and applying them to the challenging world of developing communities. Although it is beyond our jurisdiction as students and our scope of the project, we would choose a professor in the Economics department, Engineering Studies department or possibly select an interdisciplinary partnership to teach the course.

## OBJECTIVES

Through our research of engineering for development, we were able to ascertain the concepts that we deemed most important for students to learn. The stated objectives of the course are for the students to be able to:

- Define the developing world
- Describe the importance of engineering for development
- Identify key issues that engineers face in projects in developing countries
- Assess engineering case studies that have both failed and succeeded in developing countries
- Relate non-engineering contexts (cultural/social, historical, political, economical, geographical etc.) to engineering solutions in the developing world

Our first course objective comes from a broad research base identifying the contemporary developing world. For example, reading assignments and discussion questions will come from Paul Collier's 2007 book, *The Bottom Billion*, which describes the poverty traps that plague the poorest billion people in the world. The second course objective comes from teaching tools used to address the same concept of development challenges in engineering at the college level. One source that we found useful is a published teaching methodology from Europe, *Sustainable Development in Engineering Education: A Pedagogical Approach*. The next course objective, regarding key issues that engineers face in projects in developing countries, comes from a wide range of sources that expose examples and case studies in sustainable community development. These include an Annual Report from Engineers Without Borders USA and Nieuwma & Riley's publication, *Designs on development: engineering, globalization, and social justice*. This article expands upon two case studies, based on the personal experiences of the authors that identify specific reasons for failures of engineering in developing countries.

The fourth objective expands upon these case studies to discover the contexts that predicated their success or failure. Journal articles from the *Journal of Professional Issues in Engineering* as well as a TED Talk titled *Engineering a Better Life for All* are used as course readings. The final learning objective summarizes the previous contexts and provides a framework for successfully addressing contemporary challenges in engineering development. Another journal article from the *Journal of Professional Issues in Engineering* is used as a learning tool.

## PRODUCT

We met these course objectives by creating a three-week course syllabus and lesson plan. We have identified relevant sources to use for our own benefit and to assign as reading assignments for the course. The syllabus identifies the course objectives and assigns a topic to each week of the course. The syllabus contains required readings, a weekly lesson plan, three essay prompts and field trips that students will take.

The idea for this course is not entirely our own. A similar course exists at Columbia University, called *Engineering for Developing Countries*. This course, first offered in 2012, is described as being an introduction to engineering problems faced by developing communities around the world and exploration of design solutions in the context of a real project with a community client. In 2006, University of Colorado-Boulder pioneered a degree track in Engineering for Developing Communities (EDC) that integrated sustainability, appropriate technology, renewable energy, international education and development, business, health and humanities with the traditional engineering curriculum.

### CONCLUSION

At the completion of our capstone project, we addressed challenges such as: the issue of coverage, lesson-plan design and sorting through case studies to make meaningful comparisons between successes and failures in previous engineering for development efforts. Our syllabus is multi-faceted, which is why it will be a success. It contains a wide variety of case studies that emphasize how there is not one standardized solution to engineering development projects. We used a range of teaching methods so that each student will be able to benefit from the lessons, no matter what their unique learning style is. The in-class discussions and writing assignments will ensure that students think critically and formulate their own opinions about engineering for development. The field trips will give students a hands-on perspective so that they see the complications that arise in developmental engineering. Our comprehensive look at engineering for development provides a course structure that can be effectively used in the future.

### RECOMMENDED NEXT STEPS

In order for the course to come to fruition, a professor would have to be identified to tackle the challenge of teaching the course. We are unfamiliar with the course-approval process at Lafayette, so our successors would have to take the necessary steps to get the course approved for credit through the IDEAL center. Then, the class would have to be advertised to potential students through campus-wide emails and flyers sent to individual mailboxes. Lastly, the daily lectures would have to be facilitated by the professor and the course's effectiveness would be measured through standard course evaluations.

### APPENDIX

Appendix A: Annotated Bibliography.....Pg. 4-9

Ahrens, A., & Zascerinska, J. (2012). Sustainable Development in Engineering Education: A Pedagogical Approach.

Andreas Ahrens is a German professor of technology, business and design, and Jelena Zascerinska is a Latvian senior researcher for the Center for Education and Innovation Research. The aim of the research is to analyze efficiency of engineering curriculum in the context of sustainable development underpinning elaboration of pedagogical guidelines on the development of students' social responsibility in engineering education. The analysis involves a process of analyzing the meaning of the key concepts "sustainable development" and "engineering curriculum." Moreover, the study demonstrates how the key concepts are related to the idea of efficiency. Descriptive statistics was implemented for primary data analysis. The findings of the research allow drawing conclusions on efficiency of engineering curriculum for the development of students' social responsibility in the context of sustainable development. This article will provide a European perspective to our educational framework.

Amadei, B., Sandekian, R. (2010, April). Model of Integrating Humanitarian Development into Engineering Education. *Journal of Professional Issues in Engineering* 136(2), 84-92.

This source is going to lead our group to other sources that will describe engineering in developing countries. It lists the education that students- soon to be engineers- should be obtaining before moving out into the "real world" in order to help the ninety percent of the world that needs sustainable community development. It bases this discussion off of analyzing the importance of soft and hard skills, interdisciplinary skills, managerial projects, necessary characteristics and approaches necessary for development, and technological knowledge that is essential. It concludes with the ethical obligations that engineers are faced with while in developing countries, which is an interesting subset of engineering that has not been discussed in previous sources. This article will provide many more sources as well as be a useful source in designing an Engineering in Developing Countries learning module. One author, Amadei, is a civil engineer teaching at the University of Colorado at Boulder. The author, Sandekian, is an aerospace engineer and managing director of the Mortenson Center in Engineering for University of Colorado at Boulder.

Collier, P. (2009). *The bottom billion, why the poorest countries are failing and what can be done about it*. Oxford: New York.

Paul Collier is an economist that reveals that fifty failed states -- home to the poorest one billion people on Earth--pose the central challenge of the developing world in the twenty-first century. The book shines light on this group of small nations, largely unnoticed by the industrialized West, that are dropping further and further behind

the majority of the world's people, often falling into an absolute decline in living standards. He uses case studies and statistical analysis to present facts about the poorest billion people in the world. Understanding the roots of the developing world is critical to knowing how to move forward. Collier offers no easy solution, but reminds the reader to be conscious that poverty is a growing problem. Previously assigned as a reading for a *Development Economics* course, this book can be used as a reading assignment for the course curriculum because it highlights important cause-and-effect relationships that define the billion poorest people in the world. The book is somewhat limited by its focus in favor of economics instead of engineering, but remains a valuable tool in understanding the developing world.

Engineers Without Borders USA. (2011). *Annual report*. Retrieved from <http://www.ewb-usa.org/about-ewb-usa/annual-reports>

This Annual Report describes the mission and vision of the nonprofit organization, Engineers Without Borders USA (EWB), along with their statement of financial position. This functions as merely an estimate of how much money is necessary to implement sustainable community development projects, and explains in part why it is difficult for developing countries to engineer solutions to their problems. The Annual Report goes on to describe the projects and programs that were completed in the year 2011. They were categorized by what type of assistance EWB provided, which is an indication of the overriding problems that developing countries face. The categories are as follows: structures, sanitation, energy, agriculture, and civil works. To support the necessity of travel and aid, EWB provides facts that reveal the current existing conditions; these conditions provide a convincing argument. These projects can be used as perfect examples in our course. EWB is a nonprofit organization that supports sustainable community development.

Laine, C. (2009, October). Engineering a better life for all [Video file]. Retrieved from [http://www.ted.com/talks/cat\\_laine\\_engineering\\_a\\_better\\_life\\_for\\_all.html](http://www.ted.com/talks/cat_laine_engineering_a_better_life_for_all.html)

Cat Laine, in this TED Talk, argues that it is unacceptable for developed countries to not provide assistance to developing countries. She explains her reasoning behind this by first defining the large-scale social forces and the barriers that stop Haiti from developing. She lists these barriers as: a lack of affordable products for the poor, poor regional infrastructure and a lack of locally produced alternatives. These barriers cannot be broken down unless developed countries provide necessary initial assistance. He attributes the lack of help to the ignorance and indifference of human suffering that many developed countries have. Her discussion of renewable energy, sanitation and clean water will be useful in designing our course module, since these are components that the majority of developing countries suffer from. Laine's study of Haiti can be used as a proper template for other developing countries. The speaker is the Deputy Director of Appropriate Infrastructure Development Group.

Lee, J. (2001). Education for technology readiness: Prospects for developing countries. *Journal of Human Development*, 2, 115-151.

Jong-Wha Lee is the Head of the Asian Development Bank's Office of Regional Economic Integration (OREI). He is also the Acting Chief Economist. This article discusses the measures in building appropriate human capacities for the adaptation of new technologies in developing countries by focusing on the education strategies of East Asian economies. His main argument is that substantial disparities in technological innovation and adaptation still exist between developing and developed countries, and the only way to solve this problem is to improve human skills to reduce the skill gap. The article focuses on the unique ability of developing countries to imitate and adapt existing technologies without the costs of invention. However, this provides its own set of challenges, which the author carefully explores in the article. This will be useful for the capstone project because it outlines a very specific way to understand the challenges adaptation of new technologies in developing counties. However, it is limited by its narrow scope in the East Asia region, and may have to be combined with similar studies in other regions in the world. Published in 2001, it is also slightly outdated, and may need to be supplemented with more recent publications. This source provides a specifically Asian context that will be useful for developing a well-rounded and global curriculum.

Md Zain, S., Hamidon Wan Badaruzzaman, W., Atiq O. K. Rahmat, R., Jaafar, O., Ezlin Ahmad Basri, N., & Basri, H. (2012). Learning Outcomes for Environmental and Sustainable Development Component in the Field of Civil Engineering. *Asian Social Science*, 8(16), 153-162.

This article was written by Malaysian civil engineering faculty members in 2012. The focus of the article is to prescribe recommendations from the Department of Civil and Structural Engineering that include sustainable and environmental development components. The authors discuss the assessment and relationship between course outcomes and program outcomes for three specific courses at Universiti Kebangsaan in Selangor, Malaysia. The department has outlined ten program outcomes that must be achieved by students and two components related to the environment and sustainable development. This source provides a unique cultural perspective on the values regarding the social, cultural, global, and environmental responsibilities of a professional engineer. It is limited, however, by its narrow focus on Civil and Structural Engineering in Malaysia.

Navaretti, G. B., Soloaga, I., and Takacs, W. (2000). The World Bank Economic Review, Vol. 14, No. 1, 91-109.

This book was written by economists of Italian and American background. Economists take empirical evidence to understand the implications of antiquated technologies and lack of skills used in exported engineering development projects from the United States. The authors frame the challenges of doing business in developing countries by explaining discriminatory trade policies and the problems they create. They model a developing country's firm's choice between new and used machines, looking at the implications of each decision. We will be able to assign this reading for a class discussion about the deterioration and amortization of equipment and how it behaves differently in developing communities.

Nieusma, D., and Riley, D. (2010). Designs on development: engineering, globalization, and social justice. *Engineering Studies*, 2(1), 29-59.

This article takes a critical look at engineering development initiatives and seeks to improve methodologies for approaching interactions with developing countries. One important component of the course curriculum will revolve around understanding the causes and effects of particular case study failures. This article outlines and analyzes what went wrong with two well-meaning engineering projects in Honduras and Nicaragua. Real world examples are critical to understanding sector shortcomings and how to solve existing problems. These case studies will serve as models for developing course projects and streamlining the curriculum to explain the problems faced by engineers entering different cultures and societies. This part of the curriculum may need to be supplemented with other sources, however, to reduce the apparent bias of the authors in this publication.

Parsons, LB. (1996, October) Engineering In Context: Engineering In Developing Countries. *Journal of Professional Issues in Engineering Education and Practice*. 122(4), 170-176.

This article is a handbook on what engineers looking to work in developing countries should know. The author, a civil engineer, made the argument is that engineers must listen to local populations and work within the social, environmental and economic constraints of the project in order for it to be successful long-term. It dissects the reason behind the failure of projects in the past, attributing some factors to be: a lack of comprehensiveness on the locals' as well as engineers' parts, much focus on the hardware, lack of attention to the code of ethics, the wrong attitude, and improper evaluations. To provide support for her argument, she lists projects that have failed and explains why. She then looks at successful projects and explains why they worked as well as they did. Two main points included power dynamics and appropriate technology, points that our group would like to focus on for our course module. A portion of the article that will be extremely helpful is where Parsons breaks down, through the use of a

study, the main problems in knowledge/technology transfer in three developing areas; the West Indies, South Asia, Sub-Saharan Africa. This article was geared toward students and recently graduated engineers, which is why the entire article pertains to and will be a great resource for our Development Engineering course.

Pérez-Foguet, A., & Oliete-Josa, S. (2000). Development education and engineering: A framework for incorporating reality of developing countries into engineering studies. *International Journal of Sustainability in Higher Education*, 6, 278-303.

The purpose of this article is to show the key points of a development education program for engineering studies fitted within the framework of the human development paradigm. The authors are Spanish engineers. This article presents and puts in context the development education activities pushed coordinately between a non-governmental organization and an engineering school. It can be of major interest to structuring the curriculum based on empirical evidence from different educational programs. This source provides a unique education-based perspective that will be helpful in logistically developing a course curriculum for studies in development engineering. However, the proposal is based primarily on five-year Spanish engineering curricula, so some topics may have to be adapted for our purposes.

Wesley, L. (1987). Western Engineers In Developing Countries. *Journal of Professional Issues in Engineering*. 113(3), 249-256.

This article contains three main arguments about western engineering in developing countries. It starts off by making the point that engineering in developing countries is different than in developed countries, and that westerners approaches have been largely unsuccessful. They go on to state that just because of unsuccessful attempts in the past does not mean that westerners should discontinue efforts to help in developed countries. They defend their point by exploring economic conditions, the influence of the current state of development and cultural influences to define differences in engineering practices, and then use case studies as well as statistics from the World Bank to argue that most sustainable community development attempts have been unsuccessful. The author of the article worked as geotechnical engineer in five different countries. Even though the question of whether or not engineers should travel to other countries to aid development is not the focus of the class module, the differences in engineering in the west and in developing countries will be important in our research. The three subtopics in the article explain that the main differences are: influence of the current state of development, differing economic conditions and cultural influences. These are all factors that I consider most important in community development.



Zolli, A. (2012, November 2). Learning to Bounce Back. The New York Times.  
Retrieved from <http://www.nytimes.com/2012/11/03/opinion/forget-sustainability-its-about-resilience.html?pagewanted=all>

This article, being from the New York Times, is not a peer-reviewed article. Nevertheless, it will be very useful. The author is an author, writer for the New York Times, and Executive Director of PopTech (an elite group of thought leaders exploring forces that influence the future). He provides an interesting point that could bring up a lot of discussion in a class module. It is targeted toward those in this type of course, forcing people to challenge new ideas. Instead of sustainability, which he defines as putting the world back into balance, he argues that resilience is the key. He defines it as finding ways to manage while the world is imbalanced. He backs this argument up by showing examples in the present day where infrastructure was updated to account for possible threats, and describing his idea of “soft” infrastructure. He pointed out that if resilience was practiced, many of the issues that we as well as developing countries are faced with can be less devastating. This is an opinion article, and this is an article that calls for discussion of the class’s opinions.