Experiencing Mathematics Abroad

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Abstract Study abroad experiences have been recognized as providing students with valuable opportunities to work with individuals and groups different from themselves, to incorporate diverse viewpoints into their work, and to engage in meaningful experiences outside their culture. This article focuses on one of the mathematics courses in Belmont University's study abroad program that was designed to synthesize course content and authentic learning experiences in order to address the diverse set of student learning outcomes. While improved student engagement in cultural understanding and the promotion of intellectual diversity took on a central role in the course design and assessment, a secondary goal was an improved student perception of mathematics and its application. We examine the course in action by looking at three example assignments, followed by their connections to program experiences, and how these things coordinate to meet the student learning outcomes.

1 Introduction

Global learning opportunities that provide students with international perspectives have become a goal of many university programs, especially those that aim to provide students with opportunities to improve cultural understanding, and promote intellectual diversity. Although these global opportunities are becoming more common, it often remains a challenge to measure competencies and effectiveness in programs that focus on cross-cultural experiences.

Study abroad experiences have, however, been recognized as providing students with valuable opportunities to work with individuals and groups different from themselves, to incorporate diverse viewpoints into their work, and to engage in meaningful experiences outside their culture [4, 5]. In an effort to help educators

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align study abroad programs with the Essential Learning Outcomes laid out by the Association of American Colleges & Universities [2], the Center for Capacity Building in Study Abroad—a joint project between National Association of Foreign Student Advisers (NAFSA) and the Association of Public and Land-grant Universities (APLU)—argues that meaningfully engaging students in global questions that demand integration of knowledge, skills, and personal and social responsibility is an essential outcome of study abroad programs [6].

The program discussed here is aimed at addressing these concerns by using mathematics as a universal language to better understand and connect people and social issues across different cultures. The program has been implemented in three study abroad trips in Europe and Australia. While improved student engagement in cultural understanding and the promotion of intellectual diversity took on a central role in design and assessment, a secondary goal was an improved student perception of mathematics and its application. This article focuses mainly on one of the mathematics courses in this program abroad developed to benefit student capacity for such engagement while promoting diverse cultural understanding and appreciation. As such, the course was designed to synthesize course content and authentic study abroad learning experiences in order to address the diverse set of student learning outcomes. We will begin with a course overview and the development of student learning outcomes. Next, we examine the course in action by looking at three example assignments, followed by their connections to program experiences, and how these things coordinate to meet the student learning outcomes. Lastly, we will examine qualitative data aimed at examining perceived growth in content and cultural understanding.

2 Course Overview

The authors teach courses at Belmont University, a liberal arts university in Nashville, Tennessee. Students at Belmont must complete a core liberal arts curriculum, including one mathematics course focusing on quantitative literacy and reasoning. Hence, the study abroad course we will examine was designed around the application of basic mathematics skills to the analysis and interpretation of real-world quantitative information in order to tackle problems both relevant to students in their lives and to the communities and cultures in which they were studying. We found that a Math for Social Justice course provided a natural framework for addressing both study abroad and mathematics learning goals.

The course was originally developed by the authors to satisfy the mathematics requirement in the core liberal arts curriculum at Belmont University and was partly inspired by conversations with faculty at other institutions, especially Dr. David T. Kung of St. Mary's College of Maryland. It ran multiple times over the course of four consecutive fall and spring semesters before being adapted to the study abroad format explored here. At the time of this publication, the course will have run three consecutive summer terms in Australia, once in Europe, and will have

expanded to include a version in Scandinavia. This course looks to take active learning experiences beyond the institution and home region—highlighting issues of social and economic justice on local, national, and global levels. Further, students would see how mathematics can act as an analytical tool in understanding cultural interdependence, power, and privilege. More succinctly, the goal is to give students means and methods to quantify and interpret complex social issues affecting the people, land, and culture.

As mentioned, this particular Math for Social Justice course has run in the summer as part of an interdisciplinary study abroad program in Australia, during which students spent over three weeks near Brisbane, Townsville, Cairns, and Sydney, as part of a program designed to provide authentic and formative experiences with different communities and cultures. The location selection allows for different experiences in metropolitan cities and smaller coastal towns, with members of multiple Aboriginal groups, and at a Queensland University research station on North Stradbroke Island. The location diversity allows for encounters with a variety of environmental ecosystems, cultures, and peoples—each of which brings different opportunities to quantify issues of change and social justice.

2.1 Student Learning Outcomes and Preprogram Elements

Developing learning outcomes is an essential first step toward effective teaching. Thus, in designing a mathematics course to fit in the study abroad context, it was important to identify learning outcomes that would be effectively served by the course content while also fulfilling the expanded goals of a study abroad course. As appears in [6], NAFSA and the APLU have provided a broad framework in which students should be engaging during a study abroad experience. This framework for Essential Learning Outcomes (ELOs) centers on four areas:

- Personal and Social Responsibility;
- Intellectual and Practical Skills;
- Integrative Learning;
- Knowledge of Human Cultures and the Physical World.

Further, ELOs should be met in an environment which provides perspective and opportunities beyond what is available to students at their home campus. We desired for these changed perspectives to be a result of synthesis between content and cultural learning, as opposed to being inspired solely by non-discipline related experiences abroad. In addition to the above framework, special consideration was given to engage students in deep learning outcomes, as outlined by the National Survey of Student Engagement (NSSE) [10]. These outcomes focus on Higher Order, Integrative, and Reflective experiences which inspired the learning outcome language used in this course. Its inclusion in the design is evidenced in the three activities referenced in this paper: A “Press Release” activity, a “Discussion Lead” assignment, and “Program Journal” component, each of which appears in the Appendix.

In order to lay the groundwork for the above goals, this course would need to establish an effective entry point for a deeper appreciation of mathematical content while also meaningfully engaging students in the outcomes laid out in [6]. We used internal learning objectives, those outlined by other institutions, such as UMASS Lowell [13], and the AAC&U's VALUE rubric for quantitative literacy [1] as guides to help shape the content objectives, particularly focusing on developing curriculum that would be adjustable for different program locations going forward. Considerable attention was given to making the Math for Social Justice course a transferable model for connecting authentic cross-cultural experiences and quantitative reasoning content, while opening the door for a deepened understanding of the complex issues of whichever culture, community, or country students encountered.

Each course operated as a hybrid classroom, containing both online and in-class components. The students had weekly online learning modules (five pre-trip, two during the abroad portion, and one post-trip), accompanied by in-person class meetings multiple times before the trip and interspersed group meetings during the program. This allowed students the opportunity to individually practice and demonstrate skills knowledge while also engaging in progressively more challenging problems, projects, and discussion in a collaborative setting. It also helped ensure sufficient content mastery and exposure to mathematical applications to cultural and social issues prior to being abroad. These elements provided reference points for integrative exposure and encounters with cultures and communities unfamiliar to the students.

Finally, a well-known difficulty study abroad programs face is in combatting the student perception that they are studying but "on vacation" abroad [3]. As many study abroad facilitators and faculty have noted, a disconnect between content and cultural encounters may increase the likeliness of this attitude emerging during the program. In addition to emphasizing the importance of the synthesis of course content and cultural experiences, this was combatted with the inclusion of multiple service-learning components, which have been shown to play an important role in connective learning [9, 11]. The preprogram assignments, discussion, and project preparation sought to help bridge any perceived gap between curricular activities and cultural experiences, priming students to make connections with built-in opportunity for reflection throughout the program.

3 Course in Action

While much of the skills practice was completed individually prior to the program, larger projects and assignments were designed to function as collaborative learning experiences and tasks that could be refined and submitted during the program. Some of these activities utilized small groups in which students submitted a common work, while others had multiple components that were submitted in stages in order to allow for feedback, revision, and discussion. We now look at several of the activities and how they aligned with goals of a quantitative reasoning course,

effectively met the underlying ELOs for the study abroad program, and connected meaningfully to site visits and cultural experiences during the program. We will first detail the assignments, each of which is presented in the Appendix. This is by no means an exhaustive list, nor are learning outcome adaptations addressed in only one activity. as they appear in the previous section.

3.1 Activities

The first activity is a "Press Release" assignment that could be modified to address how a variety of social issues—such as poverty rates, incarceration rates, educational performance—are quantified. It could also be scaled up in length and difficulty via an added debate component or a more in-depth analysis. Students were divided into groups, with each group selecting a country comparable to where students would be traveling to abroad (Australia, in this case). The groups were then tasked with collecting data regarding that country or region's energy production coming from renewable sources such as wind or solar over the last 10 years. The groups produced two press releases: one as though they were working for an environmental group that advocates for more funding and support for renewable energy and one in which they were public relations representatives for the country's department of energy. These two statements were to present a case either arguing for increased renewable energy sources or an argument supporting the country's current energy policies. Part of their submission involved a collection of footnotes detailing how statistical measures presented were calculated. Groups were encouraged to be creative with their quantitative arguments, including providing meaningful comparisons to the countries of other groups, while also outlining potential consequences of each side of the argument.

In terms of addressing mathematical content objectives, this activity required students to collect data, form basic statistical measures, and establish evidence to support the positions assigned. In addition, the groups had to take on multiple viewpoints of an important contemporary global issue and attempt to frame the data to serve each side of the debate. Students needed to demonstrate an understanding of the positions presented and the arguments defending each position, as well as be able to decipher the origin of statistics used to support claims. They were assessed on the appropriateness and clarity of data presented, as well as on the accuracy of an accompanied explanation of each statistic presented. This activity also served to assess the group's ability to communicate mathematics effectively. Finally, it served as an opportunity for feedback from both instructor and classmates regarding how effective students were at communicating quantitative information. Polished presentations highlighted the importance that framing plays in communicating quantitative information.

Next was a "Discussion Lead" assignment that required students to research a social, environmental, or ecological issue relevant to the program locations, provide articles and references citing quantitative measures regarding the issue,

and then develop the framework for a group discussion which they led near the end of the program. In preparation for this—during each week of the pre-trip portion of the course—students took turns submitting articles or studies containing quantitative data on issues concerning inequality or injustice relevant to Australia and its citizens. Students began developing the inclination to skeptically view how data and mathematics are used in application. They explained concepts like percentage change, correlation, and p-values in the context of social, economic, and environmental issues before and after the mathematical content was rigorously covered in the course. They then engaged in instructor-facilitated discussion about different methods and conclusions of the various articles. For example, in the first week students read articles concerning wealth inequality in Australia, culminating with them learning about Gini coefficients and Lorenz curves as applied to the issue. This practice allowed students to develop their skills of evaluating claims and questioning quantitative evidence prior to the closing "Discussion Lead" assignment. The discussions were required to address the quantitative information in the references, while also challenging the audience to consider how their experiences abroad connected to the topic chosen.

In addition to peer feedback, students were provided a rubric detailing how they would be assessed on four components of their facilitation of discussion: "Content Relevance and Clarity," "Motivation and Connections to Experiences," "Engagement of Classmates," and "Impact Analysis" (including future questions to consider). As "Engagement" was an assessed component, students were encouraged to utilize different active learning strategies they had been exposed to throughout the course (e.g., "Think-Pair-Share"; "One-minute Papers") in order to deepen the discussion. Topics that students selected included: disparities in rates of domestic violence, mental health disorders, and incarceration rates across different demographics in Australia; issues of legal discrimination and land right battles of different indigenous groups; economic and environmental factors involved in bans on plastic bags; and measuring Great Barrier Reef restoration efforts. Each of the discussions presented different challenges and viewpoints in terms of what was being measured, methods used in collecting information, analyses and conclusions drawn from data collected, and the impact on the people and culture. This goal of this assignment was to prime students for connecting the quantifying of social issues with their own experiences abroad, along with highlighting the natural inclination for students to identify and articulate parallels to issues present in their own culture. Further, students were asked to apply content knowledge to determine the degree in which they considered the data presented to be a meaningful representation of reality.

Finally, given that the program aimed to aid students in expanding their understanding of cultures different from their own, the course had a required journaling assignment designed to provide an opportunity for reflection on growth and increased self-awareness. The hope of this activity was to have students identify and describe changes in their own learning, specifically focusing on the contribution of contextual components linked to their cross-cultural experiences. There were structured, common journal prompts assigned as part of the abroad portion of the

program, as well as other required entries allowed to be on a topic of the student's choosing. Then, a final prompt, revealed at the end of the program, required students to reflect on the role that quantitative representations played in applying moral reasoning to either social or ethical issues they encountered on the program, while noting any challenges or limitations they encountered in doing so.

Again, the goal was to ensure that the journals went beyond a simple means of recording experiences and instead involve meaningful reflection and assessment of one's own self-awareness, while also providing ample opportunity for autonomy in selecting themes on which connect their own growth. Students completed at least six journal entries throughout the program, each one-to-two pages in length. By this stage of the program, students who had put great effort into quantifying and testing measures of inequality mathematically and critically were tasked with reflecting on their experiences with the people and cultures they had been studying. Further, students were faced with the reality that, although mathematics is essential in measuring and understanding complex issues including cultural differences, it provides only a portion of the insight necessary to understand these differences in full.

3.2 Connecting Activities, Experiences, and ELOs

A challenging aspect of course design in an abroad program is finding and arranging experiences that contribute to student learning and are different than what students may experience on their home campus. A great deal of the program's logistical success in this area is due to Dr. Alison Parker of Belmont University, and the program's organizing partner of Arcadia University. We now look at a selection of the experiences students had in Australia and some ways in which they connected to the Essential Learning Outcomes stated in Sect. 2.1 and the activities outlined in Sect. 3.1.

The "Personal and Social Responsibility" learning outcome encompasses the importance of civic and intercultural knowledge and engagement. As such, it was important for students to complement their quantitative study of complex issues affecting both local and global communities with an ethical reasoning process. For example, in the "Press Release" activity, students are asked to look at different viewpoints of an important issue, the use of renewable energy, and then gather and express quantitative evidence in support of an argument concerning that issue. This emphasis on civic knowledge was present throughout the various "Discussion Lead" topics as well. As a result of differing viewpoints surfacing in discussion, these assignments also required students to interpret and propose hypotheses that indicated a deep understanding of the issues, while engaging in ethical reasoning in determining how to address them.

This outcome was further supported by several abroad experiences. One example was when students met with the CEO and COO of a car-sharing company that utilized statistical analyses to optimize hub locations, reduce emissions, and relieve

parking space scarcity in Sydney, Australia. The company not only looked to illuminate the transportation needs of different communities within the city, but it also aimed to help address the real-world challenge of reducing carbon emissions while providing means of affordable transportation. The students also visited an environmental project development firm, Green Collar, that detailed how it applies data analysis in its role as an environmental market investor and sustainable land developer. Unlike the USA, Australia utilizes a carbon credit system and this company works with land owners to make environmentally beneficial farming and agricultural practices more affordable and profitable. While students were exposed to data collection and the development and application of some basic mathematical models, they also witnessed how environmentalism can benefit from the application of some of these mathematical tools. In both of these instances, the experiences not only promoted civic engagement in the issues of sustainability and social responsibility, but they also highlighted the importance of communicating quantitative information effectively, as the companies were often required to convince potential clients, collaborators, and even government officials with compelling quantitative arguments similar to those the students made.

Lastly, within the "Discussion Lead" assignment, several of the topics covered revolved around the challenges facing Australia's unique ecosystems as a result of both humanity's influence and global climate change. With the nonprofit organization Reef Ecologic, students participated in a Citizen Science expedition during which they gathered and analyzed data relevant to an environmental issue of local and national importance—the health of the Great Barrier Reef. They then participated in a case study detailing various proposals aimed at measuring and addressing how pollution and land development affect local ecosystems comprised mainly of wildlife endemic to the area. These assignments and experiences all required students to understand the contexts of critical issues involving sustainability and the environment, a matter of great importance to the land, people, and culture of Australia. Further, students practiced ethical reasoning while witnessing the application of the skills they had developed by the various organizations.

Given the course's focus on quantitative literacy, the activities and experiences almost all had components that addressed the "Intellectual and Practical Skills" learning outcome. Both the "Press Release" and "Discussion Lead" assignments looked to assess the students' quantitative inquiry and analysis skills. Likewise, experiences with the car-sharing company and Green Collar involved the application of these skills in a real-world setting. While these basic quantitative literacy outcomes were important, there were also activities that allowed students to engage in creative and critical thinking processes while practicing oral and written communication, most clearly demonstrated with the "Program Journal" assignment.

In terms of experiences serving these outcomes, the aforementioned Citizen Science expedition provided an authentic opportunity for students to take concepts they had learned examining other people's data and apply them to their own project. Being involved in the entire process, from logistical planning to data collection to analysis, forced students to draw appropriate conclusions based on analysis of

data while making judgments about the limitations of data as well. Further, the expedition involved team problem-solving, as groups were tasked with deriving potential solutions and interventions in a post-activity discussion.

Finally, students had the opportunity to engage in meaningful conversation with people of different cultures and communities while abroad. One such opportunity occurred within conversations students had with a member of the Quandamooka Aboriginal people, Matt Burns. As a guest lecturer, Matt delivered an active-learning lecture about his people's culture and the ways in which they had previously and continue to face discrimination and marginalization. He not only provided students with insight and understanding unique to his life experiences, but he also challenged students to describe what they knew about the inequality and injustices facing Aboriginal people. Students who had studied and practiced identifying and quantifying indicators of marginalization of Aboriginal people in the pre-trip component of the "Discussion Lead" activity were now being asked to relay their understanding to someone who had directly encountered and endured them.

Many of the experiences we have described focused on applying skills and knowledge to complex problems. The broad outcomes of "Integrative Learning" and "Knowledge of Human Culture and the Physical and Natural World" were at the heart of each scheduled experience during the program. As these experiences were often pre-empted by relevant pre-trip readings as part of the "Discussion Lead" activity or with faculty-led group discussion, students were repeatedly challenged to take their previous knowledge—regarding both content and cultural—and apply it in new settings. Similarly, the "Program Journal" assignment was meant to be a medium for acknowledgement of the synthesis of current and past learning, as well as an opportunity for students to articulate the connections between content, context, and their own self-awareness. For example, one student responded to the final journal prompt by expressing appreciation for the application of quantitative reasoning, but also frustration and resignation in the limitations of that pursuit because "data will never tell us enough of the story."

Many of the examples in which students not only integrated their knowledge, but also engaged in an activity meant to broaden their cultural understanding, centered around students' experiences connecting with members of different Aboriginal communities. Students had been exposed to a variety of issues affecting Aboriginal people via the "Discussion Lead" activity pre-trip. They had responded to articles examining topics ranging from the prevalence of suicide and depression in certain Aboriginal communities to struggles of these traditional land owners attempting to reclaim their land rights. In these and other contexts, students had experience attempting to quantify the effects of discrimination against these people, but we wanted them to achieve a deeper understanding of these issues of injustice and inequality during their time in Australia.

At different points of the trip, members of both the Quandamooka and Nyawaygi people were willing to discuss with students the challenges their people have faced such as loss of land, liberty, and life. One of the most meaningful aspects of the trip for multiple students, as relayed in the "Program Journal" assignment, was learning

from people affected by the inequalities and injustices that students had studied pre-trip. Students were asked to connect the quantitative information on which they have honed their mathematical skills with the experiences and understanding stemming from these conversations. These reflections and subsequent discussions were the least mathematical components of the course, as students grappled with viewpoint of the victims of the injustice and inequality they have been trying to quantify, along with the reality that advantages and power possessed by one culture may often create disadvantages and despair for others.

This was an important component of the student's learning experience, because although they can read and research and attempt to quantify the injustice and inequality affecting people around the world, there is, hopefully, unique understanding gained in the opportunity to hear from the people affected. Though some students described experiencing a feeling of unease as they grappled with these issues during post-activity discussions, these experiences aimed to serve deeper goals in the addressing of one's own lack of understanding. Whether it was reflection on complex questions about other cultures and diverse groups or cogently connecting life experiences and academic knowledge, the journaling provided another forum for students to articulate their own formation of the synthesis of mathematical content and their experiences.

4 Student Perceptions on Learning

There has been recent research connecting study abroad programs to students' cross-cultural awareness [8] and openness to diversity [7, 12] that provided hope that this program could achieve similar ends. In an effort to measure how successful the program was in achieving its desired outcomes, students were provided with an anonymous, voluntary post-program survey.[1] Given the nature of short-term study abroad programs, the level of student interest in mathematical courses, and the relative recency of the program's development, respondent data is limited. In fact, the data set size ($n < 20$) is still too small to make meaningful conclusions based on quantitative results. However, we feel the nature of the questions and the limited data attained are still of interest in beginning to understanding student perception and also illustrate some potentially useful information in course assessment.

First, students were asked to respond with the degree to which they agreed the program affected them in a number of potential ways. Responses were given on a five-point scale: strongly disagree, disagree, neutral, agree, and strongly agree. The statements below had greater than 90% of students agreeing or strongly agreeing with the statement. Students indicated that they felt the program achieved a variety of goals, including the following:

[1] Belmont IRB Exemption, Protocol ID 690.

- Contributed to them developing a more sophisticated way of looking at the world.
- Increased the likelihood they would seek out opportunities to engage with cultures other than their own.
- Was likely to have a lasting impact on their worldview.
- Increased their appreciation of mathematics.
- Helped them to better understand cultural/global issues with increasing complexity.
- Influenced their understanding of cultural values and biases outside of themselves.

The statement that received the highest level of disagreement was "The course caused you to refine your social or political views." This may indicate that, despite wrestling with complex social issues, the problems and solutions examined and discussed were not tied closely to one's own political identity.

Qualitative data were also compiled from short-response questions. Students responded to the following prompts:

- In what ways do you think taking the mathematics class abroad deepened your understanding and appreciation for different cultural and global issues?
- In what ways did the abroad experience affect your interest or appreciation of the mathematical content studied?
- The following is an opportunity to further comment on your experience taking a mathematics course as part of your study abroad. Of particular interest is any effect it had on your appreciation/awareness of cross-cultural issues.

Responses illustrated an appreciation for the intentional connections between course content and cross-cultural experiences and an appreciation for growth and change in students' cultural perspectives. For example, one response focused on achieving deeper understanding in these areas is included here.

"I began to intentionally learn more about other cultures and issues surrounding an area very different from what I was used to. Hearing directly from people in other cultures helped me to gain a deeper understanding of global issues. Another thing that really deepened my understanding and appreciation of global issues was participating in hands on experiences while in Australia."

Along these lines, another student commented, "If it weren't for this class, my perspective on culture, global issues and politics would not have changed for the greater good." These responses demonstrate some degree of growth, while also a level of self-awareness in current and previous cultural perspectives.

Similarly, students noted the importance of connecting cultural activities with course content and the effect doing so had on their growth and learning, with one student writing,

> "Being able to explore another culture through math allowed me to view the Australian culture in a way that was interesting to me, and in turn it allowed me to develop a deeper appreciation for the culture there. Had I taken the class in Nashville, I don't think it would have had as much of an impact because I would not have been able to actually see the interactions in that culture."

Other students made similar observations, with one noting,

> "Being in a different country and learning about mathematical social justice puts a perspective on a person that no other circumstance could... Learning about the differences and similarities between the two countries helps one realize how far off the stereotypes are. If I wasn't majoring in music, I would be majoring in Math for social justice (if that was a major)!"

Finally, multiple students mentioned a growth in appreciation for mathematics and its role in understanding complex issues, as illustrated by one responder's comments, "Studying abroad with this specific content has helped shape and really educate me on the cross-cultural issues and how to respect and appreciate other cultures." Another student added, "I like math. This trip made me like it more," while yet another indicated she or he would be adding a math minor.

4.1 Future Considerations

Study abroad courses often face some inherent difficulties and limitations, such as limited face-to-face class time or opportunity for active learning experiences. Hence, reflection on our mathematics course abroad has revealed areas of limitation as well as opportunities for improvement. While the course was designed to be adaptable to different programs and locations, it is worth highlighting a few of these issues here.

Looking first at limitations in teaching mathematics abroad, many of the course and program elements that make the synthesis of content and experience effective involve substantial cooperation with groups at the destination location. A clear understanding of course elements and open collaboration with universities and organizations abroad can help optimize the meaningfulness and appropriateness of cultural experiences abroad. However, this can not only be difficult in organizing meaningful site visits or guest speakers for a course, but it may also inflate budgets.

There are also a number of opportunities for improving the mathematics abroad course we have developed moving forward. One opportunity touched on by student comments is providing ample time for connecting discussion and written components of the course. In particular, students felt they could benefit from more scheduled opportunities for discussion after students engaged in reflection and journaling. Previous program design provided students with first an opportunity for discussion and then written reflection. The aim was to give students time to process discussion and experiences before reflecting in their journals, but they may also benefit from a follow-up discussion in which they can compare aspects of their reflection with their classmates. This may prove difficult, however, due to time considerations during abroad programs.

Other potential limitations stem from the class size and issues arising with either small or large enrollments. A larger course or program enrollment can potentially benefit more students, but many activities become less engaging or logistically difficult to implement effectively with a larger number of students. This can significantly impact the effectiveness of activities requiring students to individually communicate mathematical reasoning, as time may be a limiting factor on discussion. On the other side is low-enrollment concern and a matter of driving student interest in mathematics courses abroad. Mathematics courses can often suffer from disinterest or fear, and the added abroad component can be a daunting and determining factor in students avoiding the course.

Overall, the effectiveness of this course, and others like it, hinges on synthesizing content with application to complex problems connected to site visits and encounters while abroad. An important aspect of this is the surrounding discussion and reflection which encourages students to reassess their perspectives and worldview through the dual lenses of both mathematical content and cross-cultural exposure. Quantitative literacy and reasoning are necessary tools for studying and quantifying the elements of power, opportunity, privilege, and interdependence with regard to cross-cultural learning. The perceived value of these mathematics abroad experiences suggests these elements of content exposure and discussion, project application, cultural engagement, and reflective writing provide profound and lasting growth for students in study abroad programs.

Appendix

"Press Release" Activity

Below is the exact version of the assignment that students see, without the example data tables and press release.

Press Release Activity

On the following pages you will find some example data for the total and per capita wind power capacity in megawatts that the select could produce at the end of each year in 2016 and an example press release from the Department of Energy of

the United States. Your first task is to collect similar data from the last ten years for both Australia and another country from the provided list. Each group will select a distinct country. Once you have done so, you will be responsible for crafting two press releases.

Side 1
Suppose you worked for the PR department at the Department of Energy for one of the given countries when these data were released (I am requiring that one group will be United States and another will be Australia). Write a press release ($\geq$ 2 paragraphs) that puts these data in the best possible light, supporting your country's energy policy.

Side 2
Suppose you worked for an environmental group that advocates for more support for renewable energy sources like wind. Write a press release that puts these data in the worst possible light, supporting you argument that your country is falling further behind the rest of the world.

Your goal is to establish arguments with evidence drawn from the data. Both of the above releases may involve comparative data as well. Included with your statements should be validation for each statistic you cite. Fore example, if I describe a certain percent change in capacity from 2014–2015, there should be a footnote providing the calculation made to get that percent change value.

Be sure to avoid some of the pratfalls that we have identified in the use of percentages, rates, and ratios (such as averaging percent increase in capacity over a number of years).

"Discussion Lead" Activity

Discussion Lead Assignment

I am asking that you prepare to lead an engaging and informative discussion appropriate for our Math for Social Justice course while on our trip. The scope of the discussion topic is up to you, but I encourage you to use the examples we have done already as a guide. There will be components of this assignment due both before and during our trip, as laid out below:

Pre-trip
Once you have selected your topic, you must provide at least three (3) reputable sources for fellow students to serve as references. These sources should contain quantitative information regarding your topic, giving your fellow students statistics to consider as they prepare to participate in fruitful discussion.

Your source must be uploaded by July 1st to the Blackboard discussion board forum "Discussion Leads". This will allow your fellow students the time to download copies of the articles before the trip, as well as familiarize themselves with the quantitative information on the topic.

While Abroad
I expect this to be approximately a thirty (30) minute discussion (NOT a lecture). The rubric is attached. The main criteria are that this is a quantitative-driven discussion of a social justice issue and the effectiveness at engaging of your fellow classmates in challenging discussion. Good discussions will connect course content with experiences abroad and challenge the participants to consider potential responses and methods for social change, if appropriate.

Expectations for Participation
- Prepare to engage in meaningful discussion centered around quantitative literacy and social justice while in Australia (I may provide further articles).
- Be engaged in group activities, experiences, panels, and lectures to the best of your ability.
- Focus on making connections between course content and cultural experiences abroad.

"Program Journal" Activity

The "Program Journal" activity was completed during the abroad component of the program, allowing students to reflect on their experiences in country. The final journal entry prompt, as mentioned before, was not given to students until the end of the program. It asked students to reflect on the role that quantitative representations played in applying moral reasoning to either social or ethical issues they encountered on the program, while noting any challenges or limitations they encountered in doing so.

Journal Assignment

You will keep a journal chronicling your experiences with mathematics, cultural understanding, and social justice during the travel program. You are required to write six entries over the course of the program, about one full page in length (you may write more), and these may be written or typed. For four of these you will write in response to the experiences of specific days, with the two remaining entries being on topics of your choice but they should relate to mathematics and your experiences in Australia. Your final entry will be revealed while on the program.

Required Experience Journals

Straddie, Swamp vs. Lake Consider procedures for data collection and analysis in the field and compare the two different ecosystems. How are they similar? Different? What did this teach you about the data collection and analysis? About these ecosystems, specifically?

Reef Ecologic As you participate in this larger research project, what is your role? How did your experience and the work you have seen elsewhere on the trip and in the course prepare you to participate in this project? What are your thoughts on the "citizen science" aspect of maintaining reef health? How about the

struggle to model and quantify aspects of reef health? Discuss the overall logistics of running an ongoing project of this scale using various volunteer groups and your thoughts/feelings about participating.

Mungalla Station How do the struggles and concerns facing the Nyawaygi people compare to the Quandamooka and Nunukul? How do they connect to issues that we have discussed in class? What issues have you already worked to quantify? How, if at all, did your experience quantifying these issues fall short of illustrating the whole picture? How has this and other similar experiences affected your understanding of issues of injustice and cultural interdependence?

Green Collar What are some of the concepts utilized by Green Collar that you have seen in our course? How does their mission fit in with themes of our course and previous experiences? What aspects of their operation surprised you?

Final Entry Specific prompted response to be done in Sydney.

For your own purposes: Read through your responses to the questions from our pre-departure meeting. Respond to your pre-departure self. How are you the same? How are you different? Describe some of your emotions/thoughts/feelings as you reflect on the last three weeks. What event/activity/encounter/conversation was most impactful for you and how will it change/impact your behavior once you get home?

References

1. Association of American Colleges and Universities, *Quantitative Literacy VALUE Rubric*, (2007), Washington, DC. Retrieved from https://www.aacu.org/sites/default/files/files/VALUE/QuantitativeLiteracy.pdf
2. Association of American Colleges and Universities, *College Learning for the New Global Century*, A report from the National Leadership Council for Liberal Education and American's Promise, (2007), Washington, DC. Retrieved from www.aacu.org/leap/documents/GlobalCentury_final.pdf
3. J. T. Day, *Student Motivation, Academic Viability, and the Summer Language Program Abroad: An Editorial*, Modern Language Journal, **71**, (1987), 261–266
4. M. M. Dwyer, *The Benefits of Study Abroad*, (2017), Retrieved from https://www.iesabroad.org/study-abroad/news/benefits-study-abroad#sthash.ZHeZBNcF.dpbs
5. M. M. Dwyer, *More Is Better: The Impact of Study Abroad Program Duration*, Frontiers: The Interdisciplinary Journal of Study Abroad, **10**, (2004), 151–163
6. K. Hovland, *Global Learning: Aligning Student Learning Outcomes with Study Abroad*, (2010). Retrieved from http://www.nafsa.org/uploadedFiles/NAFSA_Home/Resource_Library_Assets/Networks/CCB/AligningLearningOutcomes.pdf
7. B. Ismail, M. Morgan, and K. Hayes, *Effect of Short Study Abroad Course on Students Openness to Diversity*, Journal of Food Science Education, **1**, (2006), 15–18
8. A. Kitsantas, J. Meyers, *Studying Abroad: Does It Enhance College Student Cross-Cultural Awareness?*, Annual Meeting of Centers for International Business Education and Research, (2001)
9. T. Lewis, R. Niesenbaum, *Extending the Stay: Using Community-Based Research and Service Learning to Enhance Short-term Study Abroad*, Journal of Studies in International Education, (2005), **9**, no. 3, 251–264. https://dx.doi.org/10.1177/1028315305277682

10. National Survey of Student Engagement, *The NSSE 2000 report: National benchmarks of effective educational practice.* (2000).
11. B. Parker, D. Dautoff, *Service-Learning and Study Abroad: Synergistic Learning Opportunities*, Michigan Journal of Community Service Learning, (2007), 40–53
12. J. Wang, A. Peyvandi, and J.M. Moghaddam, *Impact of Short Study Abroad Programs on Students' Diversity Attitude*, International Review of Business Research Papers, **5**, (2009), no.2, 349–357
13. University of Massachusetts Lowell, Essential Learning Outcomes, 2018. https://www.uml.edu/Catalog/Undergraduate/Core-Curriculum/ELO/SRE.aspx