Characterizing Chemical Engineering Students' Decisions with the Push-Pull Model of Study Abroad Choice

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Abstract

Effective cross-cultural communication is a crucial skill for engineering students as they enter increasingly international workplaces. One way students can advance this skill is through studying abroad, which can also help students gain new perspectives, resourcefulness, and creativity. Understanding students' reasoning when selecting a study abroad program can be valuable for institutions as they design international programs. In this study, we compared students' reasoning for program choice in Virginia Tech's chemical engineering unit operations lab, where undergraduate students are required to enroll in a summer lab course and can choose between taking the class in Virginia, directly enrolling at the Technical University of Denmark, or participating in an exchange program at Ruhr University Bochum in Germany. Five to seven students in each of the three tracks were interviewed about their experiences and decision-making process for choosing a track. Using Mazzarol and Soutar's [8] theoretical framework of the push-pull model of international exchange choices, we qualitatively analyzed the answers for the push factors. Push factors in their decisions are the motivations that drive the decision to study abroad, including what the student hopes to gain from the experience. This study applies this framework to a unique context. Results of this study can inform U.S. institutions about what students value when making study abroad choices. This information can be used to improve programs based on student insights and can be helpful when deciding which aspects to highlight in advertising.

Introduction

Engineering workplaces, problems, and companies are becoming increasingly global in nature [1], [2]. Studying abroad can transform students into global engineers, with improvements including their collaborative abilities, flexibility, and ability to apply their technical and professional skills in a global context [3]–[5]. Though study abroad programs are increasing in popularity, engineering students tend to be underrepresented [6], [7]. Significant barriers to studying abroad for students in all degree programs include finances, personal costs, language, and information access [7]. For engineering students, there can be additional obstacles, such as the rigidity of an engineering curriculum and incentives to take an internship or co-op instead of going abroad [7]. There is a need to continue researching why students do or do not study abroad and how they choose which program to participate in. This could help universities better understand students' needs and design programs that minimize some of those barriers.

The widely-used push-pull framework for students' study abroad choice divides factors into those which lead students to study away from their home institutions (push) and those that interest a student about a specific destination (pull) [8]. Though created for international students earning a degree in a new country, this framework has also been applied to short-term programs where students weigh their decisions differently [9]. This study applies the push aspects of the framework to a unique set of data for a short-term engineering program. Undergraduate chemical engineering students at Virginia Tech in the United States (U.S.) are required to take a summer

lab course either at their home university, in an exchange program to Germany, or in a global program offered in Denmark. The financial barriers have been reduced through scholarships which are given to every student and, for in-state students, reciprocal tuition in Germany. It is valuable for future institutions designing study abroad programs for engineering students to gain insights into what students value as they make their decision whether to study abroad and where to go in this context where some of the barriers mentioned previously have been reduced. It can indicate which barriers still remain and significant aspects to emphasize in advertising.

Purpose

The purpose of this qualitative study is to understand what factors influence undergraduate chemical engineering students' decision to participate in a study abroad lab course. Information about their decision-making is examined using interviews with the students and analyzed through the lens of the pull-push theoretical framework's factors which influence short-term study abroad choices [8].

Research Question

1. What leads undergraduate chemical engineering students to decide to study away from their home country?

Theoretical Framework

The theoretical framework for this study is Mazzarol and Soutar's [8] model of the push-pull characterization of study abroad choices. They designed this framework to characterize how students make their decision to study internationally and where to go. The push characteristics lead students to decide to study away from their home country. The pull factors draw students to their chosen institution and location. This framework has been applied to short-term programs as well, and the influences tend to be weighed by students in their decision-making process differently [9]. For example, students may not be as interested in an institution's reputation since they will not be graduating from the exchange university but more interested in having a warm climate during their short-term program [10]. This framework informs our codebook and push categorization of students' answers to how they decided whether to study internationally or take the course at their home campus. Based on existing literature, we defined a list of a priori codes that fall under push factors [8]. These are listed below.

Push categories:

- Personal growth-Students desire to experience mindset and perspective changes through the experience of living in a different culture, perhaps from being pushed outside of their comfort zone.
- Language learning-Students wish to expand their skills in a foreign language generally. Particular second languages of interest would be a pull factor.
- Future career opportunities-Students believe that going abroad will improve their professional opportunities post-program.

- Overseas course better than local-If students think they will have a better learning experience away from their home institution, they are pushed to take the course overseas instead.
- Personal recommendations-Family, advertisers, professors, or overall reputation recommends that students study away from their home institution. If others are recommending a specific destination, that is a Pull factor.

Literature Review

The push-pull framework has been used extensively in the literature, usually in studies of international students. For example, Wilkins et al. [11] examined students' choices of studying in Western universities or international campuses of Western universities that are in the United Arab Emirates (UAE). They found that students who went to the Western universities prioritized rankings, language, and international job skills. Students who stayed in the UAE were focused on jobs within the country, cultural familiarity, and lifestyle convenience [11].

When examining short-term study abroad programs, the push and pull factors tend to be weighed differently by students. Kosmaczewska [9] surveyed students in semester-long study abroad programs in Poland and in Portugal. The researchers chose these locations because both countries send more students than they receive and both countries teach in languages that may be a barrier for international students [9]. They framed the results in terms of university, country, and city pull factors and found that attractiveness of the host university, interest in the environment of the country, and affordable cost of living in the city were the most important factors to students [9].

In the STEM context, Gesing and Glass [12] examined graduating international students in the U.S.'s location choices after graduation with a reverse push/pull framework. They found that students' economic and cultural backgrounds changed which factors were salient. Students from wealthier countries were overall more likely to return home after graduating [12]. Students from middle-income countries were pulled to stay in the U.S. by professional relationships and job opportunities. Racial and academic challenges tended to push graduates to return home [12].

Other literature has examined engineering students' study abroad decisions with different frameworks. Seccia [13] used the theory of reasoned action framework to examine engineering students' decisions to study abroad and found that personal characteristics and perceived benefits gave students the motivation to overcome barriers to studying abroad. This research indicated that personal factors far outweigh institutional ones [13].

There is a gap in the literature for engineering students' decision making for short-term experiences using the push-pull model. The results of this paper aim at reducing this gap by contributing to the literature on engineering students' decision-making around study abroad.

Contexts

One of the largest barriers to engineering students studying abroad is the disruption to students' degree program and time to graduation [14], [15]. Virginia Tech's chemical engineering

department curriculum requires a summer lab course called Unit Operations, or UO lab, that can be taken at the home university or overseas, which overcomes this difficulty. In this course, students learn to apply their theoretical knowledge to hands-on practice with lab equipment. Each program includes similar lab modules but they have different numbers of required labs. The summer program is after students' third year in the program. Virginia Tech is a university of about 30,000 undergraduate students with a significant portion of engineering students and highly ranked engineering programs. The university is located in a university-focused town in Blacksburg. The course is 6 weeks long and the only track that is graded with normal grade point average (GPA) grading, as opposed to pass/fail in the other tracks. This course requires students to complete 8 labs, while the tracks abroad have 6.

Virginia Tech has had a reciprocal exchange program with Ruhr-Universität Bochum (RUB), a public research institution, since 2015. Virginia Tech sends students to RUB for the summer lab and receives chemical engineering students during the fall semester. RUB has 22,000 students and is in the largest metro area of the three universities with 365,000 residents. The course is taught by RUB professors and the students take the course alongside students enrolled at RUB, typically with one RUB student in each lab group. The program is 8 weeks long. Outside of the course, the students also work on a research project with RUB graduate students. There is no explicit cultural learning in the course.

The technical University of Denmark (DTU) is a public technical university. It offers the UO lab course to multiple U.S. institutions in the summer. Virginia Tech students have been enrolling since 2007. It is the leading technological university of Denmark with internationally known research [16]. DTU is in a distant suburb of Copenhagen and the university has about 7,000 undergraduate students. The program runs for four weeks and is taught by DTU professors but only international students from U.S. institutions are enrolled in the course. A Virginia Tech professor travels with the students and grades their homework and lab reports. The students were assigned to research and present on a topic related to Danish culture during the final week of the course. In addition, each track had a lab safety module where the students learned the processes in their context, though there was not an explicit comparison of how the practices may differ from the U.S.

Methods

This study aims to provide insight into students' decision-making process, specifically which aspects of each track of the course were salient. Interviews are useful for eliciting individual opinions and perspectives [17]. Data were partially collected through focus groups of two members, which can draw out the group's norms as well as the variation within a group [18]. All students participating in the program were invited to be interviewed, and data were collected from all willing participants. Their responses to the question of why they chose to participate in a specific track was coded with the push-pull model of study abroad choice theoretical framework [8].

Data Collection

The participants were first recruited to participate by email from their home campus faculty and the researchers. They were not offered incentives to participate in the research. Additional recruiting was done by the researcher who went on-site to each location for the programs. The researcher asked students they met outside the classroom if they would be interested in being interviewed about their experiences.

The interviews were done individually or in a group of two students based on the participants' availability. The original plan was to perform focus groups but often students did not respond at the same time, making scheduling individual interviews easier. The researchers did not observe differences in the answers from focus groups or individual interviews. For example, the students were asked "If you feel comfortable, did finances play a role in your track selection?" and all students chose to answer the question, often saying which option was the most affordable to them. The students knew their peers in the focus group from the class at least for several weeks and often from their time in the same major at their home institution, which may have added to students' willingness to speak in front of their peers.

The interviews took between 20 and 45 minutes and were audio-recorded and transcribed with the students' consent. The interviews were also anonymized for confidentiality. Most of the interviews were done in-person, but some were completed on Zoom after the researcher left the city, based on students' specific requests.

The students were interviewed during their UO lab program for the home university's assessment purposes. The first question was "Why did you choose this track of the UO lab?" to explore their decision-making process. The interviews were semi-structured. Follow-up questions were also asked, including "Why did you choose this international track over the other study abroad option?" if they had answered generally that they wanted to study abroad and "Which international track would you have liked to do?" if they were enrolled in their home institution track.

Participants

The total number of chemical engineering undergraduate students enrolled in this course was 50 students at the U.S. institution, 11 students in Germany, and 24 students in Denmark. The highest participation rate was in Germany, where data was collected from 7 students followed by 6 in Denmark and 5 in the U.S.

This lab is designed for the summer after students' third year in the curriculum. Due to pandemic course restrictions, some students were permitted to delay the lab until after their fourth year. The students abroad had all finished their third year in chemical engineering. The students who had stayed in the U.S. had finished their third or fourth year in the degree program.

Analysis

The data analysis method for this study was structural coding, which is content-based and frequency-counted based on the number of participants from an a priori codebook [19]. Since this study has a scoped, focused research question on one topic (push factors in study abroad choice), structural coding provided answers as to the similarities, differences, and relationships between students' answers [19]. The codebook was developed based on the theoretical framework and definitions of Push factors in students' decisions to study abroad from existing literature [8], [9]. The authors generated codes and emerging themes from data outside the codebook so that students' perspectives were accurately represented [17]. The codes were collected for the identification of trends and interesting quotes. The quotes included in this paper have been edited for clarity by removing repeated and filler words (such as "like" or "um").

Limitations

One limitation of this study is that students self-selected to be interviewed. All students were invited to interview, but the ones who were willing to participate could have different opinions than those who did not. This study was designed for a specific context so there are many non-generalizable differences between the course options, such as having different durations and grading scales.

Research Quality

The results are corroborated by multiple authors agreeing on the coding results. Two of the authors performed the interviews and were familiar with the context, and one acted as an outside reviewer bringing a different perspective. One author performed the initial coding and the other author who did the interviews reviewed the complete first round of coding and offered feedback. Then there was a peer debriefing session with all three authors which enabled another review of the coding choices. Quotes that were difficult to categorize were thoroughly discussed until agreement was reached in order to prevent confirmation bias [17], [20].

Results

The push categories are the ones that led the students to enroll in the international tracks instead of staying at their home institution. This analysis also includes the reasoning of students who decided that push factors were not a compelling enough reason to study abroad. Future career opportunities and personal recommendations seemed to have a significant impact on students that chose to leave their home campus.

Personal growth led students to want to leave Virginia Tech challenge themselves by living outside of their culture. For example, one of the students from the Germany track described: "I also just didn't really want to stay at Blacksburg for the summer. I wanted to switch it up a little bit and have new experiences and put myself out of my comfort zone." Other students mentioned personal growth in terms of being able to meet and learn from other students from a different culture and saw a connection between personal growth in a global context and being able to work

with people from different backgrounds eventually in the workspace. An exemplary quote from a student who went to Denmark was:

> I don't want to just work with people from where I come from, and who look like me, but I also want to build things and design things with people from around the world. Exchange of thoughts and ideas, allows people to learn and to grow and build new things, and I want to be a part of that.

<u>Language learning</u> When students were enrolling, they were told that the Germany track would have a language course, though it ended up being canceled. Students also anticipated interacting with many people in Denmark who could speak English. None of the students talked about their desire to learn a foreign language leading to their overall choice to study abroad.

<u>Future career opportunities</u> The students in Denmark in particular talked about their interest in securing future engineering jobs in Europe or enrolling in graduate school outside of the US. They viewed their abroad experience with this program as a means to help them explore this possibility: "I'm really interested to come (to Europe) because I'm not sure I want to move here and work here instead of the United States."

Although this category primarily examines future career opportunities for those who linked it to going abroad, we saw a connection between the track choice and career opportunities for the students in the Virginia Tech track as well, which is explored in the *requirement to take the US track* emergent code.

<u>Student required to take the Virginia Tech track</u> The lab course is typically mandatory during the summer after students' third year in the program, as it is a prerequisite for capstone courses. During COVID, the international tracks were put on hold and all the students had to complete the lab in Blacksburg. In order to accommodate what became at least three times the number of students the Blacksburg track could accommodate, the chemical engineering department allowed the students the option to defer their lab to the summer of their fourth year and waived the prerequisite requirement. For these students, they could only choose the Virginia Tech track. Two students interviewed in the Virginia Tech track fell into this category. One of the students was chosen to defer the course and take it in the US because of career opportunities:

> First off, so I was mainly looking to go into the oil and gas industry, and in my last co-op term it looked like the hiring outlook wasn't great so I really wanted to explore some other opportunities with an internship the summer before senior year just to you know have different options and maybe have exposure to a couple of different areas. So that definitely made me want to… hopefully get an internship so I was really excited when they came up with that type of option [deferring] and I started applying to a bunch of places I hadn't been applying before because I was like well I'm going to be in UO lab, and that was probably the main thing.

<u>Overseas course better than local</u> There was an impression among students that the workload across the three tracks is not equal and that some tracks may be easier than others, with the

students in Blacksburg perceiving their track as most difficult since it had the most labs and a letter-graded course. For this category, one student in the Germany track did not want to take the Virginia Tech course and described it as a significant amount of work: "plus I heard that (the Virginia Tech track) it's really intense". Students did seem to take this relative difficulty into account when making their decision.

Context-specific grading scheme Related to the comparison of the course perceptions, the three tracks had different grading systems where the Virginia Tech track's lab grades would contribute to students' GPA and the two tracks abroad were based on pass/fail outcome. Students in the Virginia Tech track expressed that they were frustrated that they had a weighted scale. The students abroad did not tend to say that the grading was a push factor for their decision to study internationally. Only one student brought it up and they cited it as an advantage but not defining factor: "I would say that the pass/fail, transfer credit was honestly an added bonus, that it doesn't go into my GPA."

Personal recommendations Students in all tracks sought advice from alumni of the chemical engineering lab as a resource to inform their decisions when it comes to choosing between the tracks. Some former students did not like the Blacksburg track, while others enjoyed the international component a lot: "I had just heard that it [going abroad] was a great experience from like some older students that had done it." Besides the former students, one student in the Denmark track received personal recommendation from a coworker telling them to take any opportunity to go abroad. Students did not refer to university resources recommending that they study abroad.

Assumption of desire to go abroad An emergent theme was that many of the participants mentioned their desire to go abroad, without specifically mentioning a reason behind it. While wanting to go abroad is in itself a push factor, we weren't able to categorize it under any of the previous push categories without knowing the students' reasoning behind that choice. Examples from each study abroad track included "I knew I wanted to go abroad. And so I was mainly choosing between Denmark and Germany" and "I really wanted to have the study abroad aspect. I've never been outside the country so I saw the opportunity and I was like this would be really cool." Even a student in the U.S. track who did not have the option to go abroad expressed a similar sentiment, saying "When I was a freshman and I was declaring my major, traveling for UO lab was definitely something I was interested in is definitely something I really wanted to do so, I was kind of upset that I couldn't travel when I deferred (the course)."

Discussion and Future Work

The results of this study indicate that in this lab program, students' decision to study abroad was based on course-specific, university-encouraged, and personal reasons. Personal and professional development were significant factors for several students. Students wanted to stretch themselves by entering new contexts and thought that working cross-culturally could help their future careers. These aspects should be encouraged by institutions before students go abroad and during the program with purposefully chosen experiences and assignments.

Some aspects of this course specifically led students to study abroad or to stay in the US. In this case, students who were taking the course after their fourth year could not choose to study abroad. The US version of the course was perceived as more difficult and had a grading scale instead of being pass/fail. Students said that they wanted to avoid the difficult home course but said that the pass/fail aspect was an added benefit to studying abroad, not a primary reason they chose a track. Language learning did not seem to be a driver of these students' choice to study abroad.

Personal recommendations from peers and coworkers were mentioned by students. The importance of personal factors aligns with other research [13]. It is an interesting result that university encouragement to study abroad was not what students cited as a deciding influence. There is space to continue researching what information is presented to students through official channels and if that has an effect on students' decisions. If peer to peer advice is an influential factor, universities could invite students who traveled abroad to organize panel discussions around their experiences to encourage other students.

Finally, there was a common theme of students saying they definitely wanted to study abroad but not giving a specific reason why. Students said that they had wanted to travel internationally for years and cited the course as something they particularly liked about this university's chemical engineering curriculum. There is a need for future work that explores what students are specifically interested in about studying abroad in the cases where students do not elaborate since this factor was commonly mentioned.

The purpose of this study was to learn what answers were naturally elicited when students were asked the open-ended question: What led you to choose this track of a study abroad or domestic program? Many push-pull studies use quantitative surveys where the options for factors that influenced their decision are available to be rated [9], [11], [12]. A quantitative survey could triangulate the results of this study and compare the results.

Conclusions

This study focused on understanding undergraduate engineering students' reasoning behind choosing to enroll in a short-term study abroad program, specifically in the context of a chemical engineering unit operations lab in Germany and Denmark. Results showed the students seeking personal growth through living and working in a new context as a major factor. Language learning was not a significant motivation, which can be expected for short-term programs. Future career opportunities was another often-cited factor, whether that is exploring working in a different country or taking the opportunity to participate in a co-op in their home country. Universities should utilize the power of personal recommendations and peer-to-peer advice when it comes to promoting study abroad, and future research should further investigate how students weigh competing factors when deciding to study abroad.

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