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Assessing ABET Student Outcomes Through International Virtual Exchange

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Alia Gilbrecht founded the Virtual Exchange Collaborative at An Najah National University and is a seasoned expert in Virtual Exchange (VE) and Collaborative Online International Learning (COIL) with over seven years of experience. Throughout her tenure, she has pioneered the initiation, expansion, and refinement of high-quality VE programs that have impacted over 1500 students and fostered the development of more than 25 course-to-course COIL partnerships. Her significant contributions have not only earned An-Najah a prestigious second award from the Stevens Initiative in 2023 but also solidified its role as a lead partner in the Erasmus+-funded 'CliVEx' project, engaging over 2500 participants across MENA and Europe.

Alia's journey in VE began in 2017 with a Stevens Initiative grant, through which she developed programs initially uniting students from Palestine and the U.S. to collaborate on green building projects. This first experience illuminated the transformative potential of VE in reshaping students' global perspectives and enhancing their capabilities, driving her to continue pursuing VE opportunities and programs for students. As a UN-certified cross-cultural dialogue facilitator, Alia has over four years of experience facilitating dialogue-based virtual exchanges among diverse groups of students from across the Middle East, Europe, and the U.S., and has mentored other facilitators through the process, which have informed the intercultural dialogue framework in this research.

Assessing ABET Student Outcomes Through International Virtual Exchange

Abstract

There is an increasing global interest among universities to obtain and maintain various international accreditations; a common one being the Accreditation Board for Engineering and Technology (ABET). ABET accreditation lists seven Student Outcomes (SOs) an engineering program should ensure that students attain before graduation. The attainment process and assessment procedures vary among different programs. Furthermore, there is a global interest among universities to engage in various forms of international education, including virtual exchange. This work presents an approach to attain and assess several ABET SOs through international virtual exchange (IVE) using a case study between universities in the US and in the West Bank in the Occupied Palestinian Territories. The IVE experience was conducted over seven weeks where civil engineering students enrolled in pavement design or environmental engineering courses at the participating universities were challenged to develop innovative solutions to a pavement related problem and has been run for three iterations.

Both IVE and non-IVE teams were formed with different numbers based on the enrollment at each institution and the non-IVE teams were considered as control groups. Assessment focused on teamwork, global competencies, and application of engineering design to meet specified needs. Attainment of outcomes was assessed using direct and indirect measures that included established and adapted surveys as well as student work products. The results of this study emphasize how IVE experiences can not only have a positive impact on students' formation as engineers, but also that these experiences can help students attain SOs outlined by ABET in a meaningful and authentic way that is embedded within a course context. For example, IVE teams tended to focus on solutions that met the needs and contexts of both countries, whereas non-IVE teams focused on the context of their own country. Additionally, students on IVE teams overcame language barriers and differences in vocabulary to effectively communicate with their teammates.

Introduction and Background

In the ever-evolving landscape of engineering education, the pursuit of excellence is marked by a commitment to fostering global perspectives and cross-cultural competencies among students. As we navigate the 21st century, the need for engineers who can collaborate seamlessly across borders and understand the nuances of diverse societal contexts has become increasingly paramount. As a result, universities worldwide endeavor to secure accreditation for their engineering programs on both local and global scales.

Program Accreditation and Assessment

Worldwide, multiple accreditation systems and procedures are in place, with a predominant focus on outcomes-based models. For example, in India, the National Board of Accreditation (NBA) evaluates the qualitative competence of engineering programs by emphasizing outcomes-based education (OBE) [1]. Another significant system, the EUR-ACE, is described as “a framework and accreditation system that establishes a set of standards identifying high-quality engineering degree programs in Europe and beyond” [2]. Additional systems include the Engineering Council (EC) in the UK, the American National Standards Institute (ANSI) National Accreditation Board (ANAB), and numerous others catering to institutions within a single country [3].

One of the most popular accreditation organizations for science, technology, engineering, and mathematics (STEM) disciplines is the Accreditation Board for Engineering and Technology (ABET), a nonprofit, non-governmental organization that accredits programs in applied and natural science, computing, engineering, and engineering technology. According to ABET, the purpose of program accreditation is to assure confidence that a graduate of a program has met the standards essential to enter critical fields in the global workforce. While there are eight general criteria, the foundation of ABET accreditation is an ongoing assessment process related to three criteria [4]:

ABET Criterion 2: Program Educational Objectives
ABET Criterion 3: Student Outcomes
ABET Criterion 4: Continuous Improvement

Each program must establish a set of program educational objectives (PEOs) that broadly express what graduates are expected to be able to do within a few years following graduation. A program typically has two to three PEOs that are based on the needs of the program’s constituencies. Student outcomes (SOs) describe what students will be able to do and know by the time they graduate from the program. For engineering programs, ABET defines seven SOs that all engineering programs must include [5].

SO 1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

SO 2: an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

SO 3: an ability to communicate effectively with a range of audiences

SO 4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

SO 5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

SO 6: an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

SO 7: an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

To satisfy Criterion 4, programs develop and implement a continuous improvement plan to ensure that graduates attain the SOs. A continuous improvement plan is a cycle that includes three main steps as illustrated in Figure 1: Assess, Evaluate, and Act. While accreditation is at the program level, assessment of SOs is typically done at the course level with additional assessments conducted outside of courses.

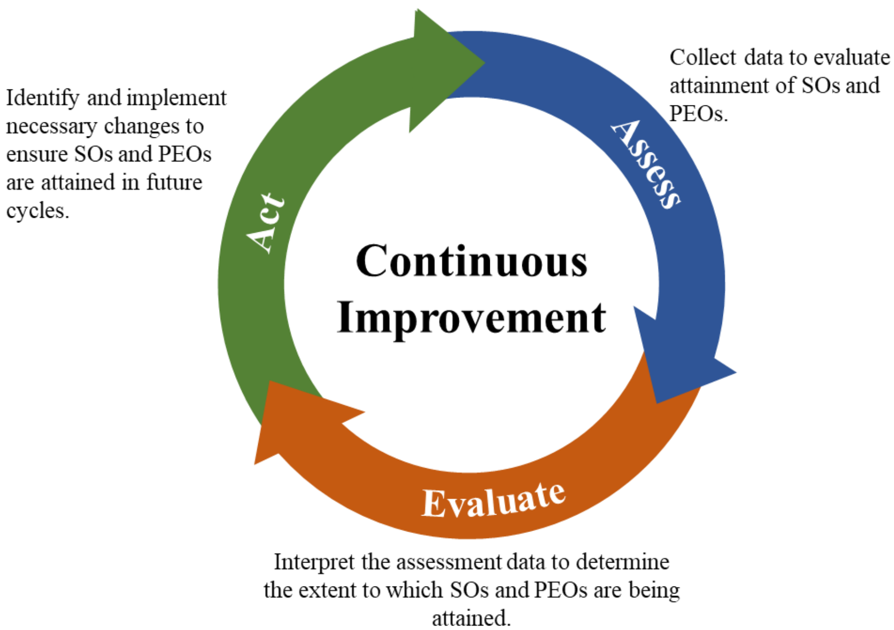


Figure 1. Typical continuous improvement cycle

Assessment includes both direct and indirect methods to measure student attainment of SOs. Typically, direct assessment throughout multiple courses within a program is conducted using instruments such as exams, quizzes, projects, presentations, written reports, and other assignments. These techniques provide direct feedback and strong evidence of student learning. However, not all learning can easily be measured in a direct way, so indirect assessments can also be employed even though it can sometimes be challenging. On indirect assessment, Rogers states [6]:

> *"Indirect assessments of student learning ascertain the perceived extent or value of learning experiences. They assess opinions or thoughts about student knowledge or skills. Indirect measures can provide information about the respondent's perception of student learning."*

Therefore, indirect evidence is not as strong as direct methods due to the challenges in interpreting and validating the students' perceptions. On the other hand, an indirect assessment is useful in identifying certain implicit qualities of student learning, such as values, perceptions, and attitudes, from a variety of perspectives. It is recommended to include a mix of direct and indirect measures for each SO within an assessment plan.

Indirect assessment methods typically involve surveys administered to students during their enrollment in the program (SOs at the course level), exit surveys upon graduation (SOs at the program level), and post-graduation alumni surveys (program level PEOs). Additionally, feedback from employer surveys and external industrial advisory boards serves as alternative indirect assessment sources. Other forms of indirect assessment also exist. Nevertheless, it has been noted that the accuracy of perceived values in some of these surveys may be compromised, a common challenge in survey research. For example, students enrolled in the program might feel compelled, rather than voluntarily inclined, to complete the surveys, potentially undermining the authenticity of their responses. A similar reluctance may be present in exit surveys. External evaluations by employers, alumni, and the industrial advisory boards, while valuable for reflecting industry perspectives on the program and its graduates, are conducted from a distance and may lack direct interaction with the program and graduates. Consequently, these assessments may not always provide wholly accurate reflections.

Rogers also indicated that all assessment methods have their limitations and contain some bias [6]. Therefore, it is more meaningful to use both direct and indirect assessments from a variety of sources. These could be students, alumni, faculty, employers, etc., and through a variety of techniques such as archival data, exit surveys, questionnaires, interviews, focus groups, etc. Multiple assessment methods would, therefore, cover evidence of student learning [7].

Numerous studies, including those by Mutalib et al. [8] and Wahab et al. [9] have addressed ABET accreditation systems, evaluation methods, and attainment levels in general and for specific programs or at particular universities. Several other studies focused on indirect and direct assessment methods and challenges highlighting the issue of lack of knowledge regarding the methods of evaluating ABET SOs, which might cause confusion at times [7], [10], [11], and [12]. Another study used a data mining technique to discover a set of rules that govern the relationship between the PEOs and SOs using 152 ABET accredited engineering program self-study reports [13].

Sarker et al. assessed engineering programs from a critical consciousness (CC) perspective, which most engineering students lack leading to exacerbating inequality, ignoring community questions and concerns, or failing to consider the consequences of communities when assessing program success [14]. The research tested CC with 150 students in two US universities through a survey consisting of 46 items that capture systems of oppression in civil engineering through three indicators (Critical Reflection: Perceived Inequality; Critical Reflection: Egalitarianism;

and Critical Action: Sociopolitical Perception). The study highlighted that such an instrument can also be used to assess ABET SOs 2 and 4.

Baideme et al. conducted an evaluation on how group learning impacted the curriculum and courses across junior- and senior-level environmental engineering courses at 14 institutions, considering ABET SO 5 which focuses on teamwork [15]. The findings revealed that team-based activities did not uniformly benefit all students. Additionally, the study observed that participating in group learning exercises did not notably enhance student learning for subsequent individual exams. Moreover, the research concluded that students who formed their own teams tended to achieve grades similar to their overall course grade. Conversely, lower-performing students, whether randomly assigned or intentionally grouped with higher-performing peers based on prior performance, often achieved higher grades on group assignments compared to other course components. However, these improved grades did not consistently correlate with enhanced individual performance.

In addition to the face-to-face in class environment, researchers investigated students' attainment level for online courses. Mohamed et al. introduced a module for teaching power systems labs that is suitable for full online education programs [16]. Their work addressed the relevance to ABET SOs and beyond. The authors concluded that the approach might be used as an educational guide for instructors at institutions that embrace distance learning programs.

Furthermore, Chilukuri highlighted several assessment techniques in engineering education mapped to course outcomes with an active learning environment; however, they were mostly offered off-line or in-class [17]. Therefore, these have limitations in time or on the number of active participants. The author also discussed several interactive online learning activities that were proposed and evaluated, including interactive videos with annotations, quizzes, hot spots, discussion, interactive presentations, etc. However, they were recognized as either expensive or offer only a set of the features required to implement a complete active online learning environment. The study suggested a tool and a framework for course design using various elements mapped to the knowledge, analytical, and application levels within a much desired active online learning experience to the users. Survey results from 61 students before and after the suggested framework were satisfactory, indicating the success of the chosen framework. With the wide-spread of online learning, there is a growing need to identify students' innovation in these environments. Usher et al. compared student innovation results between an on-campus synchronous face-to-face course (103 students) and a fully online asynchronous course (108 students) using self-reports and the learning products [18]. Pre- and post-course questionnaires indicated that both courses showed similar results of innovative behavioral tendencies. However, the face-to-face environment produced slightly higher results in individual assignments and team projects, which indicated a need to better improve the delivery of online learning.

In addition to Criteria 2-4 discussed previously, ABET also stipulates program specific criteria based on input from related professional societies. For example, civil engineering programs have several curriculum requirements. One such requirement is the application of principles of sustainability, risk, resilience, diversity, equity, and inclusion to civil engineering problems [5].

International Virtual Exchange (IVE)

With the rise of globalization, cross-border collaboration in professional industries, including engineering, is increasingly common. This shift necessitates intercultural competence as a vital skill for today's engineers, alongside their technical expertise. Global competencies involve the ability of individuals or teams from diverse cultural backgrounds to work together effectively, embracing multiple perspectives.

Universities are addressing the need to develop intercultural competence in engineering students through various programs. These include international exchange programs, internships, study abroad programs of varying durations, and international virtual exchange (IVE) programs, the latter of which is becoming increasingly popular. IVE programs, sometimes also referred to as collaborative online international learning (COIL) programs, facilitate international and intercultural interactions among students, providing a cost-effective, flexible alternative and/or complement to traditional study abroad programs. They are especially advantageous in enhancing teamwork skills across different regions and cultures, preparing students for the challenges of a global business environment.

IVE experiences typically last 5-8 weeks and use technology to bring students together from different countries and/or cultures to engage in structured intercultural exchange in synchronous or near synchronous formats. These exchanges are co-created and co-taught by faculty from partnering institutions and include collaborative exercises for the students such as project-based learning [19].

The role of IVE was further highlighted during the COVID-19 pandemic, which forced a significant shift in higher education towards virtual learning [20]. This transition accelerated the development and implementation of virtual exchange programs, along with the necessary tools to facilitate them effectively. Through IVE, students not only gain academic knowledge but also personal development, digital competency, and a capacity to contribute to global sustainability issues like climate change. These experiences equip them well for the professional phase of their careers, allowing them to collaborate effectively in an increasingly interconnected world.

The integration of international virtual exchange (IVE) programs in engineering education has gained significant attention in recent years. As part of this trend, the assessment of student outcomes through IVE has become a crucial area of research and evaluation. Recent studies, such as one conducted by East Carolina University, have demonstrated the potential of IVE to enhance student learning and academic performance [21]. The definition of IVE as "technology-mediated international experiences that are peer-driven, facilitated, collaborative, and sustained over time among geographically separated cultural groups" provides a clear framework for understanding the nature of these programs [21]. Additionally, research has highlighted the benefits of IVE in fostering global competencies, teamwork, and perceived value among students [22], [23].

Integrating IVE and Program Assessment

As previously stated, indirect assessments such as surveys conducted just prior to graduating sometimes either do not yield sufficient response rates or can seem disingenuous to students about to graduate. However, when surveys are administered within the context of an IVE program, students are more likely to willingly participate in surveys, when they are an integral part of the course. These surveys serve as vehicles for self-assessment and peer feedback, rendering them more relevant to the specific course, project, or experiential learning opportunity. This is particularly pronounced when surveys are conducted close to the completion of a project, rather than at the culmination of their degree program just before graduation. Unlike generic surveys focusing solely on the seven SOs, these assessments are concentrated on capturing the overall experience. Consequently, it is expected that such targeted and timely indirect assessments will yield more authentic and meaningful results. Furthermore, the evaluation cycle is expedited, occurring within the duration of a course, as opposed to the standard cycle, which typically takes place annually or every two to three years. In addition, the IVE can be used for direct assessment through different types of assignments and evaluation processes.

Limited studies were found to address student attainment of learning outcomes through an IVE experience in engineering programs. Emmett assessed an online global engineering course with embedded IVE after the COVID-19 pandemic [24]. Studies were also explored in the medical field and social sciences [25]. For example, O'Dowd investigated what students learn in IVE for 345 students of English in a Spanish university using qualitative analysis [26]. The study concluded that the IVE experience helped to overcome students' stereotypes and gain confidence in communicating in the second language.

In summary, extensive research has explored various assessment methods and tools for measuring student learning across various disciplines including engineering, focusing on distinct educational outcomes. As for ABET accreditation and program requirements, research prompted discussion of both direct and indirect assessment methods. Direct assessments are recognized for their clarity and straightforwardness, whereas challenges associated with indirect assessments have been underscored. With the widespread use of online learning alongside traditional in-class settings, research has delved into assessing attainment of learning outcomes in both environments, with few assessments in IVE classes. However, few prior studies have specifically addressed ABET assessment at the course or program levels within the IVE, an aspect viewed in this study as a vital tool for such an assessment. This could potentially mitigate certain hurdles inherent in indirect assessments.

Objective and Scope

The aim of this study was to introduce an alternative and authentic tool for assessing learning outcomes in alignment with ABET and beyond, using IVE. Informed by the experience of a case study IVE experience that evolved over the course of three years, this paper presents guidelines for integrating IVE into engineering curricula, in alignment with ABET criteria in a way that will elevate the overall quality of engineering education. By redefining the role of IVE in engineering education, we can move it from a mere supplement to a substantive and impactful tool for preparing students for success in the increasingly interconnected and diverse professional landscape.

Case Study: Innovative Pavement Solutions

The authors, representing universities in the United States (US) (Bucknell University and Clemson University) and the West Bank in the Occupied Palestinian Territories (An-Najah National University) have led an IVE experience for civil engineering students for three consecutive years. In this team-based project, students were challenged to develop innovative solutions to pavement related problems with a connection to at least one UN Sustainable Development Goal (SDG). As initially designed, there were three primary learning outcomes associated with this project where students should be able to:

- Apply the design thinking process to identify a specific problem and develop a creative and/or innovative solution to address this problem. (Design Thinking)
- Function effectively on a team. (Teamwork)
- Demonstrate a knowledge of the country(ies) and culture(s) of their team members. (Global Competency)

Students worked in one of three different types of teams:

- IVE teams included two students from a US institution (either Bucknell or Clemson) and two from An-Najah.
- US non-IVE teams included four students from Clemson University.
- Palestinian non-IVE teams included four to five students from An-Najah.

The reasoning for having these three different types of teams included that (a) there weren't enough students from the two countries to have all balanced IVE teams, (b) since this was still a pilot project, students were not forced to participate on a bi-national team if they didn't want to, and (c) not all students felt comfortable with their communication skills in English.

The IVE experience lasted seven weeks and was divided into three stages as illustrated in Figure 2:

Stage 1: Intercultural Dialogue (2 weeks). IVE team members were introduced and spent time learning about and practicing elements of intercultural dialogue. This period also focused on team formation through the development of a team contract. While the dedicated intercultural dialogue sessions lasted for just the first two weeks, intercultural dialogue was emphasized throughout the entire project duration by reinforcing practices that promote clear communication and understanding within a team.

Stage 2: Design Thinking (3 weeks). Teams worked through different steps of the design thinking process (Figure 3).

Stage 3: Project Completion (2 weeks). In the final two weeks, teams completed their final deliverables which included a poster and a presentation.

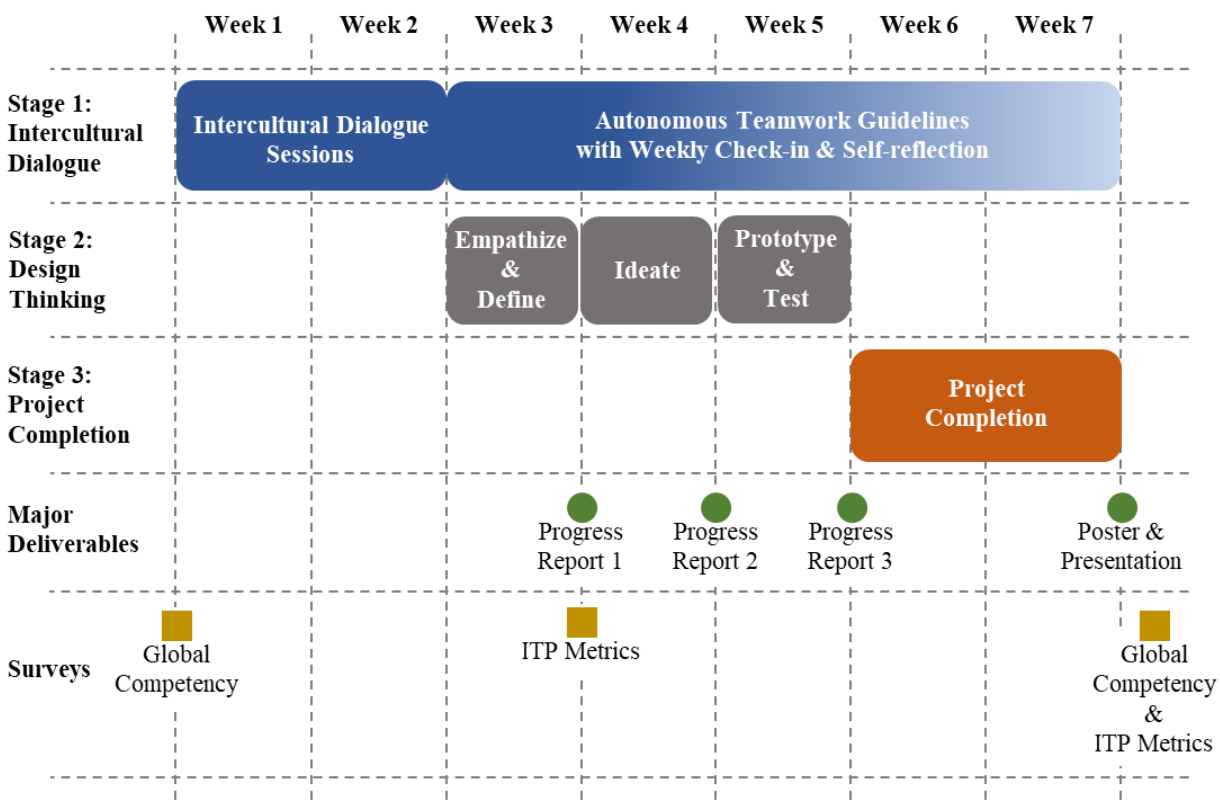


Figure 2. Three-stage IVE project framework

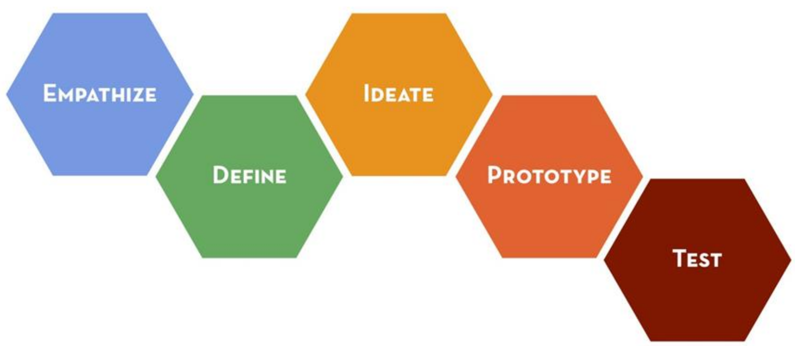


Figure 3. Design thinking process (from Stanford d.school)

As shown in Figure 2, student teams completed five main deliverables:

> **Progress Report 1.** Written report summarizing the steps the team took to identify and explore different stakeholder perspectives, this included a stakeholder map and empathy maps for multiple stakeholder groups. Teams also wrote a problem statement (500 words max) to document the problem they planned to focus on including background

information supporting the importance of the issue and a discussion of the benefits of addressing the issue.

Progress Report 2. Written report including a revised problem statement (500 words max) incorporating feedback received from Progress Report 1. This report also summarized the team's ideation process and results, and the initial solution idea that the team would develop into a conceptual design (or prototype). This progress report was converted to a recorded presentation in the third offering.

Progress Report 3. Written report including a refined problem statement (100 words max) and a brief description of their solution. Teams also described their initial prototype and how they plan to test it.

Poster. Digital poster summarizing the following elements of the project, at a minimum:

- Problem statement with supporting background information
- Description of the solution with supporting documentation (e.g., drawings, renderings, or other visuals as appropriate)
- Justification to support the solution
- Recommendations and guidelines for how the solution should be used in practice

Presentation. A three to five-minute long presentation to pitch the team's solution to the instructional team and invited guests. The presentations were delivered live via Zoom for the first two offerings and were recorded for the third offering.

In addition to these major deliverables, students submitted a weekly reflection responding to the following prompts as part of Stage 1 that lasted the project duration:

- Write a few sentences about the things you hear and see, what you are learning from the dialogue and collaboration process in terms of cross-cultural interactions, teamwork, and your own personality. Share a sentence summary on the country trivia questions you and your group shared in *WhatsApp*.
- How are the team meetings going? Who facilitated the last meeting? Is everyone contributing? What can you and your team members do to improve the collaboration process?

This project was not initially designed with ABET assessment in mind. It was initially piloted to expose students to the experience of working on multicultural teams, then it evolved into a research study evaluating the impact of the IVE experience on student growth in each of these outcomes throughout the course of the project. The project outcomes were assessed using the assignments mentioned above and surveys. The assignments were the primary method used to measure the students' ability to apply the design thinking process to identify a specific problem and develop a solution to the problem (direct assessment). Teamwork was assessed using the ITP Metrics *Peer Feedback and Team Dynamics* survey (itpmetrics.com) and global competencies were assessed using an adaptation of the *Common Survey Items for Virtual Exchange Programs* published by the Stevens Initiative with particular focus on the students' knowledge of the other country and culture, their cross-cultural comfort, and their ability to generate innovative ideas for and solve complex global problems [27].

Figures 4 and 5 present a sampling of the data collected over the course of this collaboration and more can be found in a previous study by the authors [22]. Figure 4 summarizes the overall teamwork ratings based on peer feedback after project completion. This rating is based on 0-5 scale with 5 being the highest rating. The results show that US students performed similarly regardless of whether they were part of an IVE team or not. The Palestinian students who participated on IVE teams generally had higher teamwork scores compared to their non-IVE counterparts, but the results were not statistically significant ($\alpha = 0.05$).

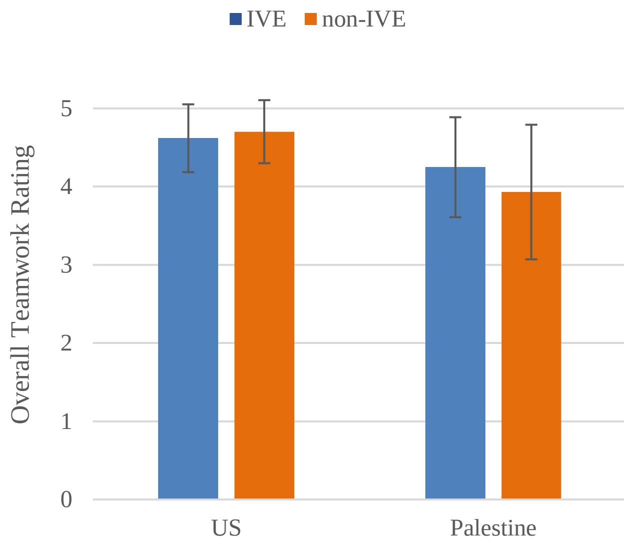
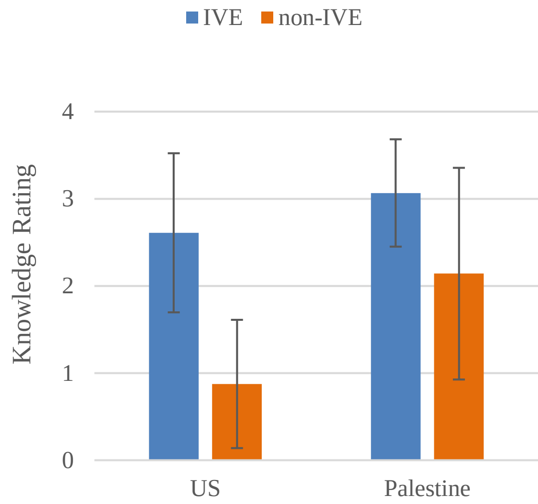
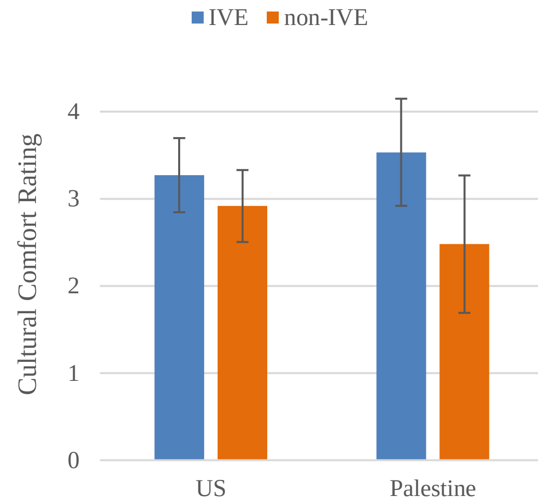


Figure 4. Average post-project teamwork rating based on peer evaluations *(error bars indicate one standard deviation)*

The results of the relevant aspects of the Global Competency survey are summarized in Figure 5 and show that for all categories, the IVE students had higher ratings than their non-IVE peers from the same institution. These differences were statistically significant for the Knowledge rating (student knowledge of the other country and culture) and Cross-cultural Comfort rating based on t-tests at a 95% level of significance, whereas the differences in the Innovation & Problem Solving ratings were not significant.



(a)



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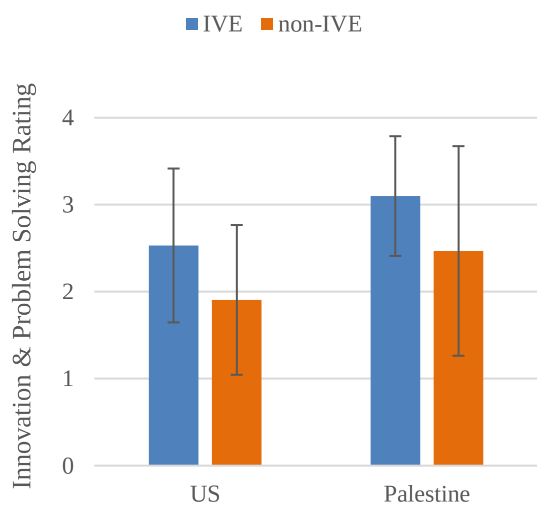

(c)

Figure 5. Average ratings from Global Competencies survey after completion of the project for (a) knowledge of the other country and culture; (b) cross-cultural comfort; and (c) innovation and problem solving *(error bars indicate one standard deviation)*

Case Study in an ABET Framework

As previously stated, the IVE project and assessment presented in this case study was not designed specifically to integrate with the ABET continuous improvement process at either institution. To align with ABET processes, the continuous improvement framework presented earlier would be followed to map this project to the SOs as outlined herein.

The first step in this process would be to identify the relevant SOs, then revise or develop the project activities and deliverables accordingly. Next, we would revise the existing, or develop new assessment methods to measure the specific outcomes. It is important to note that a single project or experience does not need to map to every SO. Rather, assessment of the SOs should be distributed across the curriculum and other program elements. What follows are some potential opportunities for student outcomes assessment for this case study.

Once the project is mapped to the SOs as shown in Table 1, the instructional team would develop performance indicators (PIs) and assessments to measure the attainment of each outcome. For this project a rubric similar to that in Table 2 could be used to assess the final poster from each team. This rubric maps to SOs 1-4 as indicated in each item on the rubric and Table 3 includes the specific PIs for each SO and how they map to the rubric. The assessment data included in the rubric would be summarized for each team by calculating the average score for each PI in Table 3. These scores would be compared to the standard set by the program assessment plan (e.g., average value of 2.0) to determine the percentage of teams meeting the standard for each PI. If the percentage of teams meeting the standard is equal to or above the target value (e.g., 70%), then no action may be needed. However, if the target is not met, then the assessment team would consider what corrective action is required to address the shortcoming prior to the next offering of the IVE project. For this project, similar direct assessment rubrics would be created for the final presentation and Progress Report 3.

Table 1. Student outcome mapping example for this project. Note: “D” denotes that the instrument is a direct measure and “ID” denotes that it is an indirect measure.

ABET Student Outcome	**IVE Project Stage and Assessment Instrument**
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	Stages 2 & 3 • Progress Report 3 (D) • Poster (D) • Presentation (D)
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	Stages 2 & 3 • Poster (D) • Presentation (D)
3. an ability to communicate effectively with a range of audiences	Stages 1-3 • ITP Metrics Peer Evaluation (D) • Poster (D) • Presentation (D)
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	Stages 1-3 • Progress Report 3 (D) • Poster (D) • Presentation (D)
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Stages 1-3 • ITP Metrics Peer Evaluation (D)
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	Not applicable to this project
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	Stage 1-2 • Self-reflection (ID)

Table 2. Example rubric for assessing the project posters. *Note that the criteria for each rating in each category (A-I) should be set by the instructional team to ensure consistent assessment from rater to rater and team to team.*

	Rating / **Criteria**	**Unacceptable** (Score = 0)	**Developing** (Score = 1)	**Meets Expectations** (Score = 2)	**Exceeds Expectations** (Score = 3)
Problem Statement	A. One or more stakeholder groups were identified and described to understand their needs related to the topic (SO1)				
	B. Background information supporting the importance of the issue (SO1)				
	C. Describes specific needs related to global, cultural, social, environmental, and/or economic factors (SO2)				
	D. Explicit connection to at least one UN SDG (SO2)				
Solution	E. Addresses the needs outlined in the problem statement (SO2)				
	F. Explains any limitations or potential impacts of the solution related to global, economic, environmental and/or societal contexts (SO4)				
Overall	G. Organization (SO3)				
	H. Quality of writing (SO3)				
	I. Effective use of graphic elements (SO3)				

Table 3. Student outcomes and performance indicators mapped to the project poster and assessment rubric example shown in Table 2.

Student Outcome	Performance Indicator	Rubric Items
1	Ability to identify a problem and develop a problem definition using the design thinking process.	A, B
	Ability to develop a solution to a specific problem definition using the design thinking process.	E
2	Ability to develop a solution to meet specific needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	C, D, E
3	Ability to effectively communicate to a broad audience using written means.	F
4	Ability to make informed judgments, considering the impact of engineering solutions in global, economic, environmental, and societal contexts.	G, H, I

Integrating IVE into Program-Level Assessment

As mentioned earlier, an IVE program possesses significant potential for meeting ABET SOs and program specific criteria at various levels, contingent upon the extent and substance of the program. As demonstrated in the case study presented in this paper, multiple SOs can be mapped to IVE experiences in a more authentic way than other traditional methods. Both direct and indirect assessments can be leveraged to assess these SOs. Therefore, drawing from our previous experience, the following recommended guidelines are proposed to integrate IVE into an engineering program to (a) provide meaningful intercultural exchange and collaboration where students develop essential global competencies to complement their technical skills and (b) strengthen a program's assessment of the attainment of ABET SOs.

General Guidelines

The IVE experience presented in this paper was developed by the authors independent of any program criteria or plan and fortunately, we have sustained this for offerings in three consecutive years so far. However, only a fraction of the students in each program had this experience. To engage all students in an IVE experience, it is important to ensure that IVE is consistently incorporated into courses that will engage all students in the program. It is recommended that IVE be incorporated into multiple required courses to expose students to multiple intercultural experiences at different academic levels, potentially with students from different countries. By integrating IVE into multiple courses, specific SOs and other program specific criteria can be distributed across these experiences where they are most relevant to the course.

Based on our experience, it is recommended that when forming bi-national teams that students from each institution have the ability to select their teammates from their home institution. This allows for some level of familiarity in what can be an intimidating or uncomfortable experience for the students. When matching teams from each institution, this can be done somewhat randomly, but it is recommended that factors such as gender be considered to minimize the isolation of students demographically.

We integrated an intercultural dialogue framework at the beginning and throughout the course plan. These sessions and framework not only helped students get to know each other prior to embarking on a collaborative project, but they also helped them learn strategies to navigate difference and conflict as part of a diverse team. This framework focused on asking good questions and the results on team performance and satisfaction were significant [22].

Additionally, we found that establishing regular synchronous meeting times when the students and instructional team were present was also critical to the project success. Throughout the project, we had a regular meeting time one day per week. This time was used to provide some instruction and guidance on the current project stage, provide feedback and answer questions, and allow student teams to work collaboratively at a dedicated time to complete the project deliverables. Many student teams also scheduled synchronous meetings as their schedules allowed in addition to asynchronous collaboration. Be mindful of time zone differences when scheduling these sessions.

Assessment Strategies

Since assessment is a critical aspect of program accreditation and continuous improvement, it is important to identify instruments that enable the instructors to assess the level of attainment of project and program outcomes. This can include both direct and indirect measures, but it is beneficial for students to understand the relevance of the assessment for their individual growth and benefit. It is also recommended that each assessment (i.e., assignment or survey) have a specific purpose and is mapped to a specific SO or PI. It may also be beneficial that the purpose be communicated to the students.

IVE experiences can be conducive to indirect assessment, which can be a challenge in the ABET assessment process. IVE offers distinct advantages in this aspect. Indirect assessments, such as surveys or student reflections, not only help instructors assess what level students have attained specific outcomes, they also encourage the students to reflect on their own learning, which can be a powerful exercise. This can be especially beneficial if students reflect at multiple points during an IVE experience. While these measures are beneficial, however, it is important to avoid excessive length and frequency to maintain student interest and authenticity in their responses.

Team meetings can serve as another opportunity for assessment, focusing on areas such as teamwork or communication. Through direct observation by instructors or facilitators, these meetings can provide insights into students' collaborative skills and can contribute to the assessment of one or two specific SOs (i.e., SOs 3 and 5), enhancing the overall assessment process.

It can also be beneficial for some assessments to be implemented at multiple stages of a project for the students to see how their knowledge, skills, and/or abilities have evolved over the experience. For example, we recommend that the preferred teamwork survey be administered at the midpoint and after completion of the project. The mid-project results give students valuable feedback that they can learn from to become better teammates. It also allows the instructors to provide specific coaching to teams and individuals to improve team dynamics. The post-project survey allows the students and instructors to gauge how adjustments helped to address specific issues.

Conclusions

This study has explored the ever-evolving crossroads between engineering education and international virtual exchange (IVE) programs. Against the backdrop of worldwide accreditation standards, like those set by ABET, it has become imperative to adopt innovative teaching and learning methods that equip students with the skills needed to navigate a diverse and interconnected global landscape.

Over three years, a collaboration explored the intersection of IVE programs between universities in the US and the West Bank in the Occupied Palestinian Territories. The valuable insights gained from this study shed light on the evolution of the program, initially created to foster cross-cultural collaboration, into a more extensive research endeavor. Through various assessments, including assignments and surveys, a nuanced understanding emerged of student growth in critical areas.

The study found that IVE teams exhibited superior global competencies in comparison to non-IVE teams. Additionally, the Palestinian IVE teams, generally exhibited better teamwork than their non-IVE peers. This highlights the program’s success in cultivating a global outlook, as IVE teams were able to effectively address the needs of both countries through their problem-solving efforts. Moreover, overcoming language barriers and navigating cultural differences showcased the practical development of intercultural competence among IVE participants, further emphasizing the program’s effectiveness. In an ABET context, these gains relate to SOs 2, 3, 4, and 5 and our assessment process would need to be revised slightly, but not substantially, to fold it into a program assessment plan. Linking ABET assessment to IVE experiences can help programs create more authentic assessments for outcomes that can otherwise be challenging to measure in a meaningful way.

The case study presented also corresponds with the recent updates to the program criteria for civil engineering programs that the curriculum must incorporate principles of sustainability, risk assessment, resilience, diversity, equity, and inclusion into civil engineering contexts. Integrating IVE into civil engineering programs can help achieve these goals and the proposed framework provides guidance for the integration of IVE into courses with assessment strategies to consider.

The holistic approach to IVE program evaluation involves incorporating both direct and indirect assessments with the primary goal of continuous improvement by which we have benefited. By utilizing peer evaluations, project deliverables, and instructor observations, the direct assessments effectively target specific student learning outcomes. Additional surveys and self-reflections play a crucial role in the indirect assessments, providing valuable insights regarding student development. With this combination of assessment methods, a comprehensive understanding of student attainment of learning outcomes can be obtained.

As an overall conclusion, this study not only demonstrates the effectiveness of IVE in improving student learning and achieving ABET SOs, but also offers guidance for educators and institutions seeking to establish or improve similar programs. The results confirm that IVE is not simply an add-on, but rather a powerful and authentic tool for equipping engineering students with the skills and knowledge needed to thrive in today's globally-connected and diverse workplace. As universities strive to provide top-notch engineering education, the incorporation of IVE is an effective way to promote intercultural competence, collaborative teamwork, and a comprehensive grasp of engineering principles in a global context.

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