Exploring the Impact of STEM COIL Modules on Global Competence: A Study of Indonesian Physics Undergraduates and International Engineering Students in Japan

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Exploring the Impact of STEM COIL Modules on Global Competence: A Study of Indonesian Physics Undergraduates and International Engineering Students in Japan

Abstract

This study explores the effect of Collaborative Online International Learning (COIL) programs on the global competence scores of a diverse group of science and engineering students. In these STEM fields, academics and industry professionals frequently collaborate in global research teams and multinational companies, making cross-cultural teamwork increasingly essential. Over the past decade 'global competence' has become widely recognised by universities and by organisations such as the OECD as a meaningful measure of the skill sets needed to collaborate effectively in multicultural teams. As such, the study authors chose to focus on how global competence (GC) might be improved for STEM students. The research team – comprised of professors from both the STEM and humanities disciplines at Shibaura Institute of Technology (SIT) in Tokyo, Japan, and of STEM professors at Sepuluh Nopember Institute of Technology (ITS) in Surabaya, Indonesia – shares the belief that understanding the historical context surrounding scientific discoveries and the evolution of physical theories is crucial for a comprehensive grasp of physics. A new STEM COIL module incorporating a history component was therefore created, and launched at the Japanese university, with Indonesian undergraduates also taking the course as remote learners. To evaluate the effectiveness of the new interdisciplinary COIL, it was assessed alongside five other existing modules and the results were compared, with the key object of investigation being the effect on participating students' global competence. In total two STEM non-COIL modules, two STEM COIL modules (including the newly created one with a history component), and two history modules (one COIL and one non-COIL) had their pre- and post-program GC scores calculated using the Miville-Guzman Universality Diversity Scale – Short Form (MGUDS-S). Results indicated that the two STEM non-COILs and the single STEM COIL saw declines in student GC scores (–0.71, –1.69, and –2.13 respectively), although the changes were not statistically significant. The newly created STEM COIL with a supplementary history component saw a smaller decline (GC –0.36 points) than those observed in the other STEM modules. Additionally, the new module showed a positive change in one of the three aspects of global competence, 'Comfort with Difference' (+1.55 points). Both the history modules (COIL and non-COIL) displayed improvements in students' GC. These results suggest that while STEM-focused COILs alone may not enhance GC, adding an interdisciplinary element – such as a history component – can have a positive effect. If fostering broader cultural competence is a priority, future STEM COIL initiatives should incorporate an interdisciplinary element.

Keywords: Global Competence Assessment Using MGUDS-S, STEM COIL and Cross-Cultural Learning, Interdisciplinary STEM Education, Indonesian Undergraduate Students, International Engineering Students

1. Introduction

This study investigates the effectiveness of COIL programs on the development of global competence (GC) among Indonesian physics undergraduates and engineering undergraduates studying at ITS in Surabaya, Indonesia, and among international engineering students studying at SIT in Tokyo, Japan. The cohorts of students considered were 'diverse' in terms of their countries of origin and first languages spoken, and the programs assessed all had English as the primary language of instruction. Students' GC scores were assessed before and after they completed these one-semester programs. We hypothesised that taking part in COIL programs would positively impact students' GC scores; most specifically, we anticipated that STEM COIL modules incorporating Humanities components (in this case focusing on 'historical perspectives on the development of science in Japan') might result in the highest gains in GC, especially in the 'Comfort with Difference' (CD) subscale.

1.1.History and definition of COIL:

As an educational approach, COIL leverages information and communication technology (ICT) to connect students and faculty from institutions in different countries. The COIL methodology was pioneered by the State University of New York (SUNY) COIL Center in 2004 [1]; SUNY describes COIL as "a pedagogical approach that fosters cross-cultural learning and collaboration through online platforms" [2]. This method enables interactive and collaborative learning experiences, allowing participating students and academics to easily engage in joint projects, discussions, and activities across various disciplines. COIL promotes intercultural exchange and mutual understanding, allowing students to gain diverse perspectives and increase their level of global competence without the necessity of physical mobility. As such it has been adopted by universities across the United States of America and around the world. In Japan Kansai University has been pioneers of the COIL format, contributing significantly to the growth and recognition of COIL in Japanese higher education [3].

1.2.Why global competence is increasingly essential

Global competence (GC) refers to the ability to interact effectively and respectfully with individuals from diverse cultural and social backgrounds. GC has cognitive, affective, and behavioral dimensions, including an appreciation for diversity, openness to new perspectives, and the ability to communicate effectively through cultural barriers [4]. Factors such as participation in international collaborations, cross-cultural social interactions, and exposure to

interdisciplinary educational environments have been shown to enhance GC in students. In science and engineering, both academics and industry professionals are increasingly engaged in global research collaborations and employed by multinational companies. As a result, the ability to work effectively with individuals from diverse cultural backgrounds has become more essential than ever. Over the past decade, GC has gained widespread recognition among universities and organizations like the OECD [5] as a key indicator of the skills required for successful collaboration in international and multicultural teams. This recognition motivated the research team to examine ways to enhance GC among STEM students. The study authors believe that COILs could be an effective method for enhancing students' global competence or GC since they involve collaboration among students undertaking joint problem-solving activities to foster cross-cultural learning. COIL programs are widely recognized for promoting GC, particularly in humanities and social sciences. However, their effectiveness in STEM education is still under evaluation. Ahrens et al. conducted a descriptive study that sought to verify the structural soundness of a STEM COIL model, finding that it successfully functioned. This suggests that, while STEM COIL models hold promise, additional interdisciplinary elements might further enhance their impact on GC [6].

1.3.Research objectives

The research was conducted by an international team comprised of professors from Japan, Indonesia, and Italy, who share the belief that the inclusion of humanities elements in STEM education is crucial for fostering a more comprehensive learning experience [7][8][9]; prior research has demonstrated that interdisciplinary study can improve students' attitudes towards their own chosen STEM discipline [10], in terms of aspects like self-described motivation to acquire knowledge, and perception of the ancillary benefits of learning STEM [9]. Thus, a Japanese history module already running at SIT and taught by one of the study authors was selected to function as the humanities component of a new STEM COIL (see course 5 in Figure 1). This module covers the history of scientific advancement in Japan from the 16th century to the present day, including advances in physics. The research objectives of the paper are as follows:

1) To evaluate the impact of Collaborative Online International Learning (COIL) programs on the global competence (GC) scores of STEM students.
2) To assess whether integrating a humanities component, specifically history, into a COIL STEM module influences students' GC scores.
3) To investigate the differences in GC score changes between STEM-focused COIL courses and humanities-focused COIL courses.

2. Methodology

The chosen methodology focused on measuring and comparing students' pre-program and post-program GC scores, both to evaluate the impact of the new STEM COIL module with a history component in absolute terms and to compare it with other curricula. To evaluate its effectiveness, six learning modalities including this COIL were assessed (Figure 1).

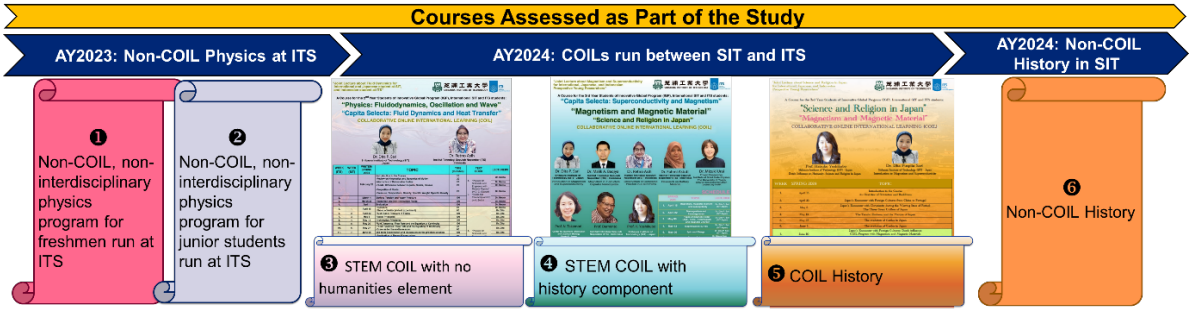

Figure 1 Courses assessed in this study

2.1.Data Collection and Analysis

It should be noted that only data from students who provided informed consent for the use of their coursework was included in the analysis. The first phase of the study examined data from ITS Surabaya's Indonesian undergraduate students enrolled in traditional physics courses (non-COIL STEM modules) during the August-December 2023 semester. In the second phase, equivalent pre- and post- program assessments were carried out for students participating in the COIL STEM modules (one purely STEM and one STEM with a history component) and in the history modules (one COIL and one non-COIL) during the April-July 2024 semester. For this phase, the study expanded to include the international students at SIT Tokyo. Thus, the student cohorts now included undergraduates from Indonesia, Europe, and South America and from other Asian countries such as Thailand, China, and Taiwan, reflecting a more diverse and globally representative student body. The breakdown of participants' nationalities in each module was as follows: For non-COIL STEM modules, the student body at the Indonesian university consisted solely of Indonesian undergraduates, whereas participants in the STEM COILs were a mixture of 'international' students in Japan (attending in person) and Indonesian undergraduates attending online. Participants in the history modules (both COIL and non-COIL) were mainly from Europe and South America, partially from Asian countries such as Thailand, China and Taiwan attending from Japan. However, the history COIL module included participants from ITS in Surabaya, Indonesia. All courses were taught entirely in English.

To measure students' GC, the Miville-Guzman Universality Diversity Scale – Short Form (MGUDSS) was used to quantify students' overall GC and its three subscales: Relativistic Appreciation (RA), Diversity of Contact (DC), and Comfort with Differences (CD). This

psychometric tool was first developed at Columbia University in New York and assesses subjects' attitudes and behaviors relating to diversity [11][12][13]. It consists of a 15-question written survey, with responses scored on a 6-point Likert scale. It outputs an 'overall score' and three sub-scores, which are as follows:
1) Diversity of Contact (DC) – the behavioral aspect of GC, measuring a subject's interest and willingness to participate in activities with people from diverse backgrounds.
2) Relativistic Appreciation (RA) – the cognitive aspect, indicating recognition of the value diversity adds to one's life and respect for cultural differences.
3) Comfort with Difference (CD) – the affective aspect, indicating the level of comfort subjects feel when interacting with people from diverse backgrounds.

The MGUDSS has been widely adopted and is considered to be well-suited for evaluating changes in GC in a wide range of settings. It is used by various institutions to assess individuals' awareness and acceptance of similarities and differences among people; notable examples include Carnegie Mellon University [14], and Purdue University [15][16]. A Japanese engineering university, at which four of this paper's authors are based, has been using the MGUDS-S to assess GC in engineering students within international programs o

3. Results and discussions

Students lacking post-program data were excluded from the pre- to post-program global competence (GC) score analysis to ensure accuracy.

3.1. Results of Non-COIL STEM modules during the August-December 2023

3.1.1. Indonesian freshmen in physics (n=27, "The Wonder of Physics")

The physics course "The Wonder of Physics" introduced foundational concepts in physics and their relevance to the development of science and technology. This course was available for Indonesian freshmen students. Participants' GC total mean scores slightly decreased from 66.30 to 65.59, a change of –0.70 points over the semester. A paired-sample *t*-test indicated that this decrease was not statistically significant (p= 0.609). However, further analysis of the three MGUDS-S subscales revealed more notable changes. DC scores showed a non-significant decrease (mean change = –0.70, p= 0.340), suggesting minimal change in students' engagement with diverse others. A statistically significant decrease in RA scores (mean change = –1.11, p= 0.020) indicates a potential reduction in students' appreciation of multiple perspectives. In contrast, CD scores increased by 1.11 points (p= 0.274), reflecting a positive—though not statistically significant—trend in students' comfort with difference. These findings suggest that while the course may foster greater ease with diversity, it may unintentionally diminish openness to relativistic perspectives. Implications for course design, including the need for scaffolded reflection and intentional exposure to difference, need to be discussed.

3.1.2. Third-Year Indonesian students in physics (n=32, “Quantum Physics”)

The ITS Third-Year STEM course “Quantum Physics” introduced the basic knowledge and mathematical development in quantum mechanics, which govern the behavior of particles at the microscopic level. Similar to “The Wonder of Physics”, participants’ GC scores decreased from 67.41 at the beginning of the semester to 65.72 at the end, reflecting a mean difference of –1.69 points. A paired-sample *t*-test revealed that this decrease was not statistically significant ($p = 0.210$). A further analysis of the M-GUDS-S subscales revealed decreases across all three: DC decreased by –0.34 ($p= 0.496$), RA by -0.91 ($p= 0.111$), and CD by −0.44 ($p= 0.685$). Although none of the subscale changes were statistically significant, the consistently negative trends across DC, RA, and CD may indicate that the course did not effectively support intercultural development — and may have had a subtle regressive effect.

Given the consistent declines in GC scores observed in both non-COIL STEM courses, these results underscore the value of incorporating COIL into the STEM curriculum to promote intercultural competence. Notably, while both groups showed declines in overall GC scores, only the first-year students exhibited a positive (though non-significant) trend in CD. This contrast may reflect developmental differences between student cohorts. First-year students are typically in a period of social and academic transition, during which they are more likely to engage with new perspectives and unfamiliar peers. In contrast, third-year students may have already formed more stable social networks and academic identities, potentially limiting their openness to intercultural engagement. These findings suggest that interventions aimed at enhancing global competence may need to be tailored to students’ developmental stages.

3.2.Results of STEM COIL modules (one purely STEM COIL and one STEM COIL with supplementary history components) during the April-July 2024

3.2.1. Indonesian participants in physics (n= 6, “Fluidodynamics”)

The physics course “Fluidodynamics” introduced basic knowledge and dynamical equations for describing the behavior of liquids and gasses close to daily and environmental applications. This course was available for Indonesian and International sophomore students in Japan. Participants’ GC scores decreased from 69.50 to 66.50, a change of –3 points. Although this decline may appear meaningful, a paired-sample *t*-test indicated that the change was not statistically significant ($p= 0.165$). All three MGUDS-S subscales – DC, RA, and CD – also showed slight declines. None of the changes in subscales were statistically significant: DC decreased by –0.67 ($p= 0.484$), RA by –0.84 ($p= 0.419$), and CD by –1.5 ($p= 0.122$). Notably, the decrease in GC in “Fluidodynamics” was greater than that observed in non-COIL STEM modules in this study. This may be attributed to the increased cognitive load associated with learning technical STEM content in an online format.

3.2.2. Indonesian participants in physics (n= 11, “Magnetism and Magnetic Materials”)

The physics course "Magnetism and Magnetic Materials" introduced the concept of magnetism and superconductivity by showing the study cases of magnetic materials and superconductors. Before transitioning from the magnetism to superconductivity explanation, the student was introduced to the historical discovery of superconductivity by the Dutch with an introduction to the impact of the Dutch on the world and Japan to some extent. This course was available for Indonesian and International junior students in Japan. Participants' GC scores decreased slightly, from 69.64 to 69.27, with a change of –0.37 points. Unlike "Fluidodynamics (STEM COIL)", which saw a larger decline (–3 points), the decrease here was minimal. A closer look at the MGUDS-S subscales shows a slight decrease in the participants' DC scores (–0.55 points), indicating a modest reduction in students' interactions with people from diverse background. Their RA scores also declined (–1.36 points), suggesting that students may have become somewhat less inclined to value diverse cultural perspectives. In contrasts, students demonstrated a moderate improvement in their CD scores (+1.54 points), indicating improved emotional ease in interacting with people from different backgrounds. While a paired-sample *t*-test showed that none of the changes were statistically significant (e.g., p= 0.849 for the total GC score), these results from a newly developed STEM COIL module incorporating humanities suggest that integrating humanities elements into STEM COILs may help mitigate GC declines, particularly by fostering openness to diverse perspectives.

3.2.3. Participants in non-COIL history (n= 15, "Science and Religion in Japan")

This non-COIL history module takes an interdisciplinary approach to exploring topics in both the humanities and sciences, focusing on Japanese history as well as the historical development of physics, particularly in magnetism and superconductivity, as supplemental elements. The participants are comprised of students mainly from Europe, Asia, and South America, with discussions held for approximately 30 minutes per week. Additionally, the course is designed to challenge students' logical thinking and creativity. To achieve this, participants are required to write weekly summary and response papers. This non-COIL version also led to increases in all GC subscales and total GC scores. Total GC score increased from 71.00 to 74.13 by 3.13 points. Although the *t*-test *p*-value (0.138) does not reach statistical significance at the conventional 0.05 level, suggesting practical significance. These findings suggest that while the gains were not statistically significant, likely due to the small sample size (n=15), they may still reflect meaningful improvements in global citizenship, particularly in RA.

3.2.4. Participants in COIL history (n=21, "Science and Religion in Japan")

Similar to the aforementioned non-COIL history module, this COIL history module, delivered through an interdisciplinary framework with two weeks of Zoom-based collaboration, was associated with an increase in students' GC scores. The pre-program mean

GC score was 69.24, rising to 71.86 post-program, a gain of 2.62 points with a statistically significant (p= 0.039). All three MGUDS-S subscales showed positive changes: DC (+0.95), RA (+0.34), and CD (+1.34). These consistent upward trends in three-subscales imply that students may have developed a broader appreciation for cultural perspectives and differences. This may reflect the increased cognitive demands of managing interdisciplinary content and intercultural communication online. Additionally, the structured nature of online tasks and the limited opportunities for spontaneous, informal cultural exchange may have constrained deeper global engagement.

3.3. Discussions on the MGUDS-S analysis comparison between the Indonesian and international students at SIT

Table I shows the MGUDS-S analysis comparison between the Indonesian and the International students at SIT. The former is the average data taken from the sample in sections 3.1.1, 3.1.2, 3.2.1, and 3.2.2 by means of some of the students who experienced taking the COIL Program and receiving some historical element in their physics course. The latter is the average data taken from the sample in sections 3.2.3 and 3.2.4 by means of some of the students who experienced the COIL program and received some physics elements in their history course. Note that no Indonesian students were attending the course at SIT in Japan. Based on their nationality, the Indonesian students obtained a decreasing MGUDS-S total score of –1.50 ±11.01 from their pre–test and post–test, while the international students obtained an increasing MGUDS–S total score of 2.71±10.88. The p-value for each data set is summarized alongside the change. The large error bar in this change can be explained by the significant error of the CD criteria and the relatively small data size. Nonetheless, it should be pointed out that Indonesian students have an increasing CD value. This implied that implementing the COIL program and adding the history elements in the physics course for Indonesian students increased their CD scores. This interpretation is almost statistically significant with the overall p-value slightly > 0.05.

Table I The MGUDSS analysis comparison between the Indonesian and international students at SIT

Nationality (size)		Indonesian (76)				International Students at SIT (38)			
		Pre-test	Post-test	Change		Pre-test	Post-test	Change	
MGUDSS	DC	25.91 ± 2.74	25.34 ± 2.83	−0.57 ± 3.94	p = 0.104	26.03 ± 2.48	26.74 ± 2.69	0.71 ± 3.66	p = 0.078
	RA	26.04 ± 2.57	24.96 ± 3.17	−1.08 ± 4.08	p = 0.001	25.71 ± 2.44	26.32 ± 3.11	0.61 ± 3.95	p = 0.203
	CD	15.75 ± 5.09	15.89 ± 5.20	0.14 ± 7.28	p = 0.820	18.13 ± 5.23	19.53 ± 5.37	1.39 ± 7.49	p = 0.074
	Total score	67.70 ± 7.96	66. 20 ± 7.70	−1.50 ± 11.01	p = 0.068	69.87 ± 6.89	72.58 ± 8.42	2.71 ± 10.88	p = 0.011

3.4. Discussions on the MGUDS-S analysis comparison between students taking the STEM course without and with implemented COIL program

To see the impact of the COIL program on Indonesian students, further analysis has been done. Table II presents a comparison of the MGUDS-S analysis between students taking the

physics course without and with the implemented COIL program. The former is the average data taken from the sample in sections 3.1.1, 3.1.2, by means the freshmen and junior students did not experience the COIL program upon taking their physics courses. The latter is the average data taken from the sample in sections 3.2.1 and 3.2.2, utilizing the sophomore and junior students who experienced the COIL program, and some of them received some history elements upon taking their physics courses. Based on this COIL implementation, the students who did not take the COIL class obtained decreasing MGUDS-S scores by –1.56±11.79 from their pre-test and post-test, while the students who took the COIL class obtained decreasing MGUDS-S scores only by –1.11±6.95. The P-value for each data set is summarized alongside the change. The large error bar in this change can be explained by the significant error of the CD criteria and the relatively small data size. Although the total overall p-value > 0.05 in these data sets, it should be pointed out that the students who took the COIL class have an increasing CD value within the error bar. These results are consistent with the fact that implementing the COIL program in the physics course for Indonesian students has reduced the decrease of their total MGUDS-S score and particularly increased their CD scores. Although it is not shown in the table, when we include the international students, the implementation of COIL increases the MGUDS-S score by 0.85, in contrast with the decline of –0.61 for the group of students who are not in the COIL program.

Table II The MGUDSS analysis comparison between students taking the physics course without and with implemented COIL program

Physics Course (size)		Indonesian Non-COIL (59)				Indonesian COIL (19)			
		Pre-test	Post-test	Change		Pre-test	Post-test	Change	
MGUDSS	DC	25.68 ± 2.79	25.12 ± 2.90	−0.56 ± 4.02	p = 0.066	26.63 ± 2.54	25.89 ± 2.49	−0.74 ± 3.56	p = 0.130
	RA	25.83 ± 2.64	24.78 ± 3.26	−1.05 ± 4.19	p = 0.005	26.63 ± 2.20	25.53 ± 2.76	−1.11 ± 3.54	p = 0.071
	CD	15.64 ± 5.54	15.69 ± 5.66	0.05 ± 7.92	p = 0.947	16.16 ± 3.67	16.89 ± 3.14	0.74 ± 4.83	p = 0.495
	Total score	67.15 ± 8.49	65.59 ± 8.19	−1.56 ± 11.79	p = 0.114	69.42 ± 4.78	68.32 ± 5.04	−1.11 ± 6.95	p = 0.383

3.5.Discussions on the MGUDS-S analysis comparison between the Indonesian students taking STEM modules without and with the history component

Furthermore, Table III presents a comparison of the MGUDS-S analysis between Indonesian students taking the physics course with and without the history component. The former is the average data taken from the sample in sections 3.1.1, 3.1.2, and 3.2.1 by means of the freshmen, sophomore, and junior students' experience taking purely physics. The latter is the average data taken from the sample in section 3.2.2, utilizing the junior students who experienced taking a physics course with some history elements in their physics course (physics+history) syllabus. Based on this additional history component, the students who took a purely physics class obtained a decreasing MGUDS-S score by –1.63±11.25 from their pre-test and post-test, while the students who took the physics course with the history component obtained a decreasing MGUDS-S score only by –0.36±7.71. The *p*-value for each data set is summarized alongside the change. The large *p*-value in the physics+history is due

to the small data size. However, if we consider the lower limit of the error bar, the reduced change in the decreasing MGUDSS score is quite significant. The change in the CD value for the students who took the physics+history class is again increasing by 1.55±4.45, showing the robustness of this piece of evidence. It becomes interesting to discuss the origin of the increase in the CD aspect in the MGUDS-S score of Indonesian students. Concisely, by implementing COIL and adding the history component to the physics course for Indonesian students, the decrease in MGUDS-S score could be reduced, and the CD aspect can be increased.

Table III The MGUDS-S analysis comparison between the Indonesian students taking physics courses without and with adding the History component

Course Element (size)		Physics (65)				Physics+History (11)			
		Pre-test	Post-test	Change		Pre-test	Post-test	Change	
MGUDSS	DC	25.78 ± 2.69	25.16 ± 2.82	−0.61 ± 3.89	p = 0.114	26.73 ± 3.10	26.18 ± 2.71	−0.55 ± 4.11	p = 0.380
	RA	25.85 ± 2.59	24.78 ± 3.18	−1.01 ± 4.10	p = 0.004	27.09 ± 2.12	25.73 ± 2.90	−1.36 ± 3.59	p = 0.096
	CD	15.76 ± 5.39	15.76 ± 5.43	0.00 ± 7.65	p = 0.894	15.82 ± 3.31	17.36 ± 2.98	1.55 ± 4.45	p = 0.299
	Total score	67.39 ± 8.09	65.76 ± 7.82	−1.63 ± 11.25	p = 0.070	69.64 ± 5.41	69.27 ± 5.50	−0.36 ± 7.71	p = 0.849

4. Conclusions

This study examined the impact of COIL programs on global competence (GC) for a cohort of Indonesian physics undergraduates and international engineering students in Japan. The results suggest that while STEM-focused COIL modules alone may not automatically enhance GC, incorporating an interdisciplinary Humanities component – such as history – can have a positive effect. The findings also highlight a broader trend: history-based modules, whether COIL or non-COIL, had a greater impact on GC than physics-focused modules. The two history courses mentioned allocated significant classroom time (roughly 30 minutes per week) to discussion-based activities, in contrast to the STEM-only courses which followed a conventional lecture format. This suggests that curricula centered on understanding cultural and historical contexts, in which students have frequent open, intra-group discussions as well as producing written assignments, can be highly effective in fostering intercultural understanding.

Returning to the STEM modules, it was also observed that the physics COIL which included a history component displayed a smaller decline in students' average GC scores than the modules that were physics-only, lending weight to the hypothesis that an interdisciplinary approach can be beneficial for the development of GC in STEM students. Notably, CD scores improved when participants completed an interdisciplinary STEM COIL with humanities elements. More than the other aspects of GC, CD aims to measure how participants actually 'feel' when working in diverse teams and is widely considered to be the most difficult aspect for educators to enhance. The two history-led modules (COIL and non-COIL) also saw improvements in students' CD scores, leading the study authors to believe that this approach

is effective for enhancing students' abilities to work in globalised environments. Despite these insights, the study had limitations especially in terms of small sample sizes. Larger sample sizes would be useful for determining how well the observed trends generalise – for example to students of different ages, and to ethnic and cultural groups other than the ones studied so far. Future research could also explore how different instructional strategies within STEM COIL modules might influence GC development. Given the increasing globalisation of STEM professions, it is crucial for universities to explore innovative pedagogical approaches that integrate technical knowledge with intercultural competencies. At present, it is accepted that COIL provides a valuable framework for international collaboration, enabling learning to be globalised in ways that weren't possible in the past. However, this study shows that the effectiveness of COILs in enhancing other desirable aspects of student development such as global competence can vary substantially depending on the extent to which interdisciplinary, discussion-driven, and reflective elements are incorporated. Future STEM COIL initiatives should consider leveraging humanities and social science perspectives to create more meaningful cross-cultural learning experiences for students.

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