

# Assessment as Pedagogy in a Compressed-Format Summer Physics Abroad Program

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## Abstract

This paper examines the impact of assessment and instructional practices in a compressed-format physics abroad program for life science students from a large U.S. university system. Using qualitative case study methodology, the study investigated the major pedagogical functions of assessments and their implications on student learning across three international sites. Findings from interviews, focus groups, and survey responses of international physics instructors indicated that instructors accommodated the unique program format and student cohort by fostering a highly supportive and collaborative environment for frequent formative assessments, feedback, and intervention. These pedagogical developments provide students the opportunity to learn physics intensively and gain disciplinary, metacognitive, and intercultural understanding.

## Keywords:

assessment; pedagogical approaches; physics education; study abroad; compressed-format course

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## Introduction

Although language and intercultural learning have been the predominant rationales for education abroad, mobility programs are increasingly embracing

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disciplinary learning, especially in short-term program options (Ogden & Brewer, 2019). The shift in programming seeks to expand access to students in disciplines that have been traditionally underserved. Postsecondary degree plans in the science, technology, engineering, and mathematics (STEM) fields tend to be more highly structured than those in the social sciences or humanities. For that reason, STEM students have typically found fewer opportunities in their course-taking schedule to participate in education abroad, encountered more difficulty obtaining academic credit at their home institution for STEM courses taken abroad, and received less encouragement from STEM advisors than their peers to participate (Blumenthal & Laughlin, 2009; Seccia, 2018).

However, more and more, STEM educators recognize the importance of international experience in the development of technologies that may have global impact; they also acknowledge that study abroad experiences can prepare students for successful collaborative work in multicultural, international teams (Klawe, 2019). Simultaneously, education abroad programs are emphasizing program development and advising based on academic requirements, academic interests, and specific learning outcomes (Seccia, 2018; Van Deusen, 2007). As such, more STEM-focused programming has become available and promoted to students in the science disciplines. STEM student participation has reached an all-time high; their representation in education programs rose from 16% in 2005-06 to 28% in 2018-19 according to the most recent nationwide survey (IIE, 2020).

The present study investigates an example of a compressed-format mobility program, whereby life science students from a large United States public university system complete a year-long physics requirement abroad in one summer. Students must navigate a different country, institution, and discipline, while their instructors adapt their assessment and instructional practice for this unique program and cohort. Through a social constructivist lens, this study uses interview, focus group, and survey data from international instructors of this education abroad program to reveal the ways in which the practice and context of assessments are key drivers in the program's pedagogical approach.

## Social Constructivist Approach

In the past several decades, constructivist theories have informed perspectives on the nature of the knowing and learning in U.S. higher education (Vande Berg, Paige, & Lou, 2012). Constructivist perspectives focus on cognitive processes that support meaning-making. As active agents of knowledge construction, students analyze new information for inconsistencies with known conceptual structures, constantly revising and transforming representations of existing mental models in their minds (Black, 2001). Through this construction process, learners develop metacognition, that is, greater awareness of what they understand and how to apply that understanding (Shepard, 2000). Social constructivism situates that development of understanding in sociocultural contexts. Rooted in Vygotsky's (1978) theories on psychological development, social constructivism proposes that human learning is mediated by tools; within interactions with others, language is the tool that propels changes in mental models and promote higher order thinking (Jones & Brader-Araje, 2002; Vygotsky, 1978). Hence, learning is necessarily constructed through interaction and cooperation with experienced instructors or peers who help the learner reflect on and transform their existing understanding (Vygotsky, 1978). This paper employs a social constructivist approach to interpret this study, namely, to explain instructors' pedagogical decisions surrounding assessment activities and their interpretation of student learning processes observed in their classrooms.

## Developments in Learner-Centered Pedagogy

The transition to a more learner-centered, social constructivist paradigm stemmed from several historical developments that had broad-reaching effects (Vande Berg, 2007; Vande Berg, Connor-Linton, & Paige, 2009). Among these developments is the mounting evidence in cognitive psychology and education research that teacher-centered, lecture-based instruction is less effective than learner-centered instruction (Vande Berg et al., 2009). In the latter, learners are actively involved in the teaching and learning process with peers and instructors, receive feedback, bridge previous with new knowledge, apply knowledge, and become more sophisticated learners (Huba & Freed, 2000). Instructors take on a coaching/facilitating role and weave ongoing assessment into instruction (Huba & Freed, 2000). Another important advancement that Vande Berg (2007) and colleagues (2009) identified is the emergence of the assessment movement spurred by calls for accountability in U.S. higher education. Institutions must demonstrate their effectiveness in fostering the sort of skills and knowledge that would prepare students for work and life post-graduation. It became increasingly important that programs evaluate student learning outcomes and provide evidence of learners' experiences that lead to those outcomes (American Association of Higher Education's Assessment Forum, 1992).

The influence of constructivist pedagogy and the assessment movement on education abroad is felt in the heightened attention paid to the quality of the learner's experience abroad and the effectiveness of programming. This shift is noted both in the use of constructivist learning theories (see Kolb, 1984; Mezirow, 1994) to frame education abroad research as well as in the corpus of studies on measuring specific learning outcomes, particularly in intercultural development (e.g., Braskamp, Braskamp, & Merrill, 2009; Carlson & Widaman, 1988; Chieffo & Griffiths, 2004; Sutton & Rubin, 2004; Vande Berg et al., 2009). Establishing educational objectives, evaluating those objectives and outcomes, and using those findings for program improvement became some of the core guiding principles in the Standards of Good Practice put forth by The Forum on Education Abroad (2020).

Similar pedagogical innovations have played out in disciplinary fields. Studies in physics education, for example, have documented the pitfalls of instruction that over-rely on the passive transmission of knowledge (Halloun & Hestenes, 1985; Wieman, 2007), while interactive engagement methods have been associated with greater gains in conceptual knowledge (Hake, 1998). Many of these interactive pedagogical strategies embody the social constructivist approach to learning, including considerations of previous knowledge and beliefs, conceptual structures that organize the understanding and retrieval of information, the metacognitive ability of students to self-monitor learning, and the advantages of peer collaboration for providing timely feedback on learning (Meltzer & Thornton, 2011; Redish, 1996, 1999; Wieman, 2007).

## Pedagogical Role of Assessment

Assessment is an indispensable process for discerning the kinds of learning taking place in an education abroad program and for informing further instruction and interventions that help students meet learning goals. While summative forms of assessments focus on understanding performance outcomes, formative assessments identify gaps in learning that can apprise further student development (Bennett, 2011; Black & Wiliam, 2018). As educational perspectives shifted to social constructivist theories, scholarship on assessment also shifted from the summative ("assessment of learning") to

the formative (“assessment for learning”), especially formative types that support students’ awareness of their own learning or motivation for learning (“assessment as learning”). Following the social constructivist paradigm, education scholars are interested in the ways that instructors implement formative assessment to discern the gap between what the learner can accomplish independently and what they can accomplish through support. The interpretation of this gap is then used to help instructors, students, or their peers (via feedback) make decisions about how best to improve learning. Active involvement of students in the assessment process is seen as a vital element to successful formative assessment (Black, 2001).

Some research in education abroad programming has emphasized ongoing assessment activities as one important form of learning for students. Periodic guided-reflection responses, for example, can reveal desired student outcomes such as transformative shifts in perspectives and thinking while abroad (Savicki & Price, 2015, 2017). Importantly, prompt feedback from instructors and peers inspires students to engage more deeply with the material by helping them assimilate, synthesize, and apply knowledge (Cotten & Thompson, 2017). Within the STEM education literature, specifically, rare examples about education abroad programming have reported that journaling, essay-writing, and discussion stimulated students to articulate their thinking and process their experiences (Demetry & Vaz, 2017; Marine, 2013; Panvini, 2020). Learning outcomes assessed in these formative assessment activities include academic content knowledge and its application as well as intercultural competence (Demetry & Vaz, 2017; Marine, 2013; Panvini, 2020). Feedback from reflective exercises then had pedagogical and motivational functions: to clear up misconceptions, offer intervention, or provide encouragement (Demetry & Vaz, 2017; Panvini, 2020). These brief examples suggest the importance of continual, meaningful interaction with instructors and peers in assessment activities for students to construct understanding, but more research is needed to clarify the connection between the assessment contexts/practices and student learning.

### Short-Term Programs and Compressed-Format Courses

A programmatic shift toward short-term education abroad programs have also been prominent in recent decades. Programs that last eight weeks or less account for the majority (65%) of all education abroad experiences in 2018-19 (IIE, 2020), a sharp increase from 1996-97 when short-term programs made up 31% of all sojourns (IIE, 1997). Institutions and providers often look to short-term programs to increase participation of traditionally underserved demographic groups (McKeown, Celaya, & Ward, 2021). The reduced duration appeals to students who are not able or willing to be away from campus for longer periods of time (Donnelly-Smith, 2009). Students in structured academic programs, like those of the STEM disciplines, can benefit from the flexibility of fitting in a short-term program during the summer or another more convenient time. Some of these programs comprise compressed-format courses, which take a full-length course and condense it to a shorter time frame (usually half or up to a quarter the length of a typical term). Short-term STEM education abroad programs have included compressed-format courses (Panvini, 2020) as well as project-based experiences (Demetry & Vaz, 2017); at times, the education abroad experience have functioned as a component of a longer, on-campus course (Marine, 2013).

There is some contention about the value of these shorter experiences. Short-term academic programs or courses—whether conducted abroad or on-campus—have drawn

criticism. Compressed-format courses, in general, raise concerns about the lack of time for instructors to cover necessary course content and provide feedback, insufficient time for students to process and integrate concepts, as well as the sacrifice of breadth, depth, and/or rigor of the course (Daniel, 2000; Lute & Davies, 2018; Scott, 1996). Short-term programs abroad carry the additional burden of comparisons to vacation rather than to other serious academic activities (Donnelly-Smith, 2009).

Scholarship in this area has argued that the focused nature of the compressed-format experience, together with the in-depth discussions and emphasis on core concepts, makes learning more memorable and can improve academic performance (Scott, 2003; Wlodkowski & Westover, 1999). Students in the compressed-format term often achieve comparable performance results to peers in non-compressed courses across subject areas (Anastasi, 2007; Austin & Gustafson, 2006; Van Scyoc & Gleason, 1993), including physics (Carroll, 2006; Hsu, 2003). Relevant to education abroad, MacKenzie and Pritchard (2013) posits the idea that an accelerated, residential education abroad program can be a space of intense immersion that enriches the academic learning experience. This immersion entails disengagement from normal routines and obligations, strong continuity of the learning experience, and more meaningful interactions with instructors and peers.

Comparative studies have found generally more positive academic, personal, intercultural, and career development outcomes for participants of longer-term programs abroad than shorter-term ones, but short-term students often make comparable gains in specific outcomes within larger outcome domains (DeLoach, Kurt, & Olitsky, 2019; Dwyer, 2004; Medina-López-Portillo, 2004; Vande Berg et al., 2009). Dwyer (2004) credited this variation to the impact that a well-planned, intensive short-term program can provide. The quality of the short-term experience could boil down to the teaching and assessment approach, the learning context, and the quality of teaching and planning (Scott, 2003). Many compressed-format courses abroad and domestic have adopted active learning pedagogies to mitigate the limitations of course compression and create an effective learning experience for students. Instructional best practices have included outlining course and assignment objectives to students; instituting active classroom discussion and peer interaction; incorporating experiential and applied learning; and creating smaller, more frequent, meaningful assignments (Giordano, 2011; Kops, 2014; Panvini, 2020; Scott, 2003).

## Present Study: Compressed-Format Summer Physics Education Abroad Program

Utilizing a qualitative approach, this investigation followed an eight-week compressed-format summer physics education abroad program offered to undergraduate life science students across a U.S. public research-intensive university system. Program participants are provided structured integration into the partner institution and host country's culture through local faculty and staff. The program was established initially in a partnership with one research-intensive university in England. In summer 2014, the systemwide mobility program collaborated with two additional research universities—one in Ireland and one in Scotland—to increase capacity for student participants. In summer 2019, nearly 900 students participated across seven sites.

High student interest in the program is attributed to students' desire to simultaneously gain international experience and meet the year-long introductory physics requirement for life science or pre-health students. Completion of the accelerated program

could reduce students' time to degree—and for those with multiple majors, help with timely graduation. This program is aimed at life science and pre-health students, and two-thirds of the 2019 cohort identified as biological or health sciences majors. Since the application of physics is a core undergraduate competency identified by the medical practitioner community and assessed in the MCAT examination, the program seeks to prepare students for more advanced studies in their undergraduate and postgraduate careers.

The present investigation examined the ways in which the program's assessments serve a pedagogical role in the physics classroom and the perceived effectiveness of the compressed-format education abroad program on student learning outcomes. The study uses qualitative methods to respond to two research questions:

1. In what ways do the assessment contexts and practices support the pedagogical approach in the compressed-format summer physics program across three of the program's international sites?
2. From the perspective of local faculty at the three sites, how do these assessment and pedagogical practices shape learning?

This focus on the learning potential derived from assessment activities fills a need in the education abroad literature, particularly in physics and other STEM disciplinary programming.

## Method

The present investigation is a case study of one compressed-format summer physics education abroad program across three institutional sites. As a qualitative method, a case study allows one to understand the phenomenon of interest within its contextual conditions (Baxter & Jack, 2008). The current study was conducted using a constructivist framework, whereby validity is “derived from community consensus regarding what is ‘real’: what is useful, and what has meaning” (Lincoln, Lyndham, & Guba, 2018, p. 109). Through this lens, the researchers incorporated multiple voices to reconstruct the phenomenon under examination.

The study drew from semi-structured online interview, focus group, and survey data that were initially collected in preparation for a program review and a planned conference among physics faculty abroad and at the U.S. university system. The U.S. investigators purposefully selected the lead instructors of the first three sites of the program to participate in this study since all three instructors have taught the program for at least three summers and can draw from their experience varied examples that address the research questions (see Table 1 for instructor characteristics). The U.S. investigators then obtained permission from the physics instructors abroad to use their qualitative responses for this project as well as their input on the representation of their perspectives and pedagogical practices. Subsequent to the initial qualitative thematic analysis conducted by the U.S. investigators, the physics instructors were asked to be co-researchers to make elaborations, reflections, and revisions, as well as to validate the findings and interpretations. Similar to works that have involved participants as co-researchers (e.g., Bindels, Baur, Cox, Heijing, & Abma, 2014; Pope, 2020), the instructors in this study could provide deeper insights as members of the investigation team than what their interview, focus group, and survey responses may uncover alone.

**Table 1. Instructor Characteristics**

Instructor	Program site	Gender	Physics teaching experience (years)	Compressed-format physics teaching experience (years)
1	English university	Female	15	11
2	Irish university	Male	30	6
3	Scottish university	Male	20	6

The three instructors first completed a 14-question survey that focused on the pedagogical approaches, the nature of assessment and instruction, the ways in which instructional practices evolved over time, and the potential impact of the compressed-format physics course sequence on students. Following the survey, 45-minute online interviews were conducted with each instructor to elaborate on their survey responses. Two 1-hour online focus groups were subsequently held with all three instructors present to discuss at greater length their observed and perceived learning outcomes of the education abroad program. The interviews and focus group discussions were recorded and transcribed verbatim.

The researchers thematically analyzed the interview transcripts following the criteria of credibility, transferability, dependability, and confirmability put forth by Lincoln and Guba (1985), as well as the procedures outlined by Nowell, Norris, White, and Moules (2017). Following the process delineated by Nowell and colleagues, the study's investigators familiarized themselves with the data, developed initial codes, identified organizing and underlying themes, and reviewed and defined the themes—with each step undergoing multiple discussions, iterations, and revisions and, at times, with prior steps revisited before the thematic structure and account of the data were finalized.

## Results

The findings are organized into two areas that align with the study's research questions: (a) the ways that practice and context of assessments guide pedagogy, and (b) the influence of assessment and pedagogical practices on student learning. Themes that underlie these areas and examples that illustrate these results are presented.

### Assessment Context and Practices as Pedagogy

Due to the compressed nature of the course, all three institutions structured and implemented assessment practices that promoted a more learner-centered pedagogical approach in this program than the majority of the typical in-semester courses that they offered. These assessment contexts and practices evolved over multiple summer terms. Although variation across the three sites exist, three common notable themes emerged: structured collaborative learning contexts; streamlined assessment, feedback, and intervention processes; and enhanced academic and social support systems. Table 2 displays the elements of the program's academic structure across sites.

**Table 2. Program Site Academic Structure**

Site	Program Structure	Assessments
English university	<ul style="list-style-type: none"> <li>- Lectures</li> <li>- Labs &amp; demonstrations</li> <li>- Workshops</li> <li>- Additional intervention sessions</li> <li>- Research lab tours</li> <li>- Help desks, office hours, online tutor forums</li> </ul>	<ul style="list-style-type: none"> <li>- In lab preparation discussion</li> <li>- Lab reports</li> <li>- Workshop quizzes</li> <li>- 2 midterms and 2 final exams</li> </ul>
Irish university	<ul style="list-style-type: none"> <li>- Lectures, with demonstrations</li> <li>- Labs</li> <li>- Group-based workshops/tutorials</li> <li>- Additional post-lecture Q&amp;A sessions</li> <li>- Additional pre-exam tutorials</li> <li>- Math drop-in tutorials</li> </ul>	<ul style="list-style-type: none"> <li>- In-class discussions and questions</li> <li>- Lab reports</li> <li>- Tutorial assessments using Socrative app</li> <li>- Tutorial group problem-solving written problem assessments</li> <li>- Midterm (multiple-choice) and final (essay + problem) exams</li> </ul>
Scottish university	<ul style="list-style-type: none"> <li>- Flipped classroom sessions</li> <li>- Inquiry-based labs</li> <li>- Workshops/tutorials</li> <li>- Additional small-group intervention sessions</li> <li>- Daily peer group sessions with dedicated mentors</li> </ul>	<ul style="list-style-type: none"> <li>- Pre-session online assignments and quizzes</li> <li>- In-class discussions</li> <li>- Lab reports</li> <li>- Tutorial consolidation exercises</li> <li>- Weekly tests</li> <li>- Final exam</li> </ul>

## Collaborative Learning Context

Interview and survey responses indicated that instructors at all three sites implemented frequent assessments within the small group context. The purpose of structured groupings was to encourage students to engage actively in their own and their peers' learning. Beyond paired or group work conducted in laboratories, students attended tutorial or workshop sessions in which physics problems and exercises were worked out in small groups. The instructional staff's role in tutorials or workshops was to be "pathfinders," as Instructor 1 described, to monitor student learning, clarify challenging concepts, and reinforce conceptual knowledge rather than to "do the work" or provide solutions.

While two of the three sites employed a traditional instructor-led lecture component to introduce core concepts, the Scottish site extended the peer learning context through a flipped classroom pedagogical design in which lectures were replaced with independent learning and additional group discussions during class sessions. Instructor 3 elaborated:

Monday and Wednesday morning are class sessions where we discuss issues arising from reading and home assignment... [M]embers of the teaching team are present at these sessions to foster group interaction and prompt students to focus on understanding difficult concepts.

The program at the Scottish university site also converted the lab format to a more collaborative model. Instructor 3 explained, "Instead of using the 'traditional' first year



labs, we now use an inquiry-based approach and allow the students to design their own experiments.” According to the instructor, this change helped students “focus more on understanding the process and generating questions and promoting peer discussion.” The compressed time frame of the program lent itself to the efficiency of active peer-instruction in formative assessments, allowing instructors at all three sites to focus attention on observing and tracking learning.

### Streamlined Assessment, Feedback, and Intervention Practices

For this eight-week program, the instructors all remarked on the value of constant assessment and timely feedback on students’ conceptual understanding and skills acquisition for informing targeted intervention and further learning. Informal assessments and feedback occurred during all small-group sessions as multiple mentors or tutors monitored and facilitated these group conversations. Formal assessments such as tutorial or workshop assignments, lab reports, quizzes, and midterm examinations also served a formative function, giving instructors near-daily opportunities to probe each student’s strengths and areas of learning need and to respond individually to those needs. The instructors stressed that the program orientation and preparation materials acquaint students with the details and expectations of the assessments before they engage in course activities.

Technology had been a tremendous aid for Instructor 2 at the Irish university site. The program at the Irish university adopted Socrative, a low-stakes formative assessment tool that can be administered frequently during the tutorial sessions. This application interactively scored student responses and provided feedback at a faster pace than can an individual tutor. Instructor 2 found that the app allowed tutors to set up and assess work in response to students’ difficulties with the material and allowed students to see their progress in real time. As another example of a recent innovation, Instructor 1 explained that the English university site had developed a lab report system to make feedback prompt and to facilitate student learning after receiving feedback. Tutors were trained to grade lab reports quickly and precisely using template paper forms attached to each lab report. Most importantly, the color-coded forms broke down the labs into key components that indicated, for specific components, the exact exercises in a separate directed feedback booklet (given at the outset of the course) that address the particular error.

The effective use of formative assessment to guide further student learning appeared to be the very essence of the instructors’ pedagogical approach. As Instructor 1 expressed,

Most of our work is about signposting. How can we understand what this student has not got? What is holding this student back? What can I signpost them? What does this one need? Oh, you need that. Just point them all in the right direction. That is the only way we can do this in eight weeks.

“Signposting,” or communicating appropriate resources and interventions that students can access depending on their attainment at each stage, comprised a large part of instructors’ practice of using assessments to inform further instruction and student learning. The actual provision of those resources and interventions after implementing assessment and feedback was a crucial aspect of the summer program. In comparing the summer program to the regular term, the instructors indicated that the teaching staff create additional opportunities for academic assistance. Both English and Scottish

university sites pinpointed students who needed more targeted intervention based on assessment data and provided those students additional sessions that focus on identified issues. The Irish university site offered extra tutorials, question-and-answer sessions with instructors, and a mathematics “drop-in” service for students who self-identified as needing more help. The English university site had also developed a help desk and an online forum where students could seek assistance as needed. Altogether, the various assessments, feedback, and interventions applied were perceived by the instructors to be an integral part of student learning.

### Enhanced Academic and Social Support

To the instructors, the collaborative learning environment and the streamlined assessment-feedback-intervention process were only possible with a large, dedicated teaching team. A large instructional team allowed for increased contact and learning time needed in a compressed-format program. At each site, team member’s roles were defined hierarchically, with the three instructors and other academic faculty or lecturers providing lectures or class session instruction and supervising senior graduate students or graduates. These senior students or graduates, in turn, oversaw the less experienced graduate or advanced undergraduate physics students (typically, referred to as “tutors” or “mentors”) who engaged most directly and frequently with the summer program students. Recognizing that the program’s students were life science majors studying in a wholly new environment, Instructor 1 mentioned that the English university site strategically used undergraduate tutors to be the peer-like “friendly face” of physics. Instructor 1 recalled that in course evaluations, students tended to rate their experience with tutors to be the most valuable aspect of the course sequence. In addition, tutors at this site led tours of physics department research labs and demonstrated the cross-over with medical science, strengthening the relevance of physics for these life science students.

The instructors discussed that all tutors or mentors underwent a period of training prior to the program and received continuous feedback on their development of instructional competencies during the program. At the English university site, additional attention was paid to the interface between the host-university tutors and the education abroad students because of past misunderstandings from communication differences. Instructor 1 shared this example:

We find that our undergraduate [tutors] regularly use sarcasm, absolutely deadpan humor with each other, which might be, for example, “How’s my graph?” “It’s absolutely terrible.” Completely deadpan. This has caused quite a lot of problems actually with students being upset. We were like, “That was sarcasm. That was really sarcasm.” This is so alien to [the students] that it can derail them.

Tutors’ attempts at building rapport could be perceived by students as an inappropriate form of humor in the classroom setting. According to Instructor 1, the adverse effects of such interactions influenced the objectives and training procedures of subsequent tutor cohorts:

We really emphasize this in training: “Think about everything you say before you say it” to our [tutors]. “Think about how this would sound if you didn’t live in [host city] and you weren’t at the [university site].” We try a little bit of role-playing. Once they’re in the lab and engaging and talking to students, we get very experienced faculty...to go around and observe the way they interact and their dynamic and

immediately meet with them afterwards for a positive, building-up debrief but to say what they thought was really good and things they thought were challenging in the communication.

These components of training and reflection that Instructor 1 described challenged tutors to be mindful of how thoughts and behaviors were shaped by latent cultural values and assumptions as well as to take the perspective of others who have a different set of lived experiences. The purpose behind incorporating these training procedures was to create a safe learning space for students and tutors alike.

One of the goals of the program was to instill a sense of belonging within their cohort, the host campus, and the greater local community. Instructor 3 emphasized a holistic approach to learning where the intensive in-classroom workload is balanced with out-of-classroom activities, experiences, and support. The instructor booked a sports facility for student use, organized class hikes on the Scottish hills, and engaged in these activities with students to promote “cohesion and social integration within the class.” The other sites likewise arranged events in the campus area and excursions to cultural landmarks. Instructor 1 mentioned that the instructional staff at the English site more recently instituted a welcome week event for priming students to engage with physics concepts and meeting peers and the instructors in a relaxed setting. These events purposefully allayed some of the anxiety students initially had about being in a new country and campus and studying a different subject.

## Influence of Assessment and Pedagogy on Learning

Instructors mentioned three key areas of learning that the program’s structure and pedagogical approach to assessment and its related activities address. Our findings revealed that while all three areas applied to the education abroad students, some of the perceived outcomes were also pertinent to the tutors and mentors that these lead instructors supervised.

### Conceptual Understanding, Problem-Solving, and Critical Thinking

The instructors stressed that the educational advantages of a supported collaborative approach to learning were the strengthened understanding of physics concepts, the ability to frame and solve problems, and the capacity to think critically and strategically—learning goals of any introductory physics program. As Instructor 2 explained, the mechanism by which peer-instruction and tutor support affect skill acquisition relied heavily on questioning and conversation during formative assessment activities:

We socialize the learning quite a lot, which suits a lot of those students, and I think they begin to learn the language of critical thinking and questioning literally in conversation with each other and with the tutors in particular... Sometimes a very fluent [lecture] delivery can mask the difficulty of the topic, and the students can say, "This is very good. This is very eloquent. I get this." They think they're in safe hands in a sense, and then they go off and work on the problem, and they don't get it. So, we make the students sweat in the tutorial, and work through that, and encounter that difficulty, and share that difficulty among themselves, and like I said, socialize the difficulty so the learning is on-the-fly there... To me, the difficulty and the encounter helps them become problem-solvers.

A clear contrast was drawn between the outcomes of active engagement and passive reception of information. Instructor 2's own reflection was that the increased resources of the summer program and, subsequently, its smaller group ratios and higher contact hours with tutors in assessment and intervention settings supported greater engagement with the material and result in "superior skills development" as compared to the local physics students in the regular term.

Although the primary skill assessed in summative exams was problem-solving, Instructor 2 elaborated that students, especially high-achieving students, did demonstrate higher-order, critical thinking. In one exam item at the Scottish site, students were required to apply the principle of conservation of energy to a problem that was ostensibly about conservation of momentum.

[The exam has] a few upside-down questions they wouldn't have seen before that they have to kind of get their head around. Now, that would be the critical thinking part...It's a momentum question. In the end they have to figure it out by using the energy concept, but it's about momentum. They're asked to check whether a collision could have been an elastic collision or not. You have to think outside the initial design of the problem. They have to really sort of put a different head on to see the answer.

Through such assessment items, students showed that they could apply conceptual definitions, identify relationships, draw inferences, make logical decisions, and display their analysis through a written explanation of their reasoning.

Modifications to the traditional lab format at the Scottish university site to promote questioning and more frequent peer-to-peer discussion had likewise yielded productive outcomes. Instructor 3 shared that comparisons of student attainment in formal assessments showed "a significant improvement" in students' conceptual understanding of the relevant topics. Specifically, these assessments also indicated to instructional staff at the Scottish university site that subsequent cohorts had achieved better assessment results after the lab redesign. Instructor 2 commented that "an additional learning outcome is the application of physics to health professions"; that is, students were able to apply physics in specific examples ("radiation, x-rays, CAT scans, vision, bone, and muscles as levers and forces").

### Metacognitive Skills

The instructors expressed that gaining a better understanding of oneself as a learner was an implicit outcome of their assessment-related activities. For example, Instructor 1 at the English university site pointed out that activating students' recognition of their own learning was built into the assessment and feedback process: "At each lab, [tutors] review previous feedback slips to reinforce and encourage students' awareness of their development." Instructor 2 at the Irish university site observed that the prompt assessment and feedback to students functioned as intended. These pedagogical practices, together with some coaching on awareness of learning styles, stimulated students to identify areas where more learning support was needed:

I have seen that the "total immersion" brought about by the intensive nature of the program has a positive effect. Feedback from assessment is both more frequent and more immediate. The students respond to the feedback very quickly and are keenly

interested in where gaps appear in their learning. Literally, “physics is almost always on their minds.”

To the instructors, their efforts to improve metacognition was also based on the recognition that this academic experience was just one of many opportunities for this group of education abroad students. They believed that their course had improved self-awareness of one’s learning that would serve the student well after they left the program. Instructor 3 shared, “Overwhelmingly, students leaving this course are much more aware of factors affecting their learning and have developed ideas of how best to tailor their learning style for a given task... They become better independent learners.”

### Intercultural Learning

The instructors commented that while students chose this summer abroad program to earn credit for physics, the major attraction was the new environment. They acknowledged that the cultural distance between the United States and their own locale might not be large since these three sites were situated in Anglophone countries, but they maintained that students broadened their experience in this short period of time. Instructor 2 commented, “It really does expose them to a new culture or different culture. Even though we’re English-speaking, and Ireland and America have a lot of similarities, we’re also quite different in many ways.” To this observation, Instructor 1 offered a brief illustrative example about colloquialisms that students had captured on a whiteboard at the English university site: “Students often have a translation of English as spoken by the lab [tutors] and English as spoken by the students. We have these funny little quips where you [tutors] mustn’t say these words but you must say these words.” Students were constantly making sense of their surroundings and their interactions with the teaching team and helping others do the same.

Naturally, as the instructors interacted most frequently with students in the classroom, their perceptions of gains in intercultural learning primarily related to adjustments to the disciplinary or institutional norms unique to the host country. Instructor 3 opined on some dimensions of the academic experience that students had to grasp:

One of the important things about study abroad is actually getting used to or understanding that there are different ways of doing things... Things like assessment, the approach of our courses, the procedure that we go through, those sometimes are quite surprising to them. There are cultural differences between how we do things here and how it’s generally done back home.

Instructor 2 offered the specific example that the way physics knowledge was assessed at the Irish university site differed from what students might be accustomed to in a past physics course in the U.S.: “We ask essay-type questions in our exams. Most of the students haven’t seen anything like this in physics. We do a little bit of training on that. They do have to do some academic acclimatization.” The instructors’ evaluation was that students did adjust quite quickly during the course of the program. As Instructor 1 emphasized, a notable learning outcome of the program was that students developed “resilience in fitting into a new environment and academic program.”

Because the effects of the interaction between students and teaching team were not unidirectional, the instructors added that the members of their instructional staff also grew from this intense experience with students from abroad. The instructors found that the

program, beyond cementing a love for physics, sparked a sense of curiosity in tutors and mentors to venture outside of their country. Instructor 1 provided several examples:

Our [tutors], after teaching or working on summer school in any capacity, seem more adventurous about travel, apply for more international positions including in the States, they're keener to work in education. They have made life-long friends. I know afterwards, there is travel backwards and forwards.

Instructor 1 also noticed that the program has led tutors to reflect on and question the typical lack of diversity in their department:

Our [tutors] are much more aware of what the potential is for diversity against the background of their norm which is underrepresented groups. One [tutor] particularly said to me, "Wow, I'm teaching in this lab, and I'm looking around, and I'm like, why doesn't my lab normally look like this?" It really hits them.

One value of the program, Instructor 1 expressed, was the contribution that the diversity of the program made to the host physics community, particularly as the "U.K. physics departments continue to suffer from underrepresentation and the opportunity to work with a cohort that is both majority international and up to 80% female is rare." Although the primary learning outcomes of the program expressed by the instructors were largely disciplinary in nature, from the point of view of the instructors, both students and their teaching team benefited from the intercultural exchange.

To accommodate a unique cohort of education abroad life science students in a compressed-format physics program, instructors developed intentional pedagogical practices to promote learning. Overall, the qualitative evidence suggests the instructors found their pedagogical approach defined by use of the small-group collaborative context within which frequent assessments could be conducted and responsive feedback and intervention could be offered. Neither the practice nor the context of assessment, feedback, and intervention could occur in this time-compressed mobility program without the structured support of a large instructional team and activities that fostered a sense of belonging. From the perspective of the three instructors, their assessment and pedagogical approach generally contributed to students' problem-solving and critical thinking skills, conceptual understanding of introductory physics, their cognitive awareness of their own learning, and students' (and tutors'/mentors') intercultural skills.

## Discussion

The purpose of this paper is to examine the major pedagogical functions of assessments in a compressed-format summer physics program abroad for non-physics students and their implications on student learning and institutional outcomes. Analyses of the qualitative data led to findings that show program instructors commonly incorporated collaborative, student-centered learning as context for assessment practices; established an efficient use of assessments to continuously gauge student learning and guide feedback and targeted interventions; and fostered a supportive instructional environment and sense of belonging through a large teaching team, campus activities, and cultural excursions. These practices, in turn, help students build knowledge and skills that are both explicit and implicit learning goals of the program. All three instructors cited the advantages of peer-based learning that align with social constructivist theory. Communication in these interactions supports learners to develop the language required to gain conceptual understanding, problem-solving abilities, and critical thinking skills.

Expanded resources in the program also allow assessments to direct more quickly what interventions students need to meet explicit disciplinary learning objectives. The instructors also spoke of students' increased awareness of their understanding as an implicit outcome in this fast-paced program. Students learn from efficient systems of assessment and feedback how to monitor their own learning. Instructors are cognizant that the benefits of metacognitive skills extend past the limits of this program. Life science students will, for example, require metacognitive skills to review physics concepts and skills upon which later biological learning is built. By promoting metacognition, instructors felt that they are addressing skills that are applicable beyond the introductory physics sequence. Lastly, instructors reported that students as well as their teaching staff benefited from the intercultural exchange. Through the tutor trainings, interactions in small groups contexts, and various activities and events meant to encourage social integration, students get a sense of nuanced linguistic differences and pedagogical distinctions, whereas more tutors or mentors feel encouraged to seek international pursuits and establish an appreciation for diversity. The ongoing formative assessment activities and pedagogical practices documented in this paper may help inform development of other compressed-format programs to enhance student learning in education abroad.

The obvious methodological limitation of this study is that these findings apply specifically to the three instructors from international partner institutions who teach compressed-format physics to life science students from a particular U.S. university system. Instructors were also experienced at teaching compressed-format physics. It would be difficult to generalize these results to the perspectives of new instructors or instructors of other compressed-format STEM programs abroad without further rigorous investigation. Although this qualitative study primarily focused on commonalities across sites, there are certainly differences in instructional styles and academic structure; between-site outcomes could be explored in future research. Nevertheless, the findings do provide support for the impact of the program. The case studies reveal that the focused nature of the compressed-format experience—together with the intentional pedagogical design that includes frequent formative assessment, feedback, and intervention in a highly collaborative and supportive environment—provides students the opportunity to learn physics intensively, gain disciplinary and metacognitive skills, and advance conceptual understanding. There is also a question of program effectiveness in the long-term; the field would benefit from a longitudinal comparison of program participants and on-campus life science students to evaluate educational, career-related, and other outcomes over time.

At the heart of most education programs is the intention to foster global and intercultural learning. These broad goals are reflected in much of the field's assessment research (e.g., Braskamp et al., 2009; Sutton & Rubin, 2004; Vande Berg et al., 2009). However, as Salisbury (2015) pointed out, it may not be realistic to expect assessments to capture the complexity of intercultural learning that takes a considerable period of time to develop. Instead, objectives should account for how the program fits into the scope of students' undergraduate learning experience (Salisbury, 2015). Programs that stress disciplinary learning can integrate disciplinary-related outcomes with intercultural outcomes that can realistically be achieved over the course of the term. From the perspectives of the program instructors in this study, intercultural learning was an implicit or secondary learning outcome to disciplinary knowledge and skill attainment. Still, past research has found that intentional program objectives and pedagogical design that are related to global and intercultural learning help guide desired student outcomes in this

area (Landon, Tarrant, Rubin, & Stoner, 2017; Vande Berg et al., 2009). Thus, anticipated, future work of the program includes a comprehensive intervention program accompanied by assessments to measure more adequately students' intercultural development. Coupled with disciplinary-specific assessment activities, such efforts can provide more robust rationale to higher education stakeholders for leveraging education abroad programming.

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## Acknowledgements

We acknowledge Melody Knutson for her initial efforts in the development of UCEAP's summer physics program and Diane Lindsey for her efforts in program coordination. We appreciate the contributions of Dr. Mark Sargent at the School of Mathematical and Physical Sciences, University of Sussex as well as the thoughtful and constructive feedback from anonymous reviewers of this journal.

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