# Using International Engineering Experiences to Inform Curriculum Development

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## Abstract

This paper outlines learning objectives for students engaged in international work and offers an example case study exemplifying how to utilize these objectives. They will serve as a basis for designing curricula and workshops to help students learn to work in foreign environments before leaving campus. These multifunctional learning objectives were based on research conducted with students participating in extracurricular international service-learning projects abroad. Prior findings of this research outlined the impacts of international engineering experiences on student growth and learning.

The objectives presented in this paper are based on the six categories of student development identified by our prior research and include: technical knowledge, communication, personal growth, project management, community-based development, and intercultural awareness. These areas of development were discovered through analysis of student reflections, interviews, and discussions of students who had traveled with Engineers Without Borders to Cameroon, Guatemala, Haiti, and Nigeria. The learning objectives for each area of development were written in reference to the six learning domains outlined in Bloom's Taxonomy.

By publishing these objectives we wish to further encourage a participatory approach from both the academic and non-academic communities at large. This compilation of objectives and potential applications can guide others as they prepare students for international engineering work.


## Introduction

International engineering service-learning has emerged as a valuable learning tool, one that can advance students' academic, interpersonal, and personal skills. Engineering programs that incorporate international service-learning are varied, spanning a variety of curricular and extracurricular program. As interest from the academic community rises, it is important to articulate specific learning objectives for these programs. Service-learning done in an international context presents a particularly valuable experience for students. These experiences challenge students to navigate language and cultural barriers, work in foreign environments, and make the most of limited resources while being part of a project team. Since engineers are increasingly asked to work in various international locations and across cultures, gaining first-hand experience during their education will be of significant value as they move forward.

Research done by our team and others in the field indicates a strong potential for international service-learning based programs to meet the criteria outlined by the Accreditation Board for Engineering and Technology (ABET)[1]. ABET and The American Society of Civil Engineering (ASCE) both acknowledge changing expectations for engineers entering the workforce, with students expected to have strong interpersonal skills such as leadership, teamwork, communication, and intercultural awareness[2]. Similarly, AMD, an industry leader, has made their expectations clear for the Future Generation of Engineers[3] to go beyond technical skills and include project management, leadership, cross cultural, collaboration and critical thinking skills. Researchers and instructors alike are starting to discuss how engineering service-learning can be used to fulfill ABET's academic program requirements[4]. See Tables 1-3 in the discussion section near the end of this paper for a comparison of these recommendations to the learning outcomes found in our research. This paper intends to fill the need for the identification of specific learning outcomes and objectives based on these recommendations.

The objectives presented here are grounded in opportunities observed through students participating in real world international engineering and have the opportunity to meet many of the requirements articulated by influential engineering organizations. We believe that by creating objectives based on actual experiences and grounded in ABET and other guidelines educators will be more successful in helping students learn the skills they need to succeed in engineering practice.

The learning objectives presented in this paper can inform the creation of a variety of resources including:

- Curricula for international engineering
- Preparation material for student travel and project work
- Specific learning modules that target one or more thematic areas, including case studies and guided learning modules
- Introductory materials for students involved in extracurricular international service-learning projects
- Program evaluation tools for existing programs
- Frameworks to guide student learning and development

This paper will first describe the research conducted to inform the objectives and conclusions. We provide background on the participants and data used for this research, and details about the analysis method used. Second, we present the initial findings of this research: a framework for recognizing the student growth and learning that occurs from participation in international engineering experiences. Third is a set of learning objectives based on the six categories included in this framework. Fourth is an example learning module based on these learning objectives and our research. Fifth, we discuss the potential applications of these objectives. Finally, we present an example instructional module and some concluding remarks.

**Methodology**

*Overview*

The learning objectives presented in this paper are based on research conducted as part of a larger study investigating the specific knowledge, skills and attitudes student engineers acquire through EWB (Engineers Without Borders) service experiences abroad. Data were collected over a three-year period through a variety of sources, including: recorded on-site discussions from abroad, on campus interviews held upon returning from abroad, journals kept while traveling abroad, and discussion-based workshops held on campus. These data were coded and analyzed in order to create a working framework that outlined areas of student learning and growth as a result of international engineering experiences. The thematic areas identified in this framework then allowed for the creation of specific learning objectives. These learning objectives were categorized using Bloom's Taxonomy as an organization structure. To view these findings in full visit www.publish.illinois.edu/engineeringabroad.

*Description of Data Set*

Participants of this study were undergraduate students who were actively involved in EWB. These students had either recently traveled abroad or were currently abroad for their specific, EWB project. The first round of data collection was from two different project teams in 2009-2010, and was acquired while on-site and upon returning. This data set included twelve un-facilitated on-site group discussions, ten journals by individual students while abroad, and seven on campus post-trip interviews conducted by members of the research team.

The second data set was collected during a workshop facilitated by two members of the research team. It was held with the objective of generating discussion amongst seven active EWB members about the impact their involvement has had on their personal, academic, and professional growth. Participants were given questions and five minutes to compose a written response before discussing as a group. These open-ended questions fueled dialogue about their individual experiences abroad, the knowledge, skills, and attitudes that were gained while on-site, and how the current structure of EWB influenced the experience.

*Background of Engineering Projects*

The first set of data collected was from projects based in Cameroon and Guatemala that were both addressing the community's accessibility to clean water. The project based in Cameroon was conducting their second site-assessment trip and included: conducting interviews with community members to better understand their habits related to water consumption and health, attending large community meetings, and land surveying. Translators were used to help facilitate communication, but English was the primary language spoken by the students on this trip. The Guatemala project was visiting the community for the second time and beginning to implement their project design. Tasks for this project included: interviewing community members, constructing biosand filters alongside local construction workers, and working with two local social workers to develop health education programs. Spanish and English were the primary languages spoken. Local community members translated for non-Spanish speakers.

*Data Analysis*

A hybridized inductive-deductive process was used for our data analysis to triangulate and verify findings[5]. After outlining specific study objectives and a focus question, we identified key areas where developmental growth was anticipated based on other research on student participation in service projects abroad[6]. For each key area a term or phrase was chosen and an operational definition assigned. This deductive process, allowed for the creation a theory-driven abbreviated codebook based on the objectives of the study[7]. Operational definitions defined the parameters of the research focus, established guidelines for coding, and supported consistency among multiple researchers.

All documents were then coded in HyperResearch[8] based on the working definitions. Of the 55 documents accumulated in this study, 29 were determined to generate substantial data that addressed the study focus. The next stage involved an inductive process to re-examine those 29 documents to determine the most prevalent and relevant categories that were emerging as well as identifying other relevant codes that were not included in the original list. An iterative analysis process was used to arrive at a working framework to summarize areas of student learning and growth.

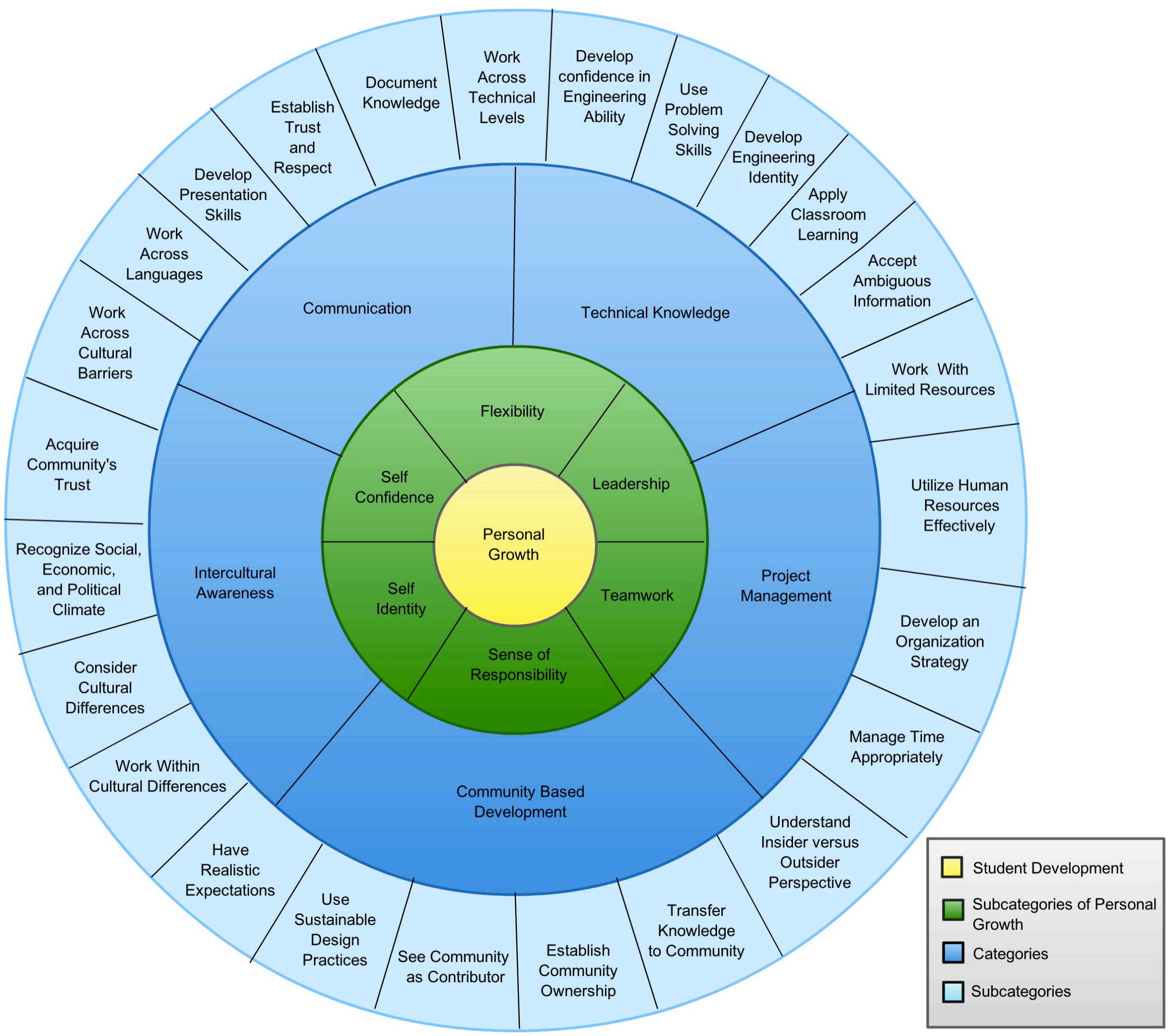
The second round of data collection further informed the components included in this framework. The discussion and written responses collected from students confirmed the initial findings and helped us to clarify which subcategories to include in each category. During the discussion certain categories were confirmed with enthusiasm across the group and with vivid examples, proving their presence and importance. After the workshop our team adjusted the framework to fit these new findings. Revisiting the initial data set allowed us to finalize the framework seen in Figure 1.

*Composition of Learning Objectives*

The learning objectives presented in this paper were written based on the knowledge, skills, and attitudes students will need to successfully work on international engineering projects. We outlined specific objectives for each of the six thematic areas of student learning and growth identified through our research. They were categorized with reference to Bloom's taxonomy for cognitive domains of learning, including: knowledge (remembering), comprehension (understanding), application (applying), analysis (analyzing), synthesis (creating), evaluation (evaluating)[9]. The thematic categories that were determined from data analysis serve as a guideline for areas in which students should demonstrate learning to ultimately be competent in the field of international engineering.

## Findings

**Figure 1: Student Development as a Result of International Engineering Experiences Abroad**




*General Overview*

The following six categories of developmental growth were: communication, cultural awareness, engineering technical skills and knowledge, community development, project management, and personal growth (Figure 1). The six categories overlap as they all play a vital role in overall student development. The six categories were further divided into subcategories, which can be seen in the outer ring of the diagram. The diagram was strategically arranged so to place similar pieces of the diagram in close proximity to each other. The overlapping subcategories are those that are fully encompassed by two categories.

To further explain these findings, the following sections will explain the thematic area, how it relates to engineering, and how it appeared in students international engineering experiences. Each category is divided into subcategories that represent specific areas of student growth and learning which help to define each category. Finally, we present learning objectives based on these categories to identify the intended outcomes as a student develops competency in each area. The learning objectives start with the most basic level of learning (comprehension) and advance to evaluation and synthesis.

### *I. Technical Development*

Deepening technical knowledge and skills in real world environments is vital to the development of engineering students who are both confident and realistic in their engineering ability. Technical development includes fundamental engineering, science, and math principles as well as gaining the ability to problem solve and work efficiently. While on-site, students gained valuable technical skills and an increased confidence in their engineering ability. Technical development, as defined here, also includes an increased confidence in engineering ability, a stronger sense of engineering identity, and the application of classroom learning to real world problems. Students also often encountered obstacles and decisions that required creative problem solving. Further, the acceptance of ambiguous information, the ability to work with limited resources, and making informed decisions deepened the students' understanding of the reality of working as an engineer in the real world. The following objectives encompass these specific components.

*Components of Technical Development*

- Develop confidence in engineering ability
- Use problem solving skills
- Apply classroom learning (math, engineering, and science fundamentals)
- Accept ambiguous information
- Work with limited resources

*Technical Development Learning Objectives*

Students will be able to:

1. Understand technical concepts encountered in international development projects.
2. Evaluate benefits and consequences of various potential technical designs/solutions.
3. Apply technical knowledge to develop designs that meet project goals.
4. Determine which technical design is appropriate for the project context and relay their reasoning.
5. Adapt and modify technical knowledge in relation to the project context.

6. Assess the effectiveness of the chosen design.

***II. Communication***

International engineering presents an opportunity for students to develop a wide range of communication skills which is one of ABET's eleven criteria for engineering programs. While abroad, students communicated across language barriers, between different cultures, and with people of varying levels of technical knowledge. In the research study, this communication was conducted in unfamiliar environments, with limited resources, and at times with less than ideal working conditions. Students presented at community meetings with over a hundred attendants, met with small groups of influential community members to make decisions regarding the project, and entered homes to conduct interviews. Through these experiences students reported an increased confidence in their communication skills.

This growth appeared to be the product of observation and practice. While traveling students would often discuss social nuances with other project members and host preparatory team meetings before many activities. Looking to these experiences for inspiration, curricula can be developed to better prepare students to respond appropriately and effectively in a broad range of circumstances. Preparing students to be aware of communication barriers they may encounter and teaching them techniques to overcome these barriers is a lifelong skill that will directly improve their professional careers. The overlap between certain elements of communication and intercultural awareness should be noted and is a product of the nature of international experiences.

*Components of Communication*

- Work across cultural and language barriers to effectively communicate and address issues and community needs and come to a consensus about project design
- Develop active listening skills
- Recognize and rectify communication breakdowns
- Communicate to establish trust and respect with community members
- Document knowledge and findings for future reference
- Develop ability to explain technical information to individuals without technical backgrounds
- Develop oral presentation skills
- Develop ability to communicate effective in group meetings with team members

*Communication Learning Objectives*

Students will be able to:

1. Identify potential communication barriers that may be encountered.
2. Differentiate between the various sources of communication barriers.
3. Develop various internal methods of working through communication barriers.

4. Determine how to appropriately react to various communication challenges.
5. Confidently navigate through various communication barriers while they are occurring.
6. Evaluate specific methods of approaching communication challenges and modify them to increase their effectiveness.

### ***III. Personal Growth***

The experience of working on an international engineering project led to personal growth amongst the participating students. Students recognized this growth in regards to the perspective they had on their individual, professional, and global selves. Personal growth in this context encompasses flexibility, teamwork, leadership, self-confidence, sense of responsibility, and a furthered engineering identity. Project teams learned to work cohesively in order to accomplish goals and furthered their ability to be accommodating of unexpected circumstances. Students gained leadership experience by being responsible to work effectively with their travel teams on a limited time frame. Being abroad also presented personal challenges and opportunities for personal growth. Gaining understanding in their role as an engineer was also an area of growth exhibited in students. The following learning objectives seek to outline specific elements of personal growth observed in students.

*Components of Personal Growth*

- Flexibility
- Teamwork
- Leadership
- Sense of Responsibility
- Self identity
- Self confidence

*Personal Growth Learning Objectives*

Students will be able to:

1. Identify their personal strengths, weaknesses, values, and skills.
2. Explain how their strengths, weaknesses, values, and skills could be utilized within a specific project.
3. Employ their personal abilities in order to contribute to their specific project group.
4. Analyze their personal growth as a result of project involvement and realize what they value in project design.
5. Improve upon targeted areas of personal growth.
6. Recognize how project involvement has influenced other areas of their personal and professional identity and have a firm grasp on their philosophy of development.

### ***IV. Project Management***

The various components of project management incorporated into EWB projects offer a great opportunity for students' to develop interpersonal and project management skills. Project management is defined to include: scheduling activities appropriately, effectively utilizing human resources, creating an information organization strategy, time management, and the understanding of the differences in having an insider or outsider perspective. Students completed tasks on a tight time schedule while working on-site in often unpredictable environments. Project management also includes the process of appropriately managing time, money, resources, and people. While immersed in a real world project, students exhibited growth in their ability to efficiently organize the resources of the team and to develop an information organization strategy. Students began to recognize the difference between the insider and outsider perspective. Gaining an insider perspective into the community is valuable for any project's success as it enables the project to be driven from the beneficiaries perspective. The dynamics of an EWB project offers insight into the valuable project management skills that can be acquired through this and other similar experiences.

*Components of Project Management*

- Manage time appropriately
- Develop an organization strategy
- Utilize human resources effectively
- Understand insider versus outsider perspective

*Project Management Learning Objectives*

Students will be able to:

1. Recall project management and leadership skills acquired in previous experiences.
2. Recognize the importance of a well-organized and structured project with specific goals and leadership.
3. Be a contributing team member by exhibiting traits of a project manager.
4. Realize specific project management components that would benefit their specific project.
5. Identify strengths and weaknesses of the current project management and be able to react appropriately.
6. Evaluate the effectiveness of project management components in regards to short and long-term project goals.

### *V. Community-Based Development*

Learning how to successfully root an engineering project in the community is vital for the long-term success and sustainability of a project. It was not until students visited the communities they were partnering with that they understood the need to establish the community as the owner of the project. They encountered challenges when transferring knowledge about the project to the local community for a variety of reasons that spoke to the need to establish a relationship of mutual trust and respect. Students arrived in the community with a working knowledge of the engineering elements of the project but often lacking the intimate understanding of the social, political, and environmental factors that also play a large role in the success of the project. Gaining a community-based perspective is necessary, but challenging as it requires successfully engaging the community throughout every stage of the project.

Students began to recognize the benefits of a bottom-up approach to development. By learning and experiencing the principles involved in community-based development, students can be better prepared to incorporate them into their project plans. Understanding the elements of sustainable international development is a vital skill for anyone involved in development work.

*Components of Community-Based Development*

- Have realistic expectations
- Use sustainable design practices
- Establish community ownership
- Transfer knowledge to community
- See community as project contributor

*Community-Based Development Learning Objectives*

Students will be able to:

1. Define community-based development.
2. Apply their knowledge of community-based development in the context of their specific project work.
3. Identify components of their project that will enhance or inhibit community involvement.
4. Incorporate community-based development theory into the design of the project.
5. Determine if the project will be effective based on whether the community is capable of independent and long-term project sustainability.

***VI. Intercultural Awareness***

While participating in international engineering experiences students became increasingly aware of cultural differences and how to integrate this understanding into their work. For engineering students to be prepared for today's global society, intercultural awareness is a necessary area of learning for all students. As defined through our research, intercultural awareness includes: the ability to work within cultural differences, an enhanced awareness of cultural differences, the realization of social, economic, and political climates, and the acquisition of community trust. While on-site, students are immersed within the local culture and thus have the opportunity to pursue a more appropriate project design by understanding the social, economic, and political elements of the community. Students expressed that developing a sense of cultural differences led to an enhanced awareness of how to move forward with the project as they more fully understood community needs in the appropriate cultural context. Finally, students realized the importance of acquiring a community's trust to create an atmosphere of project sustainability. Students have the opportunity to increase their intercultural competence while abroad, but it is also possible to address this topic within the general engineering curricula.

*Components of Intercultural Awareness*

- Realize the importance of acquiring community's trust
- Recognize social, economic, and political climate of a particular context
- Analyze cultural differences
- Adapt to cultural differences
- Develop a tolerance of ambiguity and a non-judgmental stance

*Intercultural Awareness Learning Objectives*

Students will be able to:

1. Recognize that differences between cultures exist.
2. Explain the complexity of, and specific features of, a given culture.
3. Differentiate between own and other worldviews without judgment.
4. Identify aspects of the culture that are affecting the engineering design and design process.
5. Develop project solutions that begin to take into account the cultural differences of each stakeholder.
6. Compile specific cultural differences and can propose alternative solutions that reflect various cultural perspectives.
7. Behave and communicate in a culturally appropriate manner.
8. Evaluate a specific project's success in regards to its cultural appropriateness while restraining personal cultural judgments.

**Example Instructional Module**

***Application Scenario***

The process of constructing biosand filters with local construction workers in a rural Guatemalan community.

***What Students Should Learn***

After this activity students will have a deeper understanding of how a seemingly technical engineering project actually encompasses a wide spectrum of knowledge, skills, and attitudes. Students will also realize the importance of communication, giving community ownership of the project, and acquiring trust from individual community members while working on a technical project on-site.

***Learning Objectives***

*Technical Development*

- Analysis: Student will be able to apply technical knowledge to develop designs that meet project goals.
- Synthesis: Student will be able to determine which technical design is appropriate for the project context and relay their reasoning.
- Evaluation: Student will be able to adapt and modify technical knowledge in relation to the project context.

*Communication*

- Knowledge: Student will be able to identify potential communication barriers that may be encountered.
- Application: Student will be able to develop various methods of working through communication barriers.
- Analysis: Student will be able to determine how to appropriately react to various communication challenges.

*Community-Based Development*

- Analysis: Student will be able to apply their knowledge of community-based development in the context of their specific project work.

*Intercultural Awareness*

- Analysis: Student will be able to differentiate between own and other worldviews and can act and design projects accordingly.

*Personal Growth*

- Comprehension: Student will be able to explain how their strengths, weaknesses, values, and skills could be utilized within a specific project.
- Application: Student will be able to employ their personal abilities in order to contribute to their specific project group.

*Project Management*

- Application: Student will be able to be a contributing team member by exhibiting traits of a project manager.

***Scenario for Group Discussion***

Provide the following scenario to small groups of students for discussion:

You are involved with a co-curricular group that works in a rural Guatemalan community focused on providing clean water to this community's residents. Your team is actively researching biosand filters and seeks to constantly improve the models constructed from concrete. For a more in-depth understanding of how a biosand filter works, please conduct online research. The main language spoken in this community is Spanish.

You are one of five students on the first implementation trip and are currently working with local construction workers to construct new biosand filters. The project team made one other trip to the community for a site assessment trip nine months prior and has had limited communication since. Your team is also assessing filters that were previously created for sustainability and proper construction.

*Discuss in your team your language abilities. Do any of you speak Spanish?*

Overall, how does your team plan on communicating with community members? What advantages do the team members who speak Spanish have? How can you still utilize all of your team members?

As filters that have been previously built by local construction workers are examined, it is noted that the cement was produced using too much water. However, when your team attempts to correct this situation by building new filters that have less water in the cement, a small amount of visible air pockets are seen throughout the final concrete filter.

*What mix for cement will your team choose? What technical knowledge led you to this decision?*

*Is there other information still missing? Form a list of questions you still have and ideas for how to answer them.*

After discussion, your team concludes that the mix with less water—though it produces small air pockets in the concrete filter –is better suited for construction the biosand filters than the mix with more water.

*Compare the advantages and disadvantages of the two types of filters. Are there other options you could explore?*

The community members working on the construction of the filters, however, are not convinced that the filters with air pockets are better.

*What are some reasons as to why the construction workers do not fully grasp this concept?*

Many community members fear that the filters with air pockets are of worse quality than those constructed with the more wet cement because the new filters have a visible problem and do not look as nice as the older variety.  Your team fears that the construction workers will return to the older, weaker mix once your team departs.

How can you convince the construction workers to continue using the stronger, though not visibly perfect, filters with air pockets?  When discussing this with your group, please consider:

- The technical reasoning
- Your communication strategy
- How you will acquire the trust of and gain credibility with the construction workers
- Cultural differences
- Long-term understanding and continued use of the stronger cement

***Facilitator Notes***
Divide students into groups of 5 students and give them 30 minutes to discuss the situation within their groups.  Allow students to conduct further research on laptops, etc. as needed.  Direct groups to think from both their own perspective as well as that of a local construction worker.  Next, facilitate a class discussion about what decisions the various groups made concerning the final question and how they came to those conclusions.  Allow for debate between the teams so students have time to realize the consequences and benefits of their team's final decisions.  Guide the class through this type of analysis.   Finally, discuss with the students how on-site in the actual scenario, one part of the proposed solution consisted of training one construction worker to oversee all filter construction to help ensure consistency.  He received special training and was awarded a certificate identifying him as the construction specialist.  What is the benefit of this?  Was this considered by any of the groups?

***Final Discussion Questions***
- Why did your group make the decision it did?
- What was the process that your team used to come to a decision?
- Why is culturally relevant communication important?
- What aspects of the local culture would be helpful to know in order to make a more educated decision?
- Why is important to acquire trust?

**Discussion**

***Comparison of Expectations for Graduating Engineers***
The learning objectives created as a result of our research shared many similarities to those laid out by the Accreditation Board of Engineering and Technology (see Table 1), the National Academy of Engineering's (NAE) "essential characteristics of the Engineer of 2020" (see Table 2), and AMD's Next Generation Engineer (see Figure 2 and Table 3).  In looking at the

similarities of these guidelines we can better understand what instructional changes are necessary to supply students with the knowledge, skills, and attitudes an engineer of the future will need. The tables offer a comparison of the guidelines presented by ABET, NAE, and AMD and the categories and subcategories from our research. The consistency seen among all of these institutions imply a forming consensus on the adjustments that are needed to traditional curriculum to make it more relevant to the demands of today's society.

**Table 1: ABET learning criteria, ABET[1]**

| ABET Learning Criteria | Related Category | Related Subcategory(s) |
|---|---|---|
| a) An ability to apply knowledge of mathematics, science, and engineering | Technical Knowledge | Confident in engineering ability, Apply classroom learning |
| b) An ability to design and conduct experiments, as well as to analyze and interpret data | Technical Knowledge | Problem solving, Apply classroom learning |
| c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, health and safety, manufacturability, and sustainability | Community-Based Development | Use sustainable design |
| d) An ability to function on multi-disciplinary teams<br>e) An ability to identify, formulate, and solve engineering problems | Personal Development | Teamwork |
| f) An understanding of professional and ethical responsibility | Personal Development | Sense of Responsibility |
| g) An ability to communicate effectively | Communication | Work Across Technical Levels, Cultural Barriers, Presentation Skills |
| h) The broad education necessary to | Intercultural | Recognize Social, |

| | | |
|---|---|---|
| understand the impact of engineering solutions in a global, economic, environmental, and societal context | Awareness, Community-Based Development | Economic, and Political Climate, Sustainable Development |
| i) A recognition of the need for, and an ability to engage in life-long learning | Personal Development | Furthered Engineering Identity |
| j) A knowledge of contemporary issues | Intercultural Awareness | Consider Cultural Differences |
| k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice | Technical Knowledge | Confident in Engineering Ability |

**Table 2. The Engineer of 2020, NAE[10]**

| **Engineer of 2020 Trait** | **Description** | **Related Category** | **Related Subcategory(s)** |
|---|---|---|---|
| Strong analytic skills | The use of science, mathematics, and domains of discovery for a particular challenge and for a practical purpose. | Technical Knowledge | Confident in Engineering Ability, Apply Classroom Learning |
| Practical ingenuity | Skill in planning, combining, and adapting. | Project Management | Utilization of Human Resources, Schedule Activities Appropriately |
| Creativity | A use of invention, innovation, and thinking outside the box. | Technical Knowledge | Creative Problem Solving |
| Communication | Effective use of language to achieve engineering objectives with and through multiple stakeholders. | Communication | Work Across Technical Levels, Cultural Barriers, Presentation Skills |
| Business & management | Connecting engineering to technological, economic, and | Intercultural Awareness | Recognize Social, Economic, and Political |

| | | | |
|---|---|---|---|
| | social factors in decisions and policy making. | | Climate |
| Leadership | Providing professional direction in various ways, including contributing to management and policy decisions. | Personal Development | Leadership |
| Ethics & professionalism | Making effective and wise choices that take economic, social, and environmental factors into consideration. | Community-Based Development | Sustainable Design |
| Dynamism-agility-resilience-flexibility | The elusive quality that results in quick and resourceful problem solving. | Technical Knowledge | Creative Problem Solving |
| Lifelong learners | A commitment to taking on new professional directions and challenges. | Personal Growth | Furthered Engineering Identity |

**Figure 2: Next Generation Engineer: Solving Workforce Needs, AMD[3]**

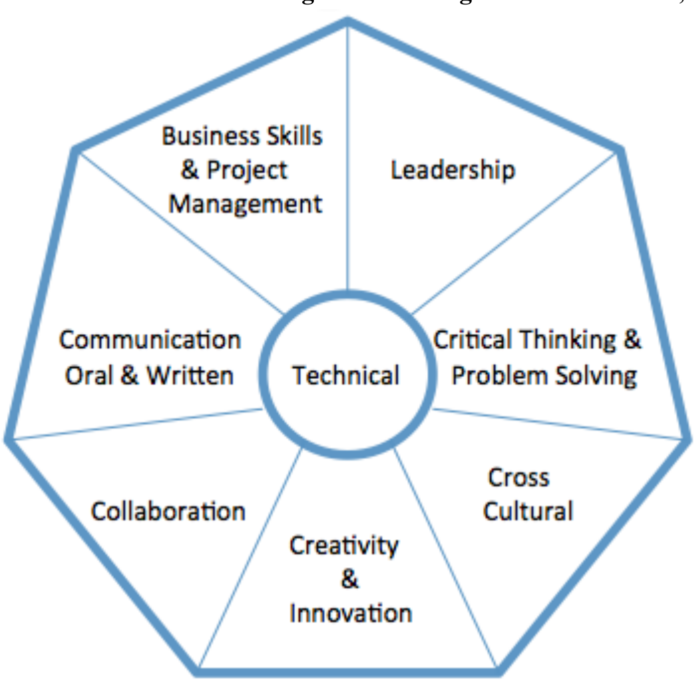


**Table 3: Next Generation Engineer, AMD**[3]

| **Next Generation Engineer Trait** | **Related Category** | **Related Subcategory(s)** |
|---|---|---|
| Technical | Technical Knowledge | Apply classroom learning, develop confidence in engineering ability |
| Leadership | Personal Growth | Leadership |
| Critical Thinking & Problem Solving | Technical Knowledge | Use problem solving skills |
| Cross Cultural | Intercultural Awareness | Work within cultural differences, work across cultural barriers |
| Creativity & Innovation | Personal Growth, Community Based Development | Flexibility, use sustainable design practices |
| Collaboration | Personal Growth | Teamwork |
| Communication Oral & Written | Communication | Document knowledge, work across technical levels, presentation skills |
| Business Skills & Project Management | Project Management | Utilize human resources effective, manage time appropriately, develop an organization strategy |

**Application**

The learning objectives detailed above have many applicable uses in both curricular and co-curricular formats and can lead to a more holistic and well-rounded engineering education. Professionals who lead service-learning and international engineering courses may utilize these objectives for specific modules as well as when outlining overall learning objectives for the course.

Organizations such as Engineers Without Borders will also be able to incorporate these objectives into various materials such as case studies, learning modules, and discussions adapted to fit their respective audience and goals. Realizing potential areas of development will enable these organizations to focus on teaching material that maximize student growth. For example, introductory materials for students new to Engineers Without Borders should discuss the aforementioned categories so students can understand the variety of ways these experiences will impact them. Having a multi-disciplinary understanding of engineering will better prepare students for real-world projects and the global society they will enter upon graduation. Technical skills and knowledge will be better understood alongside intercultural awareness, the ability to effectively communicate, project management skills, and an understanding of community or client ownership of a project.

These learning objectives also provide guidance on how to evaluate the effectiveness of existing and future programs. By assessing students in these areas pre- and post- experience, instructors will be able to gauge student learning and growth. By presenting students with a tool to measure their own progress within these areas they will be able to track their personal growth and identify their individual strengths and weaknesses.

**Conclusions**

The learning objectives and instructional module presented in this paper are based on actual learning experiences observed through student participants in international engineering projects. Prior research in this area has shown the diverse set of skills that are used and can be developed by students involved in international service learning. Instructors must be intentional about designing material that appropriately introduces students to the complexity of international work. The holistic framework presented in this paper will guide instructors through this process. We believe the academic community has a responsibility to contribute to socially responsible and sustainable development work. Through teaching students bottom-up, community-based development techniques they will be better suited for putting the societal needs of those they are serving at the forefront of their engineering work.

This paper serves as a starting point for the development of curriculum to meet these goals. Our research team intends to continue developing curriculum and other supplementary materials designed to meet these credentials. By continuing to work with students on a firsthand level, the team will be able to assess how the utilization of new educational materials impact their overall development. Others are encouraged to share the knowledge and resources they have created surrounding this topic to further advance this realm of study. Visit www.publish.illinois.edu/engineeringabroad for more information.

Ultimately the results of this research and the proposed learning objectives have the potential to be utilized by a variety of audiences and in a wide range of contexts. Though there is not an equal substitute for on-site experience, the goal of this team is to develop methods that will foster the proper knowledge, skills, and attitudes acquired by international engineering experiences in a domestic setting. This would allow for a larger range of students to experience the eye-opening and transforming personal development that has been seen as a result of on-site international engineering experiences.

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