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Engineering Rome: Assessing Outcomes from a Study Abroad Program Designed to Overcome Barriers to Participation

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Abstract

While the necessity for global interconnectedness and an understanding of societal context is critical for practicing engineers, few engineering students experience a study abroad program while in college, and engineering students represent only 4.1% of all study abroad participants – about one-fourth the participation rates in the humanities and foreign languages. Cost, time, scheduling conflicts, and lack of engineering-focused topics serve as barriers to engineering student participation. In an effort to address these typical deterrents, the authors of this paper developed an engineering study abroad program, titled "Engineering Rome." The course meets between academic periods to avoid schedule conflicts, focuses specifically on civil engineering topics, and overcomes the challenge of creating meaningful engineering learning in a diverse class containing freshmen through graduate students. Findings suggest that students develop a greater appreciation for language differences, see a connectedness between their engineering work and societal impacts, and draw connections more readily between theories presented in class and practical applications on site. Not surprisingly, our findings also suggest that students are more likely to participate in a study abroad program when their class schedules are not adversely affected and when the topic relates to their major discipline.

Introduction

Studying abroad at the post-secondary level is frequently advocated for because of the many potential benefits to student learning[1,2,3,4]. However, these benefits are not uniformly distributed across campus. There is a marked difference in study abroad rates amongst different majors with students in liberal arts and foreign languages more than four time as likely to study abroad as engineers (see Literature Review below). While there are definitely reasons for this disparity, it at least indicates that study abroad rates could potentially be higher for engineers. Given the many potential benefits it is appealing to work towards higher participation rates for engineers. Furthermore, it is important to show how such courses contribute to engineering education in order for them to be viewed as legitimate contributors to the curriculum. Specifically, documenting their contribution to ABET Criterion 3 student learning outcomes is a commonly accepted method of showing such contributions. With this in mind, we set out to design and deliver a study abroad program composed from learning theory that would specifically appeal to engineering students, overcome their typical barriers to participation, and contribute to ABET student learning outcomes.

This paper describes the motivation, key development elements, and outcomes for this course, titled Engineering Rome, which was delivered for the first time in 2013. Course outcomes are measured by student surveys and feedback comments and analysis is specifically tailored to address the following three questions:

1. To what extent did the framework of this course (time frame, subject matter, location) address issues that often impede students from participating?
2. To what extent are students considering issues related to ABET learning outcomes (d), (g), and (h) while studying abroad?
3. What are best practices that can be gleaned and disseminated from this program?

Literature Review

In general, the literature suggests that studying abroad is good for students, but there is room to improve participation rates. Generally, experiential and transformative learning theories are used to show the potential impact of study abroad while student surveys and questionnaires are used to investigate actual impact.

Studying Abroad is Generally Good for Engineering Students

Relation to learning theory. Study abroad is often advocated for based on experiential learning[5] and transformative learning theories[6]. Both acknowledge the central role that experience plays in the learning process, which works nicely with the central role of experience in a study abroad environment.

Benefits. The most commonly cited benefit of study abroad experiences are some form of what Mazzurco and Jesiek[2] call "global competence." They further break down this idea into three distinct items: (1) communicating across cultures, (2) working with or leading a multi-cultural team, and (3) appreciating and understanding other cultures. Other benefits include bonding and personal satisfaction[3] as well as broad-based and long-term shifts in self-awareness and cultural influences consistent with transformative learning[1,4]. Students report similar benefits but are more apt to cite bonding and personal satisfaction as important outcomes[3]. These benefits, however, are not a forgone conclusion for study abroad programs. McGaha and Linder[7] provide a good summary of literature that suggests study abroad does not always translate into global competence, and may, in fact, reinforce negative stereotypes.

Effective types and durations. There is no strong majority view on what type or duration of study abroad programs provide the best outcomes. Some advocate for longer (2-4 months) and more immersive programs[2,8], while others[3,9] find meaningful outcomes for much shorter programs (2-4 weeks).

Relating study abroad to ABET criterion 3 student outcomes. With specific regard to engineering students, study abroad benefits are often categorized based on their relation to three specific ABET Criterion 3 outcomes: (d) an ability to function on multidisciplinary teams, (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context, and (i) a recognition of the need for, and an ability to engage in lifelong learning. In this way study abroad programs are justified by linking them to required student outcomes (i.e., what they should learn) for accredited engineering programs. Intentionally or not, these three ABET Criterion 3 outcomes correspond directly to Mazzurco and Jesiek's[2] breakdown of global competence.

Engineering Study Abroad Rates

Even if they are not guaranteed, the benefits of studying abroad make such programs for engineers appealing and there is ample literature to describe experiences, successes and lessons learned[9,10,11,12]. Table 1 shows that engineers appear to study abroad at roughly comparable rates to business, agriculture/natural resources, and education majors. However, they are far below the rates of visual and performing arts, social sciences and history, liberal arts, and foreign languages. One way to interpret Table 1 is that a foreign language student is more than four times as likely to study abroad as an engineering student.

Table 1. Selected Study Abroad Rates Expressed as a Ratio of Fraction of Total Bachelor's Degrees to Fraction of Study Abroad Students

Bachelor's Degree	Fraction of Total Bachelor's Degrees[a]	Fraction of Total Study Abroad Students[b]	Ratio[c]
Agriculture and natural resources	1.73%	1.3%	0.75
Business	20.48%	20.4%	1.00
Education	5.91%	4.0%	0.68
Engineering	4.54%	4.1%	0.90
Foreign languages	1.22%	4.9%	4.03
Liberal arts and sciences, general studies, humanities	2.62%	10.4%	3.97
Social sciences and history	9.97%	22.1%	2.22
Visual and performing arts	5.35%	7.8%	1.46

Notes:

a. From *2014 Digest of Education Statistics*, Table 322.10
b. From the Institute of International Education O*pen Doors 2014 Report on International Educational Exchange*.
c. The ratio of fraction of study abroad students to fraction of total bachelor's degrees. A rough representation of the rate at which students in a particular field study abroad.

There Is Room to Improve Study Abroad Participation

Students, and particularly engineering students, do not participate in study abroad for a variety of reasons. First, it appears about 20-30% of students are not interested in study abroad for unspecified reasons[8,13.] In their survey of the University of Arkansas undergraduate engineering student body (2,374 students, 25.5% response rate) Specking et al.[13] identified finances (42% of respondents), time (24%), and class selection (16%) as the three top reasons prohibiting students from studying abroad. Finally, Heffron and Maresco[3] also point out that individual social anxiety can also prohibit participation in study abroad.

Best Practices for Study Abroad

Parkinson[10] offers a short list of best practices for engineering colleges considering study abroad programs:

- *Have a suite of integrated programs*. More than one program, in terms of size, type, and destination are required to meet the needs of a college.
- *Have a clear set of desired outcomes*. Outcomes should go beyond general statements and be written as course learning objectives.
- *Be proactive in recruiting students*. Use prior study abroad students, the advising process, and industrial advisory boards to recruit students.
- *Reward faculty who are program directors*. This involves pay while preparing for and directing a study abroad program, encouragement to take families, and recognition in the tenure and promotion process.
- *Long term commitment*. The resources needed for a successful program require high-level and long-term commitment from a college.
- *Integrated approach coordinated by a central office*. Have a centralized office that coordinates and services programs and serves as a central clearinghouse for students to access programs.

- *Take advantage of existing university infrastructure*. Existing physical infrastructure as well as contacts can assist program development.
- *Involve several faculty*. "Programs built around a single faculty member and his or her international connections are fragile and typically fail when that individual loses interest or moves."[14].
- *Prepare students before they go*. Weekly seminars or other training sessions beforehand.

Summary

This literature review is used to inform our development and delivery of Engineering Rome. Specifically, the following concepts are used:

- User experiential learning theory to guide class structure.
- Global competence is the likely main benefit of the program.
- Meaningful outcomes can be obtained at all the typical study abroad durations.
- It can be advantageous to relate study abroad benefits to ABET Criterion 3 outcomes.
- Engineers study abroad at rates commensurate with their fraction of bachelor's degrees. There are majors that study abroad significantly more and somewhat less.
- There is room to improve study abroad participation.
- The most common barriers to participation are cost, time and class selection. Social anxiety may also play a role.
- Parkinson[10] offers a set of best practices that can guide development at the program level.

Key Elements of Course Development

This section translates the guidance from the literature review into key program elements in course development: learning theory, program organization, course schedule and duration, and support from existing UW study abroad infrastructure.

Learning Theory

Engineering Rome incorporates project-based experiential learning, which has shown to be a type of active learning that is crucial for the development of an appreciation for lifelong learning. Lenschow[14] explains that:

> "Project-based learning (PBL) is winning ground in industry and at a slower rate in universities and colleges. PBL is pedagogically based on constructivist learning in a setting represented by Kolb's learning cycle. Kolb observed that students learn in four different ways: Kolb's idea is that the cycle shall be repeated. The cycle is best started with concrete experience, proceeding to abstraction."[14]

The basic classroom premise of the course involves exploring topics using the four elements in Kolb's[5] theory (concrete experience, reflective observation, abstract conceptualization, and active experimentation). For each topic all the elements exist, but entry into Kolb's learning circle can begin at any one of the four elements[16] with some elements overlapping one another. A typical sequence would be: (1) study engineering concepts in a classroom setting, (2) travel to location see the application of these engineering principles, (3) complete a computational assignment that incorporates classroom learning and field observations, and (4) complete a reflective assignment and/or develop their understanding by working on a final project.

For instance, lectures on masonry arches were given in the classroom. Then, students were asked to work in pairs, crossing experiential and disciplinary boundaries, to work on a simplified problem involving a 3-hinged arch. Once the students worked together to solve the in-class problem, the class took a field trip to a site (e.g. The Baths of Caracalla, Arch of Constantine) where they were asked to select an arch and again analyze the thrusts based on some rudimentary field measurements. This process was carried out across the hydraulics and sustainable city curriculum as well. At the conclusion of the program, students were asked to deepen their understanding of a specific topic via their wiki projects, which required them to do additional analysis and research on a topic of their choosing and, importantly, incorporate site visits and the knowledge gained from those visits into the project.

Finally, we borrowed some aspects of the Montessori Method[17] that we felt might prove advantageous. Engineering Rome is (1) a multi-level, course (i.e., appropriate for Freshman through graduate students) designed to foster peer learning, and (2) the final project is a guided choice work activity with the instructor serving in the role of Montessori's "directress." While Montessori's writings generally concern early aged learning (and not college students), we felt there was substantial evidence that these ideas would be beneficial. For instance, Katz et al.[18] (1990) provide a summary of reasons: a long human history of inter-age learning, stimulated thinking and cognitive growth resulting from such learning, and identifiable benefits resulting from interaction between less able and more able students. Additionally, opening Engineering Rome to all class levels made it more likely to have a large pool of motivated applicants.

Program Organization

Because Engineering Rome was open to all levels of students and all majors (even non-engineering majors), it accommodates a broad array of student abilities (e.g., math up to but not including calculus was the advertised necessary skill level). Students are assumed to be interested in engineering (such a statement was included in program advertising), but not in any specific year of instruction or major. Thus, the program is necessarily broad and cannot assume students have college-level engineering skills. Additionally, the instructors are trained in civil engineering and much less proficient on other fields of engineering.

These constraints resulted in a curriculum that (1) focused on a few fundamental civil engineering concepts represented by iconic Roman infrastructure, and (2) relied on upper classmen (i.e., juniors, seniors and graduate students) teaching lower classmen (i.e., freshmen and sophomores). A simplified course topic list follows:

- **Structural analysis**. This is represented by a study of the classical Roman arch in all its forms. Students are introduced to engineering statics, simple modeling of structural behavior, and applying these techniques to iconic Roman arch-based structures (e.g., bridges, triumphal arches, aqueducts, baths, sewers, and the Colosseum).
- **Hydraulic engineering**. This is represented by a study of ancient Roman water distribution (i.e., the Aqua Claudia viaduct still standing in Parco Acquedotti, the accessible portion of Claudia and Marcia at Vicovaro, and the endpoint of aqueduct water at the Baths of Caracalla). Students are introduced to the Bernoulli equation, basic

open channel flow concepts including depth of flow and critical depth, and the politics, financing, and purposes of water distribution.

- **Sustainable Rome**. Rome is used to represent a sustainable city because it has continuously been a city for nearly 2,800 years. Students are introduced to the different neighborhoods of modern Rome, ancient Roman city remains (often underneath modern Rome), and the juxtaposition and interplay of modern, renaissance, baroque, and modern structures. Field trips to Ostia Antica and Pompeii reinforce sustainable features of ancient Rome such as passive solar heating. The intent is to allow the students to explore a city that has functioned for millennia (perhaps defining the term "sustainable") but one that may not fit their mental model of sustainability as influenced by contemporary engineering.

Schedule and Duration

In order to address student issues with time, especially engineering students who find it difficult to schedule a study abroad program within their normal academic year of required engineering courses and prerequisites, the course was offered as a UW study abroad "Exploration Seminar." This type of study abroad program occurs entirely during the five-week break between summer quarter and fall quarter (termed "early fall") each year. This time frame avoids conflicts with all on-campus regular term courses but results in a shorter program than a typical quarter-long (10 weeks) program.

Exploration Seminars are quite popular and, like longer-duration programs, tend to attract more females than males. During the 2013 early fall period, UW offered 31 Exploration Seminars (which total about one-third of the 95 total faculty-led programs for 2012-13), which were taken by 488 students (152 male, 336 female), offered in 21 different countries. They were offered by 9 of the 16 colleges/schools at UW. The most popular destination countries were Italy (six programs including Engineering Rome), and England (three programs). Of note, only three programs had a majority male student population, with the average program being 31% male, and 69% female. This approximately 1:2 ratio of males to females appears to be relatively consistent from year-to-year.

Support from Existing UW Study Abroad Infrastructure

Support from existing infrastructure allows course development to significantly shorten what can be a long process of establishing (1) administrative processes at the home university, and (2) adequate connections and proficiency in the country abroad so that logistics and day-to-day operations of a program are manageable for the director.

Administrative processes at home were handled through the UW Office of International Programs and Exchanges (IPE), which consists of 13 full-time employees, and four student part-time employees. IPE manages not only faculty-led study abroad programs (like Engineering Rome) but also student exchange programs. Support within the UW College of Engineering is passive: faculty-led study abroad programs are offered on individual faculty initiative but there is no consistent college-level organized support or incentive.

In general, UW is quite active in study abroad but its College of Engineering is not. For the 2012/13 Academic Year the UW was ranked 14th amongst U.S. institutions for number of students studying abroad with 2,044[19] doing so in about 95 faculty-led programs as well as various exchange programs. Of these programs, there are three faculty-led engineering study abroad programs:

- Aeronautics & Astronautics Australia: Autonomous Systems and Robotics for Biological Research & Monitoring.
- Engineering Jordan: Water in an Arid Land: The Engineered Water Cycle.
- Engineering Italy: Engineering Rome.

During the 2012/13 academic year these three programs taught 41 students (17 male, 24 female), the highest total for UW study abroad engineering programs on record.

The University of Washington Rome Center

In-country connections and proficiency was essentially outsourced to the UW Rome Center. In fact, the existence of the UW Rome Center was the original impetus for developing a study abroad engineering program and locating it in Rome. Specifically, assistance from the Rome Center greatly accelerated the development and enhanced the delivery of the program. The program director began development with no foreign language proficiency, and no contacts in Rome beyond a knowledge of the Rome Center's existence and services. The Rome Center provided initial contacts, participated in meetings and discussions with the program director on his visit to Rome during his sabbatical the year before offering the program, and all the essential services described next.

The Rome Center consists of about 14,000 square feet of leased space in Palazzo Pio (adjacent to Campo dei Fiori in the center of Rome), two full-time UW staff, and one half-time student assistant. The Rome Center provides the following physical space: studios, classrooms, a library, a computer laboratory, a student lounge, a conference room and several faculty apartments. Rome Center staff provide the following support: student housing coordination, necessary local paperwork, scheduling assistance (e.g., field trips, events, transportation, tickets, contacts, etc.) as needed, an orientation to Rome, and serve as local expertise on everything from health care, to emergencies, to dinner recommendations. Key statistics for the UW Rome Center during the 2012/13 academic year (September 2012 to September 2013) are:

- 18 different UW faculty-led study abroad programs hosted. These ranged from three week to three month programs. Only one program (Engineering Rome) was engineering-focused.
- 375 students participated in these programs (118 male, 257 female).
- For the early fall period the Rome Center hosted four of the seven Italy programs, with a total of 74 students (27 male, 47 female).

The UW Rome Center is an entirely self-sustaining venture, its only sources of funding are student fees (from study abroad programs), rental income (when not used, faculty apartments are rented out to qualifying individuals), and event income.

Engineering Rome Description

Engineering Rome is a UW study abroad program. It involves a once-a-week seminar in the spring quarter (end of March through mid-June), and three-weeks in Rome (end of August through mid-September). Key statistics for the 2013 offering of Engineering Rome are:

- Students:
  - Numbers: 17 total, 7 male, 10 female
  - Class: 2 freshmen, 9 sophomores, 2 juniors, 2 seniors, 1 graduate student
  - Majors: 9 civil & environmental, 2 electrical engineering, 1 statistics/math, 1 math/physics, 1 industrial engineering, 3 undecided
- Course meeting times and location:
  - Spring quarter (April 1st through June 7th, 2013): One 1.5-hour class per week on campus. Designed to prepare students for Rome and allow them to meet one another.
  - Early fall quarter (August 28th through September 18th, 2013): in Rome, Italy. Class met most weekdays at the UW Rome Center for 1-4 hours then participated in local field trips. Some field trips took the entire day, and one was overnight to Naples, Italy.
- Facilities:
  - On campus: standard classroom
  - In Rome: UW Rome Center
- Cost:
  - Program fee: $4,800. Other administrative fees add another $300.
  - Recommended student budget: $7,000 to $7,500 is recommended for students to cover the program fee, airfare, food, and other living essentials.
- Syllabus:
  - Course catalog description: Engineering-focused Exploration Seminar that covers Roman civil engineering over 3,000 years from Ancient Rome to the present day. Introduction to civil engineering topics reinforced by practical engineering calculations, local experts and site visits. Provides international and historical perspective on engineering and the contributions of engineers to infrastructure and society.
  - Course organization: The course was organized around three civil engineering themes: the Roman arch (structural engineering), Roman water (hydraulic engineering), and sustainable cities (involving aspects of Rome throughout its history and including current issues).
  - Course learning objectives: Upon successful completion of this course, the student will be able to:
    - Communicate engineering ideas in a clear, concise and effective format both in oral presentation and written report.
    - Exercise critical thinking by making engineering judgment decisions based on real-world information that is often inconsistent or incomplete.
    - Discuss the major civil infrastructure of Rome including how it was built and the engineering principles governing its function to include, masonry arches, water supply, sewers, foundations, passive solar, roads, urban development, and sustainability.
    - Explain and analyze the function of select civil infrastructure using engineering principles, equations, and technical description. To include masonry arches, aqueducts, pavements, passive solar, and sustainability.

- Write the equivalent of a 10-20 page paper in an online Wiki format to include photos, videos, maps, a literature review, personal observations and conclusions.

Research Method

In an effort to understand the impact Engineering Rome had on students, we gave them the opportunity to participate in a study through informed consent during the first spring seminar session. This study consisted of pre- and post-class surveys as well as weekly feedback during the study abroad time in Rome. Our aim was to answer the research questions:

1. To what extent did the framework of this course (time frame, subject matter, location) address issues that often impede students from participating?
2. To what extent are students considering issues related to ABET learning outcomes (d), (g), and (h) while studying abroad?
3. What are best practices that can be gleaned and disseminated from this program?

A pre-survey was administered during the second session of the seminar followed by a post-survey at the conclusion of the study abroad time in Rome. The surveys asked questions ranging from anxiety towards studying and living abroad to cost and scheduling implications from studying abroad. The survey data were used primarily to address the first research question regarding students' motivations and deterrents to studying abroad. They are designed to provide easy pre- and post-study abroad comparisons as they ask essentially the same questions.

The feedback forms gauged students' experiences while working in the Rome Center classrooms and while working on site visits by asking four questions: 1) What was Surprising, 2) What was frustrating, 3) What was rewarding, and 4) Were there any aha moments? This format allowed students to provide as much or as little reflective responses about their experience as they felt comfortable. Each student contributed 24 responses during their time in Rome, resulting in approximately 400 responses (n = 17 participants times 24 responses per student). Their responses were then transcribed into an Excel spreadsheet so that they could be more easily studied and analyzed. Performing a deductive analysis, the first two authors explored the data both independently and then collectively for themes related to ABET Criterion 3 learning outcomes (d), (g), and (h)[20.21.22]. Only results where both coders agreed were analyzed, which may underestimate the magnitude of the prevalence of such responses. In reporting the results, we looked at the percent of participants that mentioned issues related to:

- ABET learning outcome (d): the ability to function on multidisciplinary teams.
- ABET learning outcome (g): the ability to communicate effectively.
- ABET learning outcome (h): the ability to understand the impact of engineering solutions in a global and societal context.

Results

This section summarizes the responses on the student pre- and post-surveys (Figure 1 and Figure 2) as well as provides a general overview of student responses on the weekly feedback forms.

Student Pre- and Post-Surveys

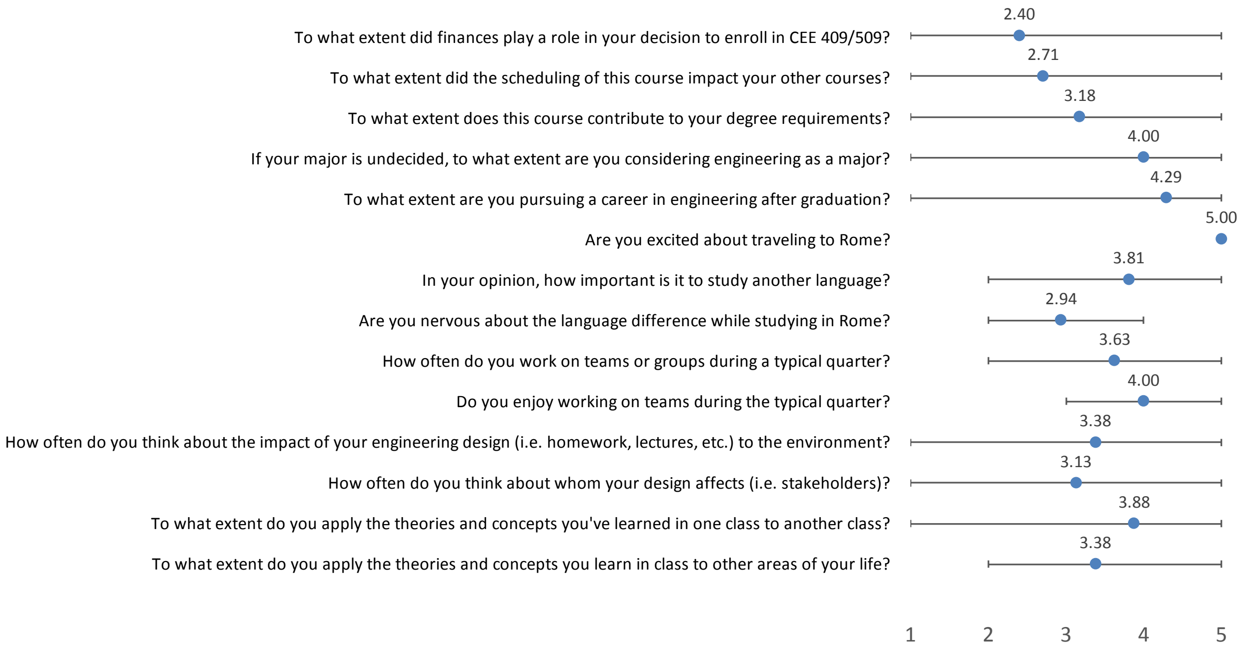

Figure 1. **<u>Pre-survey</u> summary results. 14 questions, each on a 5-point Likert scale. Graph shows average scores (dots), and minimum/maximum scores (black bars) for each question. 1 = very little, 5 = very much**

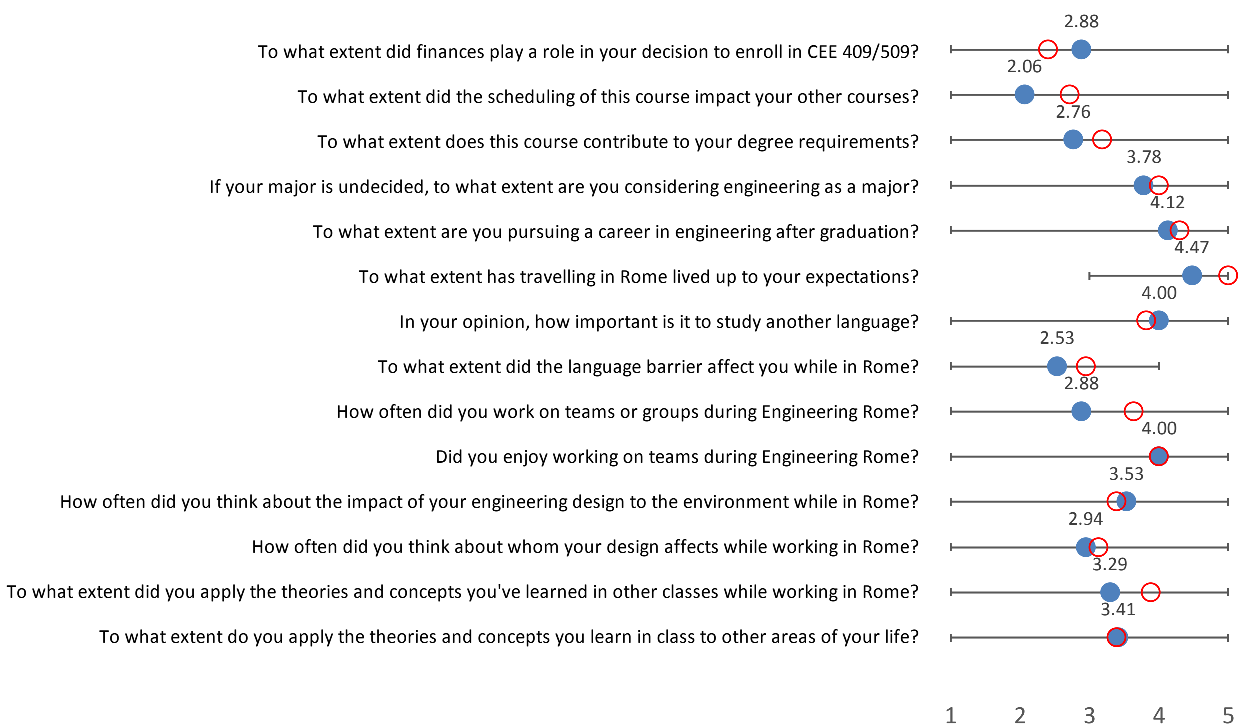

Figure 2. **<u>Post-survey</u> summary results. 14 questions, each on a 5-point Likert scale. Graph shows average scores (solid dots), minimum/maximum post-test scores (black bars), and, for easy comparison, pre-test average scores (circles). 1 = very little, 5 = very much.**

Student Weekly Feedback Comments

Of the possible 400 feedback comments, 374 were filled out with 26 left blank (Table 1 summarizes the most popular feedback form comment topics). General trends in the feedback form responses were:

- Italian comments were plentiful in week 1 (12 comments) but were rare thereafter (only 1 comment in weeks 2 and 3 combined).
- Frustrations progressed from Italian and wayfinding in week 1 (7 comments week 1, only 1 comment for weeks 2 and 3), to engineering lessons in week 2 (9 comments in week 2, 5 comments for weeks 2 and 3), to the research paper in week 3 (13 comments in week 3, no comments for weeks 1 and 2).
- Field trip frustrations were persistent (at a low level) but in week 3 they nearly all (5 of 6 comments) addressed an oversaturation of historical Rome site visits.
- Field trips and site visits were the top highlight: they showed up in the top three topics for all feedback questions and were overwhelmingly the top topic in the "rewarding" and "surprised" feedback questions.
- Engineering lessons were also consistently in the top three topics for all feedback questions.

Table 2. Three Most Popular Comment Topics on the Weekly Student Feedback Form Organized by Feedback Question.

Feedback Question	Topic	Number of Comments
Rewarding (79 total comments)	Field trips / site visits[a]	32
	Engineering lessons[b]	20
	Italian[c]	11
Frustrating (58 total comments)	Engineering lessons[b]	14
	Research experience[d]	13
	Field trips/ site visits[a]	12
Surprised (79 total comments)	Field trips / site visits[a]	36
	Engineering lessons[b]	19
	Size/pace/culture of Rome[e]	7
Ah-ha moment (65 total comments)	Field trips / site visits[a]	22
	Engineering lessons[b]	21
	Cultural enrichment[f]	6

Note:

a. Trips to see physical items in and around Rome (e.g., Colosseum, Pantheon, Metro station)
b. Material covered in classroom lessons.
c. Understanding or using Italian, usually outside of class.
d. The final project: a 10-20 page equivalent Wiki article.
e. Observations on city size, proximity of landmarks, urban activity, etc.
f. Roman / Italian cultural observations (e.g., food, riding public transit, smoking, public beach experience).

Discussion

Research Question One: Motivation and Deterrents to Studying Abroad

Engineering Rome largely attracted engineers (although it was open to all majors) and those that did participate did not identify cost, schedule, or language issues as being a deterrent. The program location, Rome, was a strong motivator.

The course largely attracted engineering majors and specifically civil engineers

Twelve of the 17 students were engineering majors and nearly all students expressed a strong intent to pursue an engineering career after graduation (4.29 and 4.12 scores on pre- and post-surveys). Furthermore, a majority (9 of 17) students were Civil Engineering majors. This may indicate that the course was perceived as a civil engineering course (perhaps based on the course identifier code: CEE 409, and the published syllabus). One non-civil engineering major expressed frustration with engineering content, “I understand it's an engineering class, but the length of time spent at San Clemente and Baths of Caracalla talking about cracks in wall. I'm not an engineer so I'll need to get over it.” However, comments from the non-engineering majors were generally positive. For example, one surprising moment was, “Applying what we learned in structures to the baths of Caracalla. Amazing site on such a large scale.” Of note, several students remarked informally to the director that they were only searching for study abroad opportunities explicitly focused on engineering topics. Expecting engineering students to participate non-engineering study abroad programs may be overly optimistic.

Cost and schedule were not deterrents to participation

Based on responses to the first two survey questions students did not find the program’s cost or schedule to be major deterrents. This is likely a results of asking a self-selected group of students already enrolled in a study abroad course and should not be generalized to all students. We also feel that this is a result of scheduling Engineering Rome as an Exploration Seminar that occurs outside of the regular academic schedule.

The language barrier was not a perceived deterrent

The pre-survey question on the language barrier scored low (2.94) while the post-survey question scored even lower (2.53). While the students were initially frustrated by language issues (7 frustration comments on Italian language in week 1), they seems to overcome this barrier by week 2 (only one more frustration comment in weeks 2 and 3).

The program’s location in Rome was a strong attractor

Survey results indicate a strong motivation to go to Rome (5.0 score in pre-survey) and a high satisfaction with the location (4.47 score in post-survey). Many feedback comments addressed the setting in Rome. For instance, one identified an aha moment as, “Homework over Campo at sunset. It's beautiful and I want to live here” while another felt “seeing the grandeur of the different monuments” was rewarding.

Research Question Two: ABET Learning Outcomes

Over 60% of student responses to the feedback forms included issues related to ABET learning outcomes (d), (g), and (h).

ABET Learning Outcome (d)

20% of the student responses related to ABET learning outcomes dealt specifically with the ability to function on a multi-disciplinary team. Students were, however, somewhat neutral on how often they worked on teams while in Rome (post-survey average score of 2.88). While a majority of the participants were self-proclaimed civil engineering students (9 of 17), their areas of emphasis ranged across the civil engineering spectrum from structural engineering to water resource engineering. Students also ranged in class rank from freshman to graduate student. Rugarcia et al.[23] explain the necessity of collaboration within engineering and the role that communication plays in navigating multidisciplinary teams:

> "Engineering is by its nature a cooperative enterprise, done by teams of people with different backgrounds, abilities, and responsibilities. The skills associated with successful teamwork – listening, understanding others' viewpoints, leading without dominating, delegating and accepting responsibility, and dealing with the interpersonal conflicts that inevitably arise – may be more vital to the success of a project than technical expertise."[23]

We believe the borrowed aspects of the Montessori Method[17], specifically the multi-level course designed to foster peer learning, contributed to ABET outcome (d). Since the students range in skill level and technical expertise, the students were required to cross the boundaries of experience and technical expertise during their collaboration. To work through problems, the students were encouraged to work together, helping those that have less experience in one area and learning from others with specialization in another area. We see that students not only benefitted from helping other students, but other students also valued the help from upper classmen. For example, one student was surprised at "how helpful I could be for others on the homework." Another student indicated surprise at "how complicated fluid dynamics can be" but reconciled this with how rewarding it was to "work on homework with help from others." Another student expressed frustration with "not understanding technical jargon," but was surprised at "how much of the engineering parts [they] understood once someone explained it." One student specifically mentioned learning from an upper classman during a site visit that "the lack of lead in the water was due to constant fluid flow."

We feel this observation is especially significant because such learning environments can be infrequent in today's post-secondary education. While collaborative capstone courses and multi-ability introductory courses are available, the bulk of engineering courses tend to segregate by field (e.g., electrical, civil, mechanical engineering, or even by sub-discipline of a single engineering type), and ability (e.g., junior, senior, or graduate level courses).

ABET Learning Outcome (g)

The pre-survey results show that 63% of the students (3.81 average score) considered studying another language to be important at the beginning of the course. At the conclusion of the course, 82% of the students (4.00 average score) indicated that studying another language was important. This is not a surprising result as nearly 15% of student responses associated with ABET learning outcomes corresponded with learning outcome (g). Student responses ranged from rewarding experiences using their newly developed Italian language skills to frustrations with their struggles in being able to effectively communicate with local Italians. One of the first class sessions that the students participated in during their time in Rome was an introductory Italian language class taught by a local Italian aimed at equipping the students with some basic conversational tools. While students grappled with issues surrounding communication, it is clear that studying abroad afforded the students the opportunity to realize the necessity of effective communication, particularly in the context of different cultures and amidst language barriers outside of the formal classroom. For example, when asked what was frustrating one student responded, "Trying to talk to Italians, only to realize that I look stupid because I don't know any words." Another student indicated that "not speaking the language" was frustrating. While some students struggled with their frustrations in not being able to effectively communicate like they do in the United States, others cited rewarding moments such as, "learning some Italian and ordering a cappuccino," and "successfully ordering breakfast at the bakery near the campo." Another student noted surprise at "the friendliness of the market vendors when trying to speak Italian." Another student indicated surprise at "how nervous I get about speaking [Italian]."

These findings support recent calls from engineering educators such as Rugarcia et al.[23] regarding the state of engineering students' abilities to effectively communicate. *The Engineer of 2020*[24] attests similar necessities regarding the role of communication in the future of Engineering:

> "As always, good engineering will require good communication. Engineering has always engaged multiple stakeholders–government, private industry, and the public. In the new century the parties that engineering ties together will increasingly involve interdisciplinary teams, globally diverse team members, public officials, and a global customer base. We envision a world where communication is enabled by an ability to listen effectively as well as to communicate through oral, visual, and written mechanisms."[24]

Engineering Rome affords students the opportunity to practice both oral and written communication skills as they are required to cross cultural and disciplinary boundaries during their time in Rome. While these responses could certainly be correlated with ABET learning outcomes (d) and (h), they were singly coded based on learning outcome (g).

ABET Learning Outcome (h)

The Engineer of 2020[24] talks about the technological context of engineering practice and that "the world in which technology will be deployed will be intensely globally interconnected," and facilitated by technological advances. The student wikis are tangible artifacts of the technological tools that Engineering Rome employs. These technological tools aid students as they explore Rome, informing their research for their final projects. Students are given the opportunity to connect globally and socially while in Rome as they complete their final projects. Not only are students given ample time to explore a different cultural environment, but the program sets aside intentional time for students to engage in global immersion, helping students to develop a stronger appreciation for the global interconnectivity of the world. In this way, it is not surprising that over 60% of student responses related to the preselected ABET criteria surrounded issues of global interconnectedness and societal impacts of engineering design, especially since the engineering curriculum meshes well with Katehi's[25] explanation of how global engineers are to be created:

> "We need engineering curricula that are not overly prescribed, that focus on how to learn and how to apply what has been learned. We need to focus on how to seek and find information. We need curricular that satisfy a few fundamental teaching principles but allow for true variations. Requirements must be flexible to react to change. Future engineers will need design skills, as well as analytical skills."[25]

> "We must also open engineering curricula to non-engineers and teach our students how to solve social problems and how to commoditize technical innovations and processes to erase poverty. We must recreate connections between engineering and the larger society and focus on tools that will improve the quality of life."[25]

The Engineering Rome curriculum allows students opportunities to engage in both prescriptive (i.e. in class lecture) as well as self-directed learning (i.e. time for personal exploration during site visits and final project topic selection). By encouraging students to select project topics that they are passionate about and then giving them time in Italy to explore anything and everything related to that topic, the students are able to take ownership of their learning.

Student responses related to global interconnectedness ranged from struggling to understand the Italian culture to an appreciation for ancient Roman engineers. Further, students developed a better sense of understanding by applying theories learned in the classroom to actual phenomena visited on site. Several students commented on their appreciation of visiting sites after lectures and the connections they made.

As students arrived in Rome, many expressed frustrations with finding their way around, the climate, and the nuances of Italian culture more generally. Many students found the heat to be frustrating, especially while walking about the city, which is the cultural norm in Rome. One student explained that "adjusting to the apartment in Rome [was] hard." Another student commented on the necessity of "wearing long pants for church visits" which is part of the culture. When a group of students took a personal trip to the beach on the weekend, one student was surprised at "having to pay to use the beach," and went a step further to say that "beaches should be public." As students arrived in Rome, they seemed to be confronted with a culture different than their own and grappled with understanding how to fit into the Roman culture. While culture shock is not specific to Engineering Rome, it is certainly a byproduct of studying abroad. Students were given the opportunity to develop an appreciation for different ways of life, and while they struggled with finding their place in Rome initially, many of them explained that they were not ready to go home at the end of the course.

Another way that students demonstrated a growing sense of global appreciation was through developing an understanding of what Roman engineers designed and constructed nearly 2,000 years ago. Many students expressed an appreciation for "how intelligent the Romans were back then and all the attention they paid to details and how they knew how to avoid the water in the aqueducts getting dirty or developing algae." Another student documents a similar surprising moment when "learning about the advanced engineering done in Rome without equations or technical knowledge." Students seemed to be developing an appreciation for how engineering practice can be carried out in different epochs as well as in different cultures. For instance, another student exclaimed the surprise that "Romans were amazing engineers, especially since they didn't have the modern technology we have today."

Other Observations

Experiential learning was evident
Students were generally surprised by "the application of what [they'd] learned in class to real life examples (i.e. fluid flow and aqueducts)." One student described an aha moment "When visiting the aqueducts in the mountain, I came away with a much better understanding of how they worked then from the class. The inside plaster and general path was much easier to see in the field." Another student documented a similar experience explaining that "getting to see the interior of St. Peter's Basilica in person and better understand what I had been writing about" was rewarding. Another student described an aha moment when "feeling the walls of the baths in ostia and that they were warm" after learning in lecture how the design of the Roman baths utilized passive solar techniques to heat the surrounding walls and thereby rooms. One student explained that "visiting sites after the arches lecture" was rewarding and the aha moment of "finally getting it when visiting the Baths of Caracalla after studying relieving arches." Students seemed to develop a stronger understanding of theories taught in class when followed by site visits, which aligns with Katehi's[25] sentiments about "focus[ing] on how to learn and how to apply what has been learned."

Some best practices were critical to program success
Based on Parkinson's[10] list, we identified several critical best practices in retrospect:

- **Take advantage of existing university infrastructure**. The Rome Center was critical to the success of Engineering Rome. It allowed planning and scheduling to happen at least three times faster than it would have otherwise. The program director, while enthusiastic, is not fluent in Italian, does not have the necessary connects in Rome (either for routine program functions like arranging housing and planning field trips, or for curriculum-specific contacts such as guest lecturers and tour guides), and does not have the departmental or college support needed to adjust his schedule, teaching and research responsibilities to make such arrangements. The Rome Center does charge a substantial fee per student for the use of its space and services, however this fee is economical when compared to the monetized time necessary to accomplish these same tasks by the program director coupled with the Rome Center's ability to locate/negotiate the best prices.
- **Be proactive in recruiting students**. The Engineering Rome budget would not have worked for a class smaller than 15 students. In order to ensure an adequately large pool of applicants Engineering Rome was publicized throughout the Department of Civil and Environmental Engineering and college of engineering. Relevant First-year Interest Groups (FIGs – a cohort of students with like interests and intentionally similar schedules) were notified and Engineering Rome participated in the annual study abroad fair on campus. Updates on program status were provided via Facebook.
- **Prepare students before they go**. The spring seminar for Engineering Rome helped to (1) accomplish the required administrative preparation work, (2) orient students to Rome in a more meaningful way (i.e., what to expect), and (3) develop familiarity and friendships between students before the study abroad experience. We believe this is

especially important for a short 3-week program like Engineering Rome where there may not be enough time abroad to establish these relationships.

Some best practices were not followed but should be
While many best practices from Parkinson[10] were followed others were not. Specifically:

- **The UW College of Engineering study abroad opportunities are few and fragmented**. They typically represent individual faculty efforts based on personal interests of convictions. No coordinated efforts exists at the college level, but perhaps such individual efforts represent the genesis of a burgeoning study abroad interest.
- **Program directors are not explicitly rewarded**. Financial compensation must usually be found without college help or is obtained through external grants (e.g., National Science Foundation "broader impact" topics). Also, at this point, it is unclear to us what importance a study abroad program would have in the promotion and tenure process. Of note, the Engineering Rome program director purposefully waited until after being granted tenure to develop the program because of this uncertainty.
- **Engineering Rome is currently built around a single faculty**. Parkinson[10] does not see this as sustainable long-term. The intention with Engineering Rome is to make it available for other faculty to direct (with their own curriculum) by 2017.

Conclusion

Studying abroad is an attractive learning approach in post-secondary education. Identified benefits include global competence (communication, working in teams, appreciating other cultures), bonding and personal satisfaction. While nearly 300,000 U.S. students study abroad each year[19], there is substantial literature devoted to continued improvement and increasing student participation. This is especially true in engineering, where participation is at a low to middling rate at best, most likely because of financial, time, and course schedule/selection limitations. Engineering Rome is a study abroad program based on learning theory that is intended to (1) specifically appeal to engineering students and overcome their typical barriers to participation, and (2) contribute meaningfully to engineering education curriculum. During the first offering in 2013, course outcomes were assessed based on student surveys and weekly feedback. Our specific interest was:

1. To what extent did the framework of this course address barriers to student participation?
2. To what extent are students considering issues related to ABET learning outcomes (d), (g), and (h) while studying abroad? Importantly, in schools were engineering study abroad is not emphasized this can provide a defensible accreditation reason for engaging in study abroad.
3. What are best practices that can be gleaned and disseminated?

Our findings are summarized here:

- It is possible to make a course that attracts engineers but the connection should be obvious in both title and syllabus.
- Scheduling Engineering Rome outside of the regular academic schedule (as an Exploration Seminar that meets between summer and fall quarters) was helpful for students in overcoming the timing/scheduling barriers to participation.

- For Rome, which is admittedly an international city heavily infiltrated by English, the language barrier caused some initial frustration but was not a deterrent to participation.
- The program's location was a strong attractor. Rome is a beautiful, vibrant, iconic world city.
- ABET learning outcomes were evident on over 60 percent of student feedback responses.
    - Outcome (d): The course was specifically structured as a multi-level, multi-discipline class to encourage cross-disciplinary teams, which, as expected produced some initial frustration but ultimately appeared to be rewarding to students.
    - Outcome (g): Effective communication was featured through the English-Italian issues experienced by the students. Student comments suggest this often occurred outside of classroom time. This may be an outcome that essentially requires experiential learning.
    - Outcome (h): global competence was a strong outcome in Engineering Rome. While study abroad essentially forces this issue, student feedback indicated it was often on in the forefront of their minds, especially on field trips to ancient Roman icons (e.g., Colosseum, Pantheon, Aqua Claudia) and during their own personal time spent in and about Rome.
- As expected, experiential learning was overwhelmingly evident. Feedback comments related to field trips tended to discuss connections and rewarding moments associated with relating engineering theory to existing infrastructure, especially ancient infrastructure.
- Existing university infrastructure, in particular the UW Rome Center, was critical to developing and delivering Engineering Rome. This type of in-country support opens up study abroad programs to be led by faculty that may not have pre-existing in-country or language expertise. It certainly allows preparations and administration of a study abroad program to proceed quicker and with better, lower-cost overall results.
- Proactively recruiting students helps ensure an adequate applicant pool.
- Preparing students before they go in a quarter-long seminar was especially beneficial in helping establish initial familiarity and friendships before the study abroad experience.
- Engineering study abroad at UW must improve if it is to be sustainable. Specifically, there are few engineering study abroad programs at UW, program directors are not rewarded, and existing programs (including Engineering Rome) are built around a single faculty.

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