ENGRC 2250: Course logistics and projects

While we are enthusiastic about the outcomes of the first pilot and the leaps students reported in CSE, we are often asked about how, exactly, the ENGRC 2250 course (with its focus on communication, professionalism, and social justice) functioned.

ENGRC 2250 course logistics

The required MAE 2250 is an Engineering Design course that teaches the basics of the design, test, refine, and produce cycle. It is a large lecture course with labs, and students work in teams for all of their lab deliverables. Teams remain the same all semester, and they produce a basic lamp (to learn machining and safety), an original design item, and a wind/water pump. Teams produce small manuals to accompany their original design projects and their wind/water pump. They also give brief talks about their projects to course instructors and TAs.

A challenge that we had with the partnered ENGRC 2250 course was how to provide additional communication instruction without privileging ENGRC students for MAE deliverables. For example, the ENGRC students could not be allowed to write/rewrite/edit refine the MAE project manuals with help from the ENGRC instructor, as that would give them an unfair advantage. Thus, we had to mirror efforts and assignments but not replicate or enhance existing MAE 2250 assignments to avoid (as much as possible), direct semester-bound advantages.

To that end, the MAE and the ENGRC instructor worked to sync up calendars, assignment cycles, lab cycles, and other moving elements. As well, the ENGRC instructor became well acquainted with the one advanced design project, the wind/water pump, that was common to all MAE 2250 student teams.

Recall, too, that our work in ENGRC 2250 was to address vertical integration into the MAE curriculum. To that end, ENGRC addressed items such as abstracts, reports, strong visuals, and other elements that would be expected of them for junior and senior-level MAE courses. We provided the basics of rhetoric, as well, to give them foundations for later communicative agility.

ENGRC 2250 Course Projects

As noted above, the challenge in providing the pilots for this partnership course for Mechanical and Aerospace Engineering was creating projects that were complimentary to the MAE content without privileging ENGRC 2250 students. In the beginning, ENGRC 2250 content was specifically designed to focus on engineering professionalism (job search materials and processes, presence in social media and online professional sites, high-functioning teams, rhetorical strategies, audience analysis, presentation prowess, and the like). Such subjects have not been the explicit mandate or expected departmental outcomes for the MAE 2250 course in the past, so these were important communication elements to bring to the students while not intruding on MAE content.

Later in the term, once MAE 2250 students had been put into project teams, the content for the communication course needed to closely align with their mechanical designs—and again, we could not privilege ENGRC 2250 students. To that end, the solution was to take the common design project for all 140+ MAE students, which was a basic wind/water pump, and use it to different purpose in ENGRC 2250.

Final team project: Technological work, social justice, and communication

The MAE engineering design project was to design a pump from basic, cheap materials that could move a specific volume of water powered by wind; student teams in MAE created their own designs for the pump under the constraints provided by the engineering instructor. However, those pump projects were stand-alone; the student teams did not have to configure a pump system beyond materials, design, and the ability to move a certain amount of water in a given time.

For ENGRC 2250, that pump design project became the cornerstone of a larger vision of the place of engineering in solving localized problems. The communications course became the place where students explored how good engineering design is always contextualized, answering the needs of a set of specific set of circumstances that are economically, environmentally, socially, and politically bound. For their writing and presenting work, ENGRC 2250 students were required to investigate thoroughly placement of their wind/water pump in a community that had a need for increased water access.

Teams in ENGRC 2250 were formed using the CATME team-making online system, with the focus on “time available outside of class” as the baseline for team formation. Week 7 began intense work that focused on team dynamics/functionality/workflow, followed quickly with the team’s proposal for the project. Proposals (written with a presentation) required that each team identified its target community for pump placement and define the wind/water pump solution could best fit that localized need. Student teams researched and chose specific communities within Bolivia, Kenya, Navajo Nation lands, Nicaragua, and Malawi that would be good candidates for a wind/water pump that was easy and cheap to make and repair.

For the final projects in ENGRC 2250, providing a context for the wind/water pump was an essential step in the journey for students, moving from the classroom + lab to the “real world.” We charged teams with the investigative task of identifying a community in need, contextualizing water access problems, exploring the history of the community and its water needs, and delving into the aspects (as best they could) that reflect the social justice challenges of engineering in that place while being sensitive to community needs and expectations without a sense of “savior” mentality. As instructors, our motive was to have students experience, even on a small scale, the complex process of moving a technological invention out of the lab and into a demanding situation that was impacted by the constraints, affordances, and challenges that every professional engineer encounters. Along the way, we examined, reflected upon, write, presented, and explored the communication strategies and channels needed for strong work and project deployment.

Final team project: Report and presentation

Final project deliverables for each team included a lengthy final report that also placed that work within their chosen community context. The intended audience for that team report was either a funding source for pump placement or a potential NGO or charity organization for partnership.

For demonstration purposes here, we have included two figures from inside different reports (Figures 2 and 3). Final reports were required to include the technical specs with tables and CAD, pump test data, materials, costing, and related technical information. As well, the report (and its associated final presentation) had to include information and approaches that demonstrated an awareness of why the pump was needed, who could benefit, who might be negatively impacted, local skilled talent for pump maintenance, translation/localization processes for pump documentation, funding partnerships, and related issues.

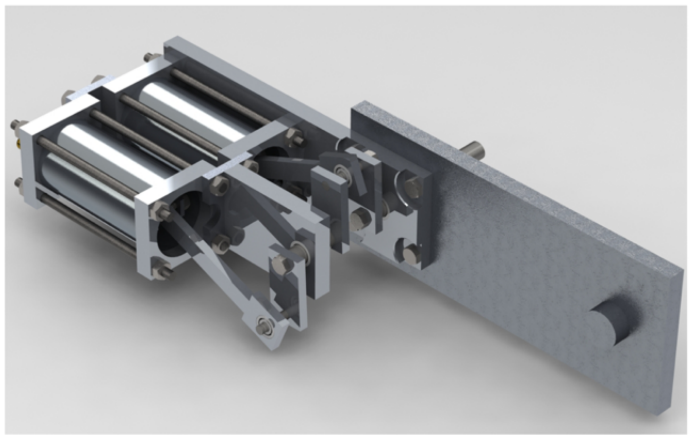

Figure 5: The Morrison Water Pump Prototype. *The Morrison Pump prototype is a dual piston single action wind-powered water pump. The pump is a very simple design with the primary mechanism being a slider crank with a crank arm radius of 1.5 inches and a connecting rod length of 4 inches. Since the design is simple and all bolts are of the same size, it can be completely assembled and disassembled for repairs by anybody with one wrench.*

Figure 2. Example pump design from a final report. This figure + caption example from a final student team report (Canez, Struble, Wiktorzak, & Xu, 2016) shows evidence of several communication aspects: good use of CAD to communicate technical design, advanced competence in caption work (label, title, caption), and brief technical information in that caption that reveals an understanding of localized engineering design (the need for easy assembly/disassembly for repair). All of these practices show evidence of higher-order communicative practices for engineering work.

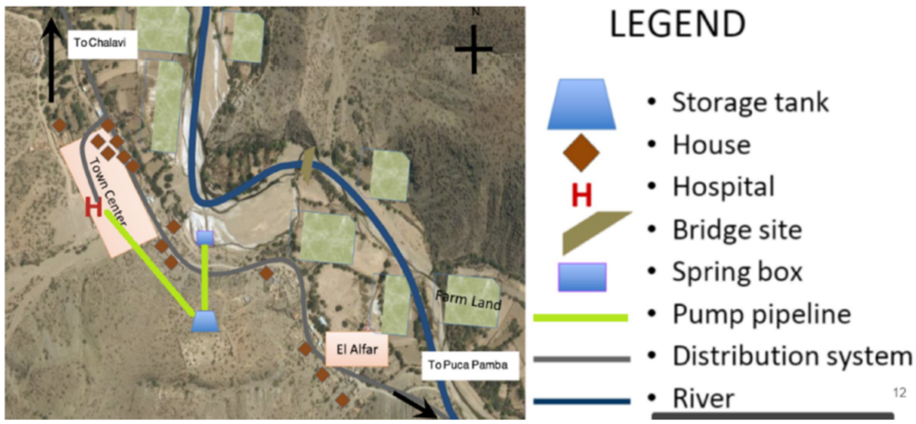

Figure 2: Calcha Map with Existing Infrastructure. *Shown in this figure is an aerial view of Calcha with the existing distribution system, pump pipeline, spring box, and storage tank. Also labeled are several houses, the hospital (where the tap-stand is), and the Vitichi River. Our proposed pump will be implented inside of the spring box (Adapted from Google Maps, 2016) [4].*

Figure 3. Example pump placement sketch from student team final technical paper. This student team researched a community that had continuous water access issues in Calcha, Bolivia (Alegria, Dominguiz, Mathews, & Williams, 2016). They found some suboptimal options from past water projects and pitched a pump placement project to enhance those existing systems. In this visual taken from the team's final technical report, we see evidence of contextualized engineering solutions, a helpful visual, strong caption work, and proper citations of sources. All of these practices show evidence of higher-order communicative practices for engineering work.

As well, teams gave a professional-level talk with an intended audience of potential financial and community partners in the room. (See Figures 4-6 for example slides from three teams). Of course, we could not import representatives from wished-for partners from all corners of the globe, but students were asked to perform as if those representatives were present. This imposition of an outside audience demanded more from the students than a presentation created for teacher or a TA. In preparation, students performed a deep audience assessment, assessed appropriate persuasive techniques, developed low-text/high-visual approaches (Alley, 2013; Garner & Alley, 2013; Garner & Alley, 2016; Nathans-Kelly & Nicometo, 2014), and purposefully crafted their slide decks as an integrated part of a complete documentation effort (Nathans-Kelly & Nicometo, Chapter 10). Students were required to use the assertion-evidence+archival notes approach to slides, which supported the spoken work and the documentation process at the same time (Alley, 2013; Nathans-Kelly & Nicometo, 2014),

Figure 4. Slide plus notes pane from student team with a pump placement within the Navajo Nation. This example from the team's final talk (Klein, Lee, Otterpohl, & Zhang, 2016) shows several ENGRC 2250 foundational elements in play: an attention to engineering needs and their related social justice issues, a wise use of the full acreage of the slide span, and extensive use of the notes pane to provide full documentation and citation of sources within the slide deck (Nathans-Kelly and Nicometo, 2014).

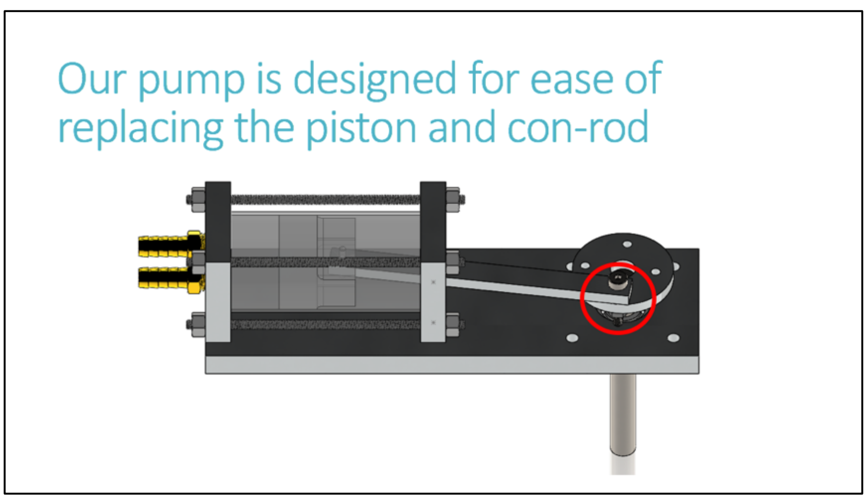

Figure 5. Example pump features from student team presentation. This team's slide example (Caffry, Cullinane, Kirchhoff, & Strejcek, 2016) shows evidence of several communication aspects: good use of CAD to communicate technical design and a strong sentence header that advances value-added features of the design while anticipating localized repair issues for a village in Malawi. All of these practices show evidence of higher-order communicative practices for engineering work.

Figure 6. Slide from student team with a pump placement in Chinandega, Nicaragua. This example from the team's final talk (Agulanna, Lederman, Russo, Salazar, 2016) demonstrates an awareness of localized engineering partnerships, an attention to related social justice issues, a wise use of the full acreage of the slide span (Slide Rules).

Course Project Alignment with Stated Foundational Concepts

Earlier in this work, we outlined the four cornerstones for the approach in the MAE/ECP Communications Initiative; those were Communicative Practice, Communicative Context, Communicative Design, and Communicative Identity. For our purposes, those were grounded in the engineering experience.

The communication course framed these concepts variously throughout the semester (see Table X). Here, for brevity's sake, we outline how the foundational concepts were evidenced in the final team project cycle.

1. **Communicative Practice:** Student teams demonstrated an awareness of engineering practice (designing and inventing with constraints) and moved their product into a specific environment. They became aware, through examples provided and readings/discussion, the complexities of communicating in an engineering arena. Teams researched, strategized, created, wrote, and presented materials not unlike those in practice outside of academia.
2. **Communicative Context:** Student teams identified, investigated, explored, and questioned the context for their engineering and communication work. Understanding difference between writing for the professor and writing for an outside client was impactful. Teams came to understand how to better reach various audiences (at the university, within a company, within a target community).

3. **Communicative Design:** Of particular note, the concept that the design of the communication is as important as the design of the engineering artifact rose to the forefront for student teams. Students became better equipped to assess how to reach particular audiences using writing, speaking, and visual evidence. Student teams were encouraged to find communicative methods that worked for their project, their designs, their pump placement, their target community, and their desired outcomes. For example, final written reports showed an advanced prowess in constructing engineering style technical reports. Figure E shows an abstract from a final report that demonstrates a team's ability to maneuver these waters well.

4. **Communicative Identity:** With early work in the semester on engineering identity (résumés, CVs, letters, interviewing skills, LinkedIn® pages, and e-portfolios), in the final project students moved more easily into creating professional team and personal identities within the frame of engineering work. Final presentations were extremely strong, and final reports were in-depth, well-constructed, and compelling for the targeted audiences.

Abstract

Team Ing-Wen is a subteam of RedInk, Inc. working with Engineers Without Borders–Cornell University (EWB–CU) to implement a solar-powered water pump in order to give clean, usable water to the people of Calcha, Bolivia. This community of 160 people is located in the Andes Mountains, and the pre-existing water distribution system does not provide sufficient water to the village during the planting season. Contamination from acid and heavy metals also affects the water in an upstream lake that feeds many tributaries in the area. Team Ing-Wen and EWB–CU will provide a solution that will result in a constant water supply to the community.

The team will implement its pump at the bank of the nearby Vitichi River, and EWB–CU will ensure a functional distibution system that takes advantage of the pre-existing infrastructure. 6400 liters of water needs to be moved up an elevation of 54 meters—including headloss—each day from the collection point to the pre-existing storage tank. The proposed pump mechanism is a single-action, single-cylinder, slider crank pump, with components made of 1012 steel, 6061-T6 aluminum and PVC Type II. The highest stressed component in the pump, the piston shaft, has a factor of safety in yielding of 11.3. The pump operates on 100 Watts of power, and delivers 6 liters per minute from a source of pre-purified water. By operating two pumps daily for nine hours each, we will successfully move 6480 liters of water per day.

Keywords: Calcha; Bolivia; Single-Action; Single Cylinder; Water Pump; Solar Power; Spring Box; Storage Tank; Water Purification;

Figure E: Abstract from a student team final report. The student team (called Ing-Wen) addresses the clients: RedInk, Inc. and Engineers Without Borders (Alegria, Dominguiz, Mathews, & Williams, 2016). The abstract alone demonstrates all of the foundational concepts, in short form, desired for the MAE/ECP Communication Initiative.