OPEN ACCESS Freely available online

CourseSource

Lesson

Advancing Global Learning Through a Collaborative Online International Learning (COIL) Module on the United Nations Sustainable Development Goals (UN SDGs)

Cody S. Bekkering[1], Chongsheng Peng[2], and Li Tian[1]*

[1]Department of Plant Sciences, University of California, Davis

[2]School of Pharmacy, Shanghai Jiao Tong University

Abstract

An increasingly interconnected world presents opportunities for globally relevant curricula in the classroom. Implementing collaborative online international learning (COIL) modules within medium-sized courses can take advantage of this interconnectedness to enhance student learning by integrating global issues and cultures into their curricula. Adoption of COIL in STEM courses is increasing but also encountering challenges related to language, course timing, learner culture, learning platforms, and instructor logistics. We present a successful implementation of a COIL lesson module that addresses these challenges. In this module, students from upper-division classes in the United States and China worked together to study medicinal plants in an eight-week group project anchored in the United Nations Sustainable Development Goals (UN SDGs). Students worked in groups across the classes to analyze a given medicinal plant in terms of its use, biological activities, cross-cultural perceptions, and connection to the UN SDGs. This synthesis was delivered in an electronic poster format to each class after the eight-week period. Students described significant personal gains from the COIL module including a broadened worldview, an inspiration to engage in more cross-cultural experiences, and a desire to learn more disciplinary knowledge about medicinal plants. Challenges encountered by students during the module included scheduling, online platform issues, and occasional language barriers. However, overcoming these challenges reinforced desired learning outcomes from the module and fostered transferable skills applicable to other intercultural experiences. These outcomes were captured by the positive responses to the post-module reflection and showcase the utility of adopting a similar COIL experience in other classrooms.

Citation: Bekkering CS, Peng C, Tian L. 2023. Advancing Global Learning Through a Collaborative Online International Learning (COIL) Module on the United Nations Sustainable Development Goals (UN SDGs). CourseSource 10. https://doi.org/10.24918/cs.2023.4

Editor: Tammy Long, Michigan State University

Received: 8/11/2022; **Accepted:** 12/5/2022; **Published:** 1/25/2023

Conflict of Interest and Funding Statement: None of the authors have a financial, personal, or professional conflict of interest related to this work.

***Correspondence to:** Li Tian, Department of Plant Sciences, Mail Stop 3, University of California, Davis, CA 95616, United States Email: ltian@ucdavis.edu

Learning Goals

Students will:

◊ understand global challenges and the United Nations Sustainable Development Goals (UN SDGs).

◊ develop shared international perspectives on medicinal plants and the UN SDGs through collaborative online international learning.

◊ develop and improve intercultural competence skills.

Learning Objectives

Students will be able to:

◊ examine the use of medicinal plants in traditional medicine and relate their functional components to their uses and bioactivities.

◊ relate the use of medicinal plants to the UN SDGs and propose how it may help advance the UN SDGs.

◊ identify similarities and differences in cultural perspectives on medicinal plants among COIL partners.

◊ work collaboratively with the class group and international partners to create a shared product.

INTRODUCTION

Background

A new era of digital communications has enabled us to instantly tap into knowledge and experiences from cultures around the world more than ever before. This has also brought a profound expansion of digital tools in our pedagogical toolkit. Instructors can use the collective sum of online resources available to their students to foster independent research investigations, collaborative projects, and just-in-time teaching in the context of global events (1). Extending beyond an individual student's access to disciplinary knowledge, the digital age also enables students to use their experiential knowledge to personally connect in real time to fellow learners around the world. The ability for students to have cross-cultural learning experiences in a virtual environment has been the basis for collaborative online international learning (COIL) experiences in which universities partner and have their students work together to address globally relevant issues (2).

COIL is a specific form of virtual exchange that utilizes online platforms to bring students together across countries and continents to work collaboratively on a joint learning project. COIL lowers the spatial barrier between students in different cultures and allows exchange of information, ideas, and perspectives between collaborative groups while fostering digital literacy and technical skills. Instructor collaboration in design and implementation of COIL is vitally important to ensure that this student learning and exchange works effectively across international student teams (3). By enabling students to engage in this online collaboration, COIL furnishes an internationalized curriculum to institutions with limited study abroad programs or with study abroad programs that have been impacted by the COVID-19 pandemic (4). Furthermore, COIL ensures an equitable and diverse international learning experience for students, as study abroad is often inaccessible due to financial or logistical reasons (5).

There have been a small but growing number of successful implementations of COIL. The SUNY COIL center, the starting place of COIL, was founded in 2004. Since its inception, the SUNY COIL center has assembled a global network of universities and a wide portfolio of subjects. Other institutions have followed this example and have coordinated a collection of successful internationalized courses. Florida International University, for example, has its own network of international COIL partners. The increasing number of COIL partnerships worldwide reflect the beneficial impacts on students; COIL has been shown to foster intercultural competence and interest in other cultures in courses including medicine, business, and language (6–9). Furthermore, student gains from international learning have also been found to be comparable across students of diverse racial backgrounds, showcasing the potential for COIL to provide an equitable internationalization of course materials (6).

Several factors germane to international learning challenge the adoption of COIL. Language and communication present the first obvious barrier for students who do not share the same native language. Logistical concerns such as differences in time zones, learning management systems (LMSs), and academic calendars also impact the extent to which international partners can work with each other (2). Differences in student expectations across cultures are also relevant, ranging from unspoken differences in learner styles to differences in codes of academic conduct across universities (such as a formalized understanding of plagiarism; 10). Finally, coordination between instructors is another challenge; though research collaborations are common across global universities, partnerships in teaching are comparatively rare (2, 4). In particular, for COIL involving different classes in different disciplines, the faculty should have some understanding of the subject taught in the COIL partner course. This presents a profound logistical challenge for instructors that plan to adopt COIL in their classrooms.

We implemented the principles of COIL with a global theme in a course context that was applicable to students in both classes. The broader context of the module was medicinal plants, which are characterized by their historical and modern use in human medicine across cultures. Medicinal plants are an important contributor to human health and wellbeing, as the bioactivities of their functional components supply means to treat various human ailments (11). The biodiversity of our planet has been explored throughout history, leading to the characterization and cultivation of thousands of medicinal plant species that complement even a modern health system. Our module focused on six medicinal plants: basil, ginseng, bitter melon, ginger, moringa, and garlic (Table 1). Each of these plants have a plethora of uses and cultivated varieties that vary by region, ecological environment, and cultural influence. These medicinal plants, their reported bioactivities, and the phytochemicals in these plants that contribute to their activities were key foci for our COIL activity. This subject matter was being discussed independently in each course outside of the module and was immediately related to both the traditional medicine course at Shanghai Jiao Tong University (SJTU), People's Republic of China, and to the plant biochemistry course at University of California, Davis (UC Davis), United States. Materials learned in the two courses are complementary to each other, thus leading to a deeper understanding of each course's subject area.

The United Nations Sustainable Development Goals (UN SDGs) were used as an overarching framework for both classes to anchor the course content into global issues and initiatives (12, 13). These SDGs are 17 objectives that encompass 169 targets set forth by UN member states to promote peace and prosperity by 2030. Several SDGs are most immediately relevant to our COIL module (Table 2), including *Climate Action* (SDG 13), *Sustainable Cities and Communities* (SDG 11), *Decent Work and Economic Growth* (SDG 8), *Life on Land* (SDG 15), and *Good Health and Well Being* (SDG 3; principal SDG of the lesson). Examining the interface between cultural heritage, medicinal plant genetic resources, and human health also uncovers connections with many other SDGs (Table 2), which supplies a framework for study that does not constrain the exploration of international student teams. The synthesis of our course content with these goals and with the international collaboration was designed to promote a more global mindset in students in both classes.

The use of COIL principles in upper division STEM classes, particularly plant biology, is a novel implementation of global learning that is currently underused. Additionally, using the UN SDGs as an overarching theme is a way to connect student investigations to global events and initiatives and to encourage students to apply their learning to complex global problems. This exploration of medicinal plants in the context of the UN SDGs promotes core competencies in the biological sciences related to the understanding of biology as interdisciplinary, collaborative, and connected to society (14). Furthermore, this use of COIL is an effective and equitable approach to enhancing students' global learning and global problem-solving experience. Here we present specific components of a lesson module that applies COIL in a virtual e-poster project based on medicinal plants that spans Chinese and American learner cultures. Feedback from students and prospects for translating into other classrooms are also reported.

Intended Audience

Our COIL module is targeted generally at students with an interest in medicinal plants and sustainable development. The target audience of our COIL module should also have an interest in phytochemicals and their impact on human nutrition and health. In the American university, this module

was implemented in an upper-division plant biochemistry course of about 60 students. At the Chinese university, this module was implemented in an upper-division traditional medicine course of about 25 students. Both participating institutions are large research universities. Both classes were held online due to the COVID-19 pandemic, but we envision that this COIL module could be used as a virtual component of an in-person class at other institutions.

Required Learning Time

Two periods of class time were used for this module. In the first period, the class in the United States was given instructions for the COIL assignment. This used about 25 minutes of the class period during the second week of instruction. Additional instructions on group assignments and medicinal plant choices were provided through email communications after this first class period. Students coordinated and worked with their international partners for eight weeks. Final presentations for the poster assignment occurred during one class period in the tenth week of instruction. The weekly time commitment for each student ranged from 45–90 minutes per week during the extended collaboration window and roughly 3–5 hours per week during the initiation and conclusion of the international collaboration. Because of the time zone differences between the two classes, most of the work done by students for this component of the course was scheduled by individual groups outside of regular class hours.

Prerequisite Student Knowledge

Students in both classes are expected to have familiarity with basic concepts of biology equivalent to the high school level in the United States. While concepts from undergraduate biochemistry and medicinal plant courses are applicable to this module, this prior coursework is not a needed prerequisite for this lesson module to be implemented. Rather, student interest in the subject matter is crucially important. Experiential and theoretical knowledge from other disciplines that can be applied to the content matter is also desirable. Student experiences in economics, humanities, medicine, and agriculture are especially transferable to this module.

Prerequisite Teacher Knowledge

Instructors implementing this lesson should be familiar with basic plant physiology, crop science, plant biochemistry, and/or agrobusiness management. Knowledge about the medicinal plants covered in this module—including their history, medicinal uses, current uses, use in agriculture, and underlying biochemistry—is helpful for implementing this lesson (Table 1). Familiarity with the 17 UN SDGs along with their targets and indicator metrics also helps instructors cultivate discussion (Table 2). Unique to this module, instructors should have cross-cultural competency with the students and instructors from their partner institution.

SCIENTIFIC TEACHING THEMES

Active Learning

Our module facilitates active learning by forming intra- and inter-class interactive groups focused on a common theme. Students reflect on their learning through questions after the eight-week international collaboration. This lesson module uses the following engagement strategies (15):

- Integrate culturally diverse examples
- Ask open ended questions
- Be explicit about promoting access and equity for all students
- Assign reporters for small groups
- Monitor student participation

Assessment

Over the eight-week project period, several formative assessment strategies were used to guide instructor input to students and to encourage progress. The instructor held weekly office hours designated for the COIL project to answer students' questions and monitor the progress of each group project. Five to ten minutes were set aside at the end of each class period (in the UC Davis classroom) for questions and clarifications related to the COIL project. Volunteer group leaders provided a brief update on their progress each week through the regular COIL office hours. The instructor was copied on the email exchanges between groups at UC Davis and SJTU. Finally, the groups shared their e-posters for feedback before the final submission and in-class presentation.

Summative assessments for the COIL assignment examined three facets of the students' engagement: the quality of the poster, peer assessment of teamwork, and a self-assessment of their own performance. The poster submission was worth 10 points, assessed using a systematic rubric that awarded points based on the delivery and organization of ideas as well as the title, bibliography, and design of the e-poster (Supporting File S1). The "Ideas and Organization" portion of the rubric was worth 60% of the assignment total and was focused on discussion topics including (A) an overview of the use and functional components of the medicinal plant, (B) the connection of the medicinal plant to SDG 3 (*Good Health and Well Being*), and (C) any additional UN SDGs that can be addressed through the use and cultivation of the assigned medicinal plant. An adequate discussion of the first topic can be achieved with a brief but well-constructed overview paragraph that incorporates external literature. Discussion of the second and third topics should similarly incorporate external literature but should extend beyond factual reporting and include an original synthesis from the group. Figures and tables are welcome additions that can complement the text while also aiding the design of the e-poster. The engagement of each student was also assessed by peers, who graded teammates' participation on a scale of 0–2. This participation score was multiplied by their group poster score to get the final score on the poster assignment out of a maximum of 20 points. Students also did a brief self-reflection just before the e-poster presentation. This was a separate assignment worth 10 points (Supporting File S2). All of the assignments in this module totaled 30 points, or ten percent of the final course grade of the US-based plant biochemistry course.

Inclusive Teaching

Cross-cultural dialog is the cornerstone of COIL and this module. By design, outside opinions and perspectives are

encouraged in the class to foster cross-cultural competencies. The instructor encouraged students from similar cultural backgrounds to join different groups to learn about new perspectives to foster such a dialog. Furthermore, the weekly reports from each group leader allowed the instructors to check in to ensure that barriers to collaboration were low within and among the two classes (see Scientific Teaching Themes – Assessment). As a result, the design of the COIL module goes beyond simply implementing inclusive teaching principles but instead depends on them for success. Thus, COIL fosters a collaborative and supportive classroom (or online classroom) climate for increasingly diverse student populations at both participating institutions.

LESSON PLAN

International learning partnership

Meetings between the collaborating faculty members were initiated as a pilot project on global classrooms funded by Universitas 21 (U21; 16) and were further supported by the Office of Global Affairs at UC Davis and the International Affairs Division at SJTU. Initial meetings were important to understand the course content, learning objectives, class composition, schedule, and student interests of the collaborating class. Potential COIL activities, collaborative platforms, assignments, and assessments were also coordinated. These initial meetings were accomplished through Zoom meetings and email communications. The virtual platform for students was chosen to be the Canvas Free LMS, which is available in both China and the United States. The timing of the COIL project was determined to be the start of the winter academic term at UC Davis, which was one month before the start of the spring term for the SJTU traditional medicine class. Padlet software was also decided upon to give students another avenue to engage with their international partners. The working language for the international collaboration was determined to be English.

The class periods

First class period

The first class period was used to prime students in both classes for the project and to outline the expectations. In the American classroom, the lecture started with course-related content. The instructor saved about 25 minutes toward the end of the lecture to introduce the COIL assignment on the UN SDGs (Table 3). This introduction started by asking the class about their familiarity with COIL and the UN SDGs. The instructor then briefly introduced the use of COIL in classrooms and the SDGs set by UN. The background of the partnership on "Global classroom and the UN sustainable development goals" between UC Davis, Tecnológico de Monterrey, and SJTU was then introduced to the students. A five-minute video made by colleagues at the UC Davis Office of Global Affairs describing the U21 project on UN SDGs was played in class. The four learning objectives of the COIL module (Supporting File S1) were emphasized after the introductions to the COIL assignment (Table 3). Well before the lesson, time should be allocated to establish a plan with the partnering university. Some aspects of the international groupwork to arrange include:

- Expectations of the project
- The timing of the COIL project in both courses
- The learning management system that will be used
- The language(s) that will be used in the collaboration
- Whether there will be a synchronous or an asynchronous component of the collaboration in the regular class meetings
- Formative and summative assessments in both classes

Students from both classes were invited to join the course webpage for the COIL assignment on the Canvas Free LMS. Groups were assigned by the instructors through Canvas Free and consisted of 9–10 students in the American classroom and 3–5 students in the Chinese Traditional Medicine class (Table 4). Links to the Padlet platform were supplied on Canvas Free, and students were invited to use the free Padlet software to work with each other if they wanted. Students in each class were given three days to designate their preferred medicinal plant to work on for the assignment. For the American class, this was done as a quiz with a dropdown list on the course Canvas site (UC Davis student access only; not the Canvas Free website). Students could choose from basil, ginseng, bitter melon, ginger, moringa, and garlic (Table 1). Most students were assigned their first choice; students that did not respond to the poll were assigned plants in a manner that ensured similar group sizes for each medicinal plant. The format and required content of the e-poster were explained in detail (Supporting File S1). Information about the due date, grading scheme of the assignment, Canvas Free platform, and working language (English) were also introduced to the class. The students were encouraged to examine the grading rubric of the e-poster closely before working on the poster and before submission to ensure that all the prompts and expectations had been addressed (Supporting File S1). The lecture period was wrapped up by describing the peer-evaluation and self-reflection portions of the assignment (Supporting File S2). Pauses for questions were given throughout this assignment introduction to address questions and concerns about any portion of the COIL assignment.

Between class periods

Student groups were given a medicinal plant to study based on their preferences given to the instructors after the first class period. Between this initial assignment and the presentation of the e-posters, international student teams worked for eight weeks to conduct research on their medicinal plant and its interrelatedness to local cultures, global issues, and the UN SDGs. Students worked in this time period on a number of virtual platforms including WeChat, email, Canvas Free, Padlet, Canva, and more. Zoom remained the most common platform used by students—as they had become familiar with Zoom from taking virtual classes during the COVID-19 pandemic. Some Chinese students noted access issues with Zoom, however. Some platforms that are commonly used in the US such as Google Docs are not available to students in the Chinese traditional medicine class. Students needed to find team-specific ways to navigate around these technical barriers.

Conversations between the two classes were scheduled carefully by groups and their respective volunteer leads with little instructor intervention. Group conversations tended to center around the e-poster assignment and the associated knowledge exchange. Students in both classes learned from their respective sets of disciplinary and experiential knowledge and brought that knowledge to the rest of their group. The newfound ability for students in the American classroom to broaden their literature analysis to studies published only

in Chinese was a consistent and profound benefit that was observed during this eight-week period. Conversations about the academic and community culture of both classes also emerged in addition to work related to the assignment.

There were several channels for groups to receive feedback from the instructors that also allowed for formative assessment. In the virtual COIL SDG project office hours, students sought feedback on their understanding of the e-poster subject matter including the SDGs (particularly SDG 3) and the use of their assigned medicinal plant. Students also sought best-practices on effective presentation of their poster and incorporation of literature. Students helped deliver feedback from these sessions to their groupmates. Volunteer group leaders took a comparatively larger role in initiating conversations with instructors and facilitating dialog within their groups. These group leaders reported on project progress and the state of the collaboration within their group each week through email to the instructor. There were also five to ten minutes at the end of each class for questions (in the UC Davis class), which group members used to get further input from the instructor. Members of each of the six groups made steady progress and sought feedback throughout the academic term. Each of these channels were invaluable for the instructors to monitor the progress of each group and the health of their collaboration. Matters that arose related to the status of the international collaboration were primarily technical and logistical in nature, rather than being indicative of disagreement within the international teams.

Second class period

Each class had their own group presentations. In the American class, presentations were conducted through the screen share function on Zoom. Each of the six presentations lasted roughly 12 minutes. Group presentation format varied from group to group. For some groups, every student that was present synchronously had a chance to present to the class, whereas other groups chose 2–3 reporters to present their poster. There were 2–3 minutes for questions from the synchronous attendees on Zoom after each presentation. Feedback from the instructor(s) was supplied to each group through a brief comment after each presentation and through comments posted using the Zoom chat function. Students also used Zoom chat to comment on each other's work, mostly with encouragement and sometimes sharing personal experiences with the medicinal plants. Two colleagues from the UC Davis Office of Global Affairs attended the presentations and were actively engaged using the Zoom chat. The class was concluded after all the presentations with a summary statement by the instructor commenting on the high quality and innovative e-posters and well-delivered oral presentations. Recorded presentations from the US class were shared with the Chinese traditional medicine class afterward.

After the class periods

Students submitted a participation report about their groupmates after the presentations. Student reports about their groupmates ranged from 0–2 and were sent to the group lead to be averaged and sent to the instructors. Most students in our class perceived their groupmates' engagement positively, and rationale was given by students when lower participation scores were suggested. The average score (0–2) served as a multiplier for each student's project grade (see Scientific Teaching Themes – Assessment).

Students also reflected on the COIL module using the following questions:

- Do you think that you have achieved the learning objectives of the COIL module on the UN SDGs? Why or why not? (50–100 words)
- Did working collaboratively online with international partners on this module have an impact on your learning experience? Why or why not? (50–100 words)
- Did you and/or your group meet any challenges when working on this COIL module? If yes, describe the challenge(s) as well as what you learned from it. If not, describe the most important thing(s) you learned from this COIL module. (50–100 words)
- In your opinion, what actions should be taken towards achieving the UN SDGs discussed in your group e-poster? (50–100 words)
- What would you like to explore further as a result of the COIL experience on the UN SDGs? (50–100 words)

Full marks were awarded for this reflection if students participated; grading was not conducted on the content of student responses to encourage useful feedback for the module. A similar (and translated) set of questions were given in the Chinese traditional medicine class, though grading and credit schemes differed across the two courses.

TEACHING DISCUSSION

Students in both classes showed visible interest in the COIL project from the beginning of the collaboration. Progress toward the learning goals could be seen both in the content and design of the final e-posters. The final presentations, even from the perspectives of the American students, clearly showed an integration of knowledge from both sides of the COIL exchange into a well-constructed final product. The self-reflection questions were valuable for us to examine student perceptions of their learning after presenting their completed projects. Students' reflections also supplied a valuable look into the challenges unique to online global learning experiences. An open coding paradigm was used to identify consistent themes that emerged in responses to each prompt from students in the plant biochemistry course at UC Davis (Supporting File S3). These themes and their parallels from students in the SJTU traditional medicine class are discussed below.

Student engagement and growth

Most students in the plant biochemistry course believed that they achieved the learning objectives of the COIL module (Table 5). The most common codes to emerge in student responses about the learning objectives were related to linking course concepts to real-world problems, gaining experience in international collaboration, and applying their knowledge to the UN SDGs (Figure 1a). Likewise, most students believed that COIL had an impact on their learning (Table 5). We further examined the direction of this impact from student responses. About three quarters of these students acknowledged an exclusively positive effect on their learning. Another 14% of students noted a mixture of positive effects and learning

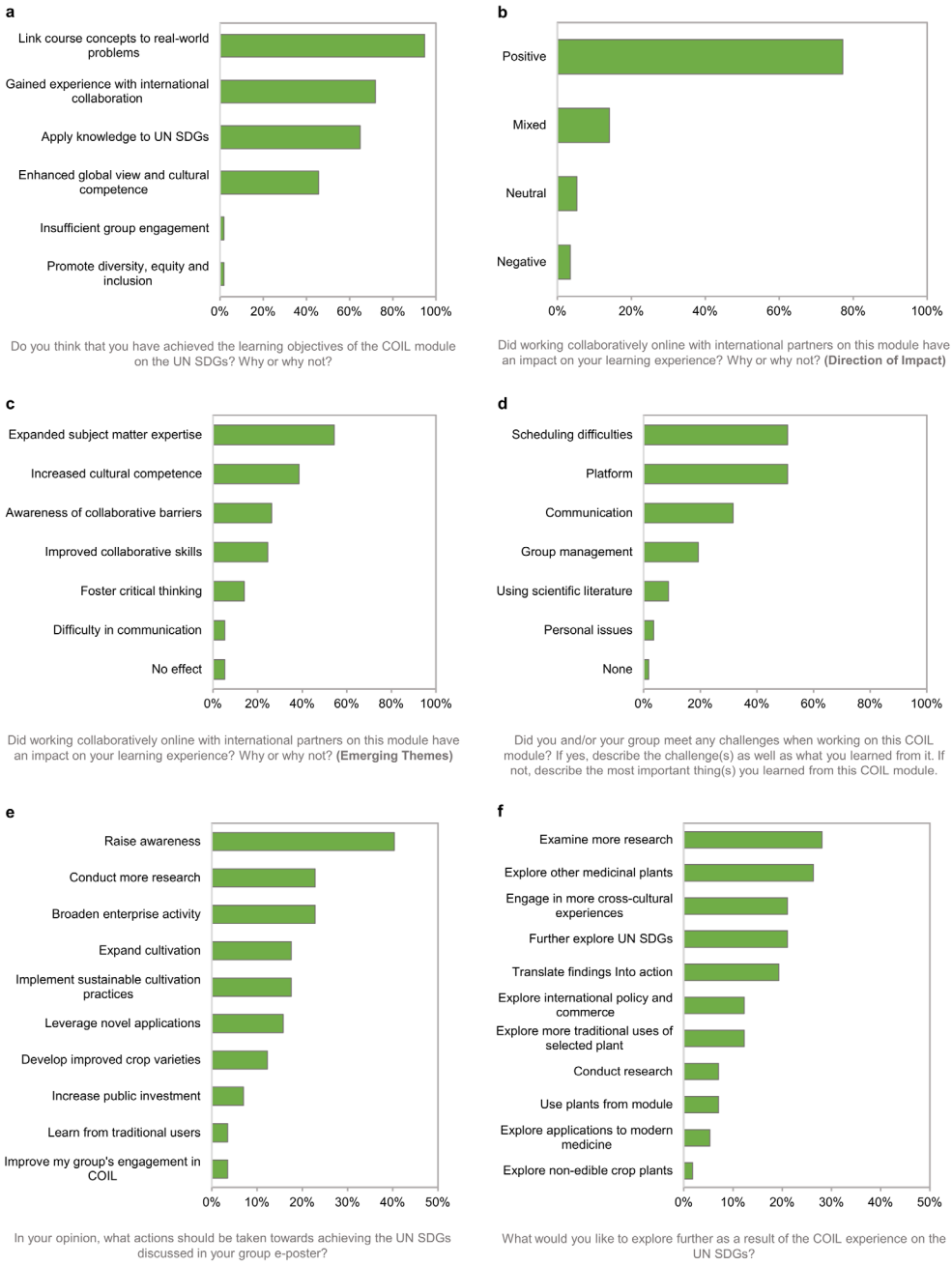

Figure 1. Frequencies of codes that emerged in student responses to the self-reflection survey. Prompts are shown in a single panel with the exception of prompt 2, which was coded both for direction of the learning impact and emerging themes.

challenges (Figure 1b). The remaining five students stated no effect or a negative effect. Common themes that emerged when students were discussing the impact of the module were gains in subject matter expertise and cultural competence (Figure 1c). An increased awareness of collaborative barriers appeared in many student responses, particularly those that described a mixed impact on their learning. Students also reported positive aspects of the module outside of the reflection survey—noting that this type of cultural experience is rare in the rest of their coursework. These responses collectively indicate that the module was a well-received component of the plant biochemistry course and that it had positive impact on students' critical thinking and open-mindedness, which aligns with other published implementations of COIL (6, 17).

The students in the plant biochemistry course (UC Davis) were prompted to suggest actions that could be taken to achieve the UN SDGs that they discussed in their project. The themes that were discussed in student responses varied widely (Supporting File S3, Figure 1e). Students often expressed interest in raising awareness of these underexplored medicinal crops (~40%). Students also expressed an interest in expanding

research, commercial applications, cultivation, and sustainable practices to achieve the wide range of SDGs noted in their e-posters (Table 4, Figure 1f). We were interested in what these students wanted to explore further after participating in the COIL module. A desire to conduct more research on their selected medicinal plant and the plants presented by other groups each emerged in slightly more than a quarter of responses. About 21% of students expressed interest in further exploring the UN SDGs (Figure 1f). Interestingly, a desire to participate in more cross-cultural experiences was mentioned in 21% of respondents. This indicates that for about one-fifth of the plant biochemistry class, the COIL module had a profound enough positive impact to inspire students to seek out more forms of internationalized curricula and activities. Several plant biochemistry students reported outside of the self-reflection survey that this COIL experience was their first in-depth engagement with the UN SDGs, highlighting both the increased global awareness fostered by the module and the novelty of this COIL experience in a broader curricular context.

We were interested in examining themes that emerged from the self-reflection responses in the SJTU traditional medicine class. The SJTU students overwhelmingly believed that they achieved the learning objectives and that their learning was impacted by working with their international partners. The SJTU students brought up several themes in common with the UC Davis students when discussing learning objectives including a broadened worldview and an understanding of the UN SDGs alongside new experience with international collaboration. When asked about the impact on their learning, impacts stemming from working with learners from other cultures and tackling barriers to international collaboration were commonly discussed. Unique to the SJTU class, an opportunity to practice written and spoken English during coursework was expressed by a large majority of the class when discussing completion of the learning objectives and the impact on their learning. When asked about what they would like to explore further because of the COIL project, SJTU students discussed many themes in common with the UC Davis students. The desire to learn more about the UN SDGs and to conduct more research appeared in a comparable proportion of the responses in the traditional medicine course. The scope of the responses to the prompt often differed in the SJTU class; responses often focused on alleviation of issues facing people in China, particularly poverty. This could stem from poverty and hunger alleviation being prevalent national priorities in China, notably for more rural regions where some of the SJTU students were from. Taken together, responses to the self-reflection in the traditional medicine class have some overlapping and distinct themes relative to the UC Davis class, but nonetheless note meaningful learning outcomes for the COIL project.

Challenges overcome by students

Students were prompted to report the challenges that they encountered when working on the COIL project. Logistical issues were commonly reported, with half of the students discussing scheduling with their Chinese collaborators as a profound challenge (Figure 1d). Feedback from the SJTU students highlighted similar challenges with the timing of group work. This was among the hurdles that was anticipated during the course design—and the large time difference between the courses was the reason why synchronous in-class activities could not be offered. Technical concerns related to digital platforms also emerged in student responses in both classes, reflecting the need to familiarize with new software that was available to students at UC Davis and at SJTU. Challenges related to communication between the groups were reported by about 31% of the UC Davis students (Figure 1d). This reflected both differences in language and the need to communicate through a relatively limited number of virtual channels. Most students in the traditional medicine class also specifically emphasized the challenge posed by doing collaborative work in a foreign language. Taken together, these challenges reported by students could also underpin the small number of students indicating a negative, neutral, or mixed impact of the COIL module on their learning in prior prompts of the survey (Table 5, Figure 1b).

The challenges overcome by the students are germane to internationalized learning, particularly between countries with large cultural and geographic differences. Importantly, these challenges reflect an additional avenue of learning rather than a needless barrier. In tackling these real-world concerns with international collaboration, students in both classes achieved profound learning gains in digital literacy and teamwork while taking important strides toward intercultural understanding. Learning gains in English language skills were attained by the partnering SJTU students also, a result of their enthusiastic engagement with the comparatively large group of international COIL partners. The benefit of this real-world experience was reflected by the extent of positive responses to the first and second prompts of the reflection in the plant biochemistry class (Table 5, Figure 1b) and in the traditional medicine class. This experience was especially valuable for senior undergraduate students, who expressed appreciation outside of the reflection for the opportunity to take on realistic collaborative challenges for relevant global issues. We believe that the professional skills cultivated in this COIL experience will be an asset to these graduating students and their classmates as they progress in their career journeys.

Adapting the lesson for other classrooms

This COIL module could be used as a component of an online course or an online component of an in-person course. The timing of components of the module could be modified to fit the aims of the instructors or to better align with schedules across partnering universities. For example, the timeframe for group work on the e-poster assignment could be extended to an entire semester. Eight weeks was sufficient for our students to collaboratively complete the e-poster project; extended versions of the module could incorporate additions such as blogs, reading lists, or video projects to promote more engagement with the subject. The conversation around the UN SDGs could be extended also either by capturing more of the first class period (Table 3) or by being incorporated into class periods during the eight-week collaboration period. Furthermore, one class period or short assignment could be added before the COIL assignment to encourage students to approach the international collaboration with an open mind, as global learning experiences are relatively uncommon components of undergraduate curricula. A class period can be added after the group presentations to reflect on the COIL module collectively as a class. The timeframe of the assignment window can be shortened also. Though the effect of the time spent on the global learning project ("dosage") on student learning is unclear (6, 18), we nonetheless encourage instructors to keep the collaboration time longer than one

month and to reduce concurrent work to ensure that students can sufficiently engage with their international groupmates.

The content of the module can also be tailored to specific course needs. Our students were given six medicinal plants to choose from for their e-poster assignment. There are many other medicinal plants that can be used in other classes that have a rich history and regional usage to inspire fruitful cultural discussions (11). The number and size of groups could be adjusted to adapt to the size of other classrooms. This COIL module can also be incorporated in courses outside traditional medicine and plant biochemistry subject matter. Courses with a high school biology prerequisite including general biology, plant biology, and medical biology can adapt this module into their curriculum. Though a novel aspect of our COIL module is its use in upper-division STEM courses, its applications can extend beyond medicine and the biological sciences. This traditional medicine context can be applied in courses in economics, language, and the humanities, which currently have a collection of exemplary COIL experiences (2, 6, 17), though some periods before the module should be allocated to familiarize students with the subject. We also anticipate that the international collaborations between courses of different subject matters could result in especially fruitful discussions within international student teams that examine medicinal plants through the lens of SDGs that were not presented in our classroom. Students from all backgrounds benefit from collaboratively examining globally relevant issues and initiatives in the context of our medicinal heritage.

Instructor and institutional collaboration are key facets of COIL experiences that underpin their success (2, 3). Finding ways to initiate these collaborations is crucial to implement modules like the one described here. Several channels exist that instructors can tap into. SUNY's COIL center initially popularized the concept of COIL and can advise, initiate, and help maintain long-term COIL collaborations, though there are fees associated with membership in the SUNY COIL network. Florida International University has a growing network of COIL collaborators and offers professional development programs for instructors that want to initiate and design a meaningful COIL experience. There are also several informal channels that can be tapped to forge instructional collaboration without the added cost of formal programs. Existing research collaborations between faculty members can be useful to pair instructors across national boundaries that have similar research interests and topically complementary courses. Professional societies provide a robust network that can extend to teaching collaborations, particularly within societies that have committees or divisions focused on teaching or outreach. Specific to the content of this module, events centrally focused on the UN SDGs are a promising channel for initiating instructional collaborations across topical areas and across wide global ranges. Like with the module presented here, international affairs offices within the instructors' institutions can assist in supporting COIL collaborations, regardless of how that collaboration is initiated. Though initiating international teaching collaborations is a uniquely challenging aspect of implementing COIL, a sustainable collaboration brings profound benefits to cohorts of students by allowing them to grapple with real-world collaborative barriers while also broadening their view of global issues and cultures.

SUPPORTING MATERIALS

- S1. COIL – e-Poster Assignment Description
- S2. COIL – Follow-Up Survey
- S3. COIL – Survey Coding Rubric

ACKNOWLEDGMENTS

We would like to thank the students in both partnering classes for their active engagement and constructive feedback. We are also grateful to the U21 network, the UC Davis Office of Global Affairs, and the International Affairs Division at SJTU for their input and support in designing and implementing this module. The authors would like to specifically acknowledge the support and engagement of Dr. Elizabeth Langridge-Noti and Ms. Jennie Konsella-Norene from the UC Davis Office of Global Affairs and Ms. Lina Tao from the International Affairs Division at SJTU.

REFERENCES

1. Vahed A, Rodriguez K. 2021. Enriching students' engaged learning experiences through the collaborative online international learning project. Innov Educ Teach Int 58:596–605. DOI:10.1080/14703297.2020.1792331.
2. Rubin J. 2017. Embedding Collaborative Online International Learning (COIL) at higher education institutions. Internationalisation of Higher Education 2:27–44.
3. Jie Z, Pearlman AMG. 2018. Expanding access to international education through technology enhanced Collaborative Online International Learning (COIL) courses. Int J Technol Teach Learn 14:1–11.
4. Liu Y, Shirley T. 2021. Without crossing a border: Exploring the impact of shifting study abroad online on students' learning and intercultural competence development during the COVID-19 pandemic. Online Learn 25:182–194. DOI:10.24059/olj.v25i1.2471.
5. NAFSA. 2020. Trends in U.S. study abroad. Retrieved from https://www.nafsa.org/policy-and-advocacy/policy-resources/trends-us-study-abroad (accessed 20 July 2022).
6. Commander NE, Schloer WF, Cushing ST. 2022. Virtual exchange: A promising high-impact practice for developing intercultural effectiveness across disciplines. J Virtual Exch 5:1–19. DOI:10.21827/jve.5.37329.
7. de Castro AB, Dyba N, Cortez ED, Pe Benito GG. 2019. Collaborative online international learning to prepare students for multicultural work environments. Nurse Educ 44:E1–E5. DOI:10.1097/NNE.0000000000000609.
8. Wood EA, Collins SL, Mueller S, Stetten NE, El-Shokry M. 2022. Transforming perspectives through virtual exchange: A US-Egypt partnership part 1. Front Public Health 10. DOI:10.3389/fpubh.2022.877547.
9. Rebek J-L, del-Corte-Lora V, Riauka E. 2022. Collaborative Online International Learning (COIL) case study: Canadian and Spanish classes develop intercultural competencies, p 345–360. *In* Smith C, Zhou G (ed), Handbook of research on teaching strategies for culturally and linguistically diverse international students. IGI Global, Hershey, PA, USA. DOI:10.4018/978-1-7998-8921-2.ch018.
10. Heitman E, Litewka S. 2011. International perspectives on plagiarism and considerations for teaching international trainees. Urol Oncol 29:104–108. DOI:10.1016/j.urolonc.2010.09.014.
11. Petrovska BB. 2012. Historical review of medicinal plants' usage. Pharmacogn Rev 6:1–5. DOI:10.4103/0973-7847.95849.
12. United Nations Department of Economic and Social Affairs. 2015. Transforming our world: The 2030 agenda for sustainable development. Retrieved from https://sdgs.un.org/2030agenda (accessed 20 July 2022).
13. Sachs J, Kroll C, Lafortune G, Fuller G, Woelm F. 2022. Sustainable development report 2022. Cambridge University Press, Cambridge, UK. DOI:10.1017/9781009210058.
14. American Association for the Advancement of Science (AAAS). 2011. Vision and change in undergraduate biology education: A call to action. AAAS, Washington, DC, USA. http://visionandchange.org/finalreport.
15. Tanner KD. 2013. Structure matters: Twenty-one teaching strategies to promote student engagement and cultivate classroom equity. CBE Life Sci Educ 12:322–331. DOI:10.1187/cbe.13-06-0115.
16. Chua A, Lam W. 2007. Quality assurance in online education: The Universitas

21 global approach. Br J Educ Technol 38:133–152. DOI:10.1111/J.1467-8535.2006.00652.X.
17. Nava-Aguirre KM, Garcia-Portillo BI, Lopez-Morales JS. 2019. Collaborative Online International Learning (COIL): An innovative strategy for experiential learning and internationalization at home, p 721–746. *In* Gonzalez-Perez MA, Lynden K, Taras V (ed), The Palgrave handbook of learning and teaching international business and management. Springer International Publishing, Cham, Switzerland. DOI:10.1007/978-3-030-20415-0_34.
18. Stevens Initiative. 2020. Annotated bibliography on virtual exchange research. The Aspen Institute, Washington, DC, USA.

Table 1. Medicinal plants used in the COIL module with descriptions and selected applications.

Medicinal Plant	Description	Select Medicinal Uses
Basil (*Ocimum basilicum* L.)	Annual herb cultivated for its leaves. The leaves are used fresh in culinary dishes as a seasoning. Flower buds are sometimes also used. Medicinal applications of basil use fresh or dried leaves as well as extract from leaves.	• Treat kidney issues • Promote oral health • Alleviate headaches • Alleviate cough
Ginseng (*Panax ginseng*)	Perennial herb cultivated for its large root. The roots of ginseng are often dried and ground into a powder. Ginseng powder is used in teas and in herbal remedies. Different species of ginseng are cultivated on different continents. *Panax ginseng* is the most cultivated species in eastern Asia.	• Support memory and recollection • Treatment of acute infection • Treat loss of energy and strength
Bitter melon (*Momordica charantia* L.)	Perennial plant with a climbing, viny grown habit. Long, narrow, and very bitter fruits are produced by the plant that can be consumed raw or used in dishes. The fruit is also dried and used for herbal teas. Bitter melon is regarded as a medicinal food in Africa, central Asia, and China.	• Relief of stomach discomfort • Enhance disease immunity • Treat inflammation • Anticancer treatment
Ginger (*Zingiber officinale* Rosc.)	Herbaceous plant cultivated for its rhizome, which is used as a spice and as a medicine. Rhizomes of ginger are known for their pungent and sweet aromas and flavors. Ginger is cultivated extensively in India and China for culinary use.	• Treat nausea and vomiting • Treat inflammation and muscle pain • Alleviate headaches
Moringa (*Moringa oleifera* L.)	Tree native to the Indian subcontinent that is cultivated for its seed pods and leaves. Bark, roots, and flowers of moringa are also occasionally used. Tissues from moringa are used in both culinary applications and traditional medicine. Moringa seed extract can be used to purify water by causing contaminants to sediment.	• Alleviate malnutrition • Antidiabetic • Promote kidney health • Treat hypertension
Garlic (*Allium sativum* L.)	Small, perennial, herbaceous plant cultivated for its bulb and aerial tissues. The bulb of garlic is dried and used in medicine and as a culinary seasoning. Garlic is commercially cultivated, and most of the world's garlic is grown in China.	• Treat arthritic pain • Treat acute bacterial infection • Antidiabetic • Anticancer treatment

Table 2. United Nations (UN) Sustainable Development Goals (SDG) relevant to the COIL module.

SDG	Description	Selected Targets
UN SDG 3 *Good Health and Well Being* (Principal SDG of the lesson)	Ensure healthy lives and promote well-being for all at all ages	• By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being • By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births
UN SDG 1 *End Poverty*	End poverty in all its forms everywhere	• By 2030, reduce at least by half the proportion of men, women, and children of all ages living in poverty in all its dimensions according to national definitions • By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters
UN SDG 2 *Zero Hunger*	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	• By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious, and sufficient food all year round • By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women, and older persons
UN SDG 6 *Clean Water and Sanitation*	Ensure availability and sustainable management of water and sanitation for all	• By 2030, achieve universal and equitable access to safe and affordable drinking water for all • By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
UN SDG 8 *Decent Work and Economic Growth*	Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all	• Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity, and innovation and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services • Improve progressively, through 2030, global resource efficiency in consumption and production and endeavor to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programs on Sustainable Consumption and Production, with developed countries taking the lead
UN SDG 9 *Industry, Innovation, and Infrastructure*	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation	• Develop quality, reliable, sustainable, and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all • Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries
UN SDG 10 *Reduced Inequalities*	Reduce inequality within and among countries	• By 2030, progressively achieve and sustain income growth of the bottom 40 percent of the population at a rate higher than the national average • By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion, or economic or other status

SDG	Description	Selected Targets
UN SDG 11 *Sustainable Cities and Communities*	Make cities and human settlements inclusive, safe, resilient, and sustainable	• By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management • Strengthen efforts to protect and safeguard the world's cultural and natural heritage
UN SDG 12 *Responsible Consumption and Production*	Ensure sustainable consumption and production patterns	• By 2030, achieve the sustainable management and efficient use of natural resources • By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses
UN SDG 13 *Climate Action*	Take urgent action to combat climate change and its impacts	• Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries • Integrate climate change measures into national policies, strategies, and planning
UN SDG 15 *Life on Land*	Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss	• By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies, and accounts • By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought, and floods and strive to achieve a land degradation-neutral world • Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed

Table 3. Lesson timetable for the COIL module including the two class periods explicitly used on the module and the period between those classes used for completion of the e-poster project.

Activity	Description	Estimated Time	Notes
COIL Project Introduction			
Gauging student baselines and introducing concepts	Instructor asked students about their familiarity with COIL. After several students had responded, the instructor introduced COIL. Similarly, familiarity with the UN SDGs was surveyed and the UN SDGs were introduced.	5 min	Instructors should consciously pause at points during these presentations to allow for questions from students about the COIL project and about the UN SDGs. Students at different universities will have varying levels of familiarity with COIL and with the UN SDGs. The time allocated to this may change depending on the student audience.
Introduction of international collaborators	The global learning partnership between UC Davis, Tecnológico de Monterrey, and SJTU was introduced to students. The details of the partnership and its focus on the UN SDGs was discussed here.	5 min	
Introduction to the U21 network	A video contributed by the UC Davis Office of Global Affairs that described the Universitas 21 (U21) project on the UN SDGs was played.	5 min	
Discussion of learning objectives	Instructor introduced the four learning objectives and three learning outcomes of the COIL project.	5 min	
Wrap-up	The instructor addressed remaining questions from students about the COIL project. The instructor also spent time to emphasize the e-poster rubric during this time. The class was concluded by instructing students to read into the medicinal plants in the module and select the plant they would like to work on using a quiz on Canvas.	5 min	
International Collaboration Phase			
Plant selection	Students briefly examined the six medicinal plants that would be used in the COIL project and selected the medicinal plants that they wanted to study for their COIL project on the Canvas page for the class.	3 days	Most students were able to get their first choice. Students who did not provide a response on Canvas were assigned to different groups to ensure an even distribution of students across the groups.
Group assignment	Students were assigned a medicinal plant based on their choices. Students in both classes were notified of other students that were working on the same plant that would be their groupmates.	1 day	Contact information for groupmates was available on the Canvas Free LMS.

Activity	Description	Estimated Time	Notes
Work on the COIL assignment	Students worked with their groupmates on the e-poster assignment. Groups needed to consider the following: • How will international collaboration work in our team given the technical and timing constraints? • Who in our group will serve as a designated reporter? • How do we determine what SDGs will be the focus of our e-poster? • How will we research our medicinal plant? What literature is needed from each classroom? • How will we lend our personal experience to the development of this project? • What will the visual delivery of these ideas look like? This exercise is free form by design. Individual groups decided their own unique ways to address these considerations and others.	8 weeks	Instructors for the class should be easily accessible during the collaboration window in case collaborative barriers are too high. In our class, the instructor was copied on all group email communications. Office hours were also held weekly specifically for the COIL assignment. Feedback was given to students throughout the project window by request.
COIL Project Presentations			
Group presentations of e-posters	Student groups presented their e-posters virtually on Zoom. Individual groups decided on the style and flow of the presentation. Each of the six groups had approximately 12 minutes for their presentation. This included about 10 minutes for the presentation of the poster content and about 2 minutes for questions. Questions were asked by fellow students and other attendees using the Zoom chat function. Students were encouraged to comment and share their personal experiences in the chat also.	~75 min	This portion can be offered synchronously or asynchronously with the partnering classroom. Instructors may need to serve as timekeepers to ensure that each group has enough time to present.
Conclusion by instructor	The session was concluded after the e-poster presentations by thanking all of the students and their group leads for their hard work on the project. Guest attendees in the class also thanked the students for their effort on this international project. Continued dialog between students was encouraged and present during this time.	5 min	Peer evaluations and self-reflections were due two days before the e-poster presentations.

Table 4. Number of students in each medicinal plant group. The UN SDGs noted in the final e-poster submissions are shown for each medicinal plant.

Medicinal Plant	Groups	Total Students – UC Davis	Total Students – SJTU	SDGs Noted
Basil	1	10	5	1, 3, 8, 11, 13, 15
Ginseng	1	9	5	3, 8, 9, 12, 15
Bitter Melon	1	10	4	1, 3, 8, 10, 12
Ginger	1	10	4	1, 3, 8, 10
Moringa	1	10	5	2, 3, 6
Garlic	1	10	3	1, 2, 3, 15

Table 5. Frequency of responses to survey prompts 1 and 2 that note completion of the learning objectives and presence/absence of an effect on learning, respectively.

Response	Number of Students	Percent Respondents
Did you achieve the learning outcomes of the COIL module?		
Yes	49	85.96%
Mixed	7	12.28%
No	1	1.75%
Did working with international partners impact your learning experience?		
Yes	53	92.98%
No	4	7.02%