Creating Innovation for Interdisciplinary Robotics Workshops: Solving Issues in the Online Project-Based Learnings in Engineering Education

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Abstract

In this paper, the study authors first introduce Shibaura Institute of Technology's 'Interdisciplinary Online Robotics Workshop', which has been carried out with our partner universities - primarily in Malaysia - since Academic Year (AY) 2020. We then describe the methods by which this online study abroad program has been evaluated. Next, we discuss the systematic issues that all online global project-based learning programs (gPBLs) can potentially be affected by. In general, issues affecting gPBLs can be grouped into two categories: those arising from participants' lack of subject knowledge, and those which are due to more 'cultural' factors, such as participants' lack of English-language skills and difficulty adapting to studying in a different cultural environment. These broad trends were discussed in our previous papers, which detail how these factors are important given the international nature of the gPBL program. This paper then highlights the most prominent issue identified in the Online Robotics workshop. Some students were not satisfied with the nature of the group projects in the online gPBLs. For online gPBLs, ongoing and proactive evaluation of students' level of engagement in group work is particularly important. As a countermeasure to this issue, two assessment tools were applied to the SIT's Online Interdisciplinary Robotics workshops held in March in AY2021 and AY2022. One is our global competence assessment framework formed by combining the Miville-Guzman Universality-Diversity Scale - Short Form (MGUDS-S) and SIT's student satisfaction survey. It will be used to evaluate participants' global competence as well as to investigate weaknesses in the design of the online gPBL program. The other new tool is a new method of assessing students' level of engagement in group work based on an analysis of students' activity within the Slack collaboration platform. We believe that Slack-based evaluation can keep a more effective, accountable track of student activity; this should increase students' motivation to engage with the program and thereby enhance the overall strength of the online gPBL format.

Keywords: Online Study Abroad Program During COVID-19, Project-based Learning, Pedagogical Issues in Robotics Workshop, Issues of Group Work, Engagement in Group Work, Slack Evaluation, Program Evaluation (MGUDS-S)

Introduction

This Online Robotics workshop is a yearly, interdisciplinary, and project-based learning workshop, which was run in collaboration with University Tun Hussein Onn Malaysia in AY2020 and AY2021. In AY2022, it was instead conducted as a collaborative online workshop with a Thai university, King Mongkut's University of Technology Thonburi (KMUTT), which had taken the role of an observer of the AY2021 workshop. The SIT's Online Robotics workshop was originally designed to be held in person, but due to the impact of the COVID-19 pandemic the program has actually been run in using the hybrid 'HyFlex' format for the past three years, with Japanese students physically present (at the SIT campus) and students from overseas participating online (Figures 1-1 and 1-2).

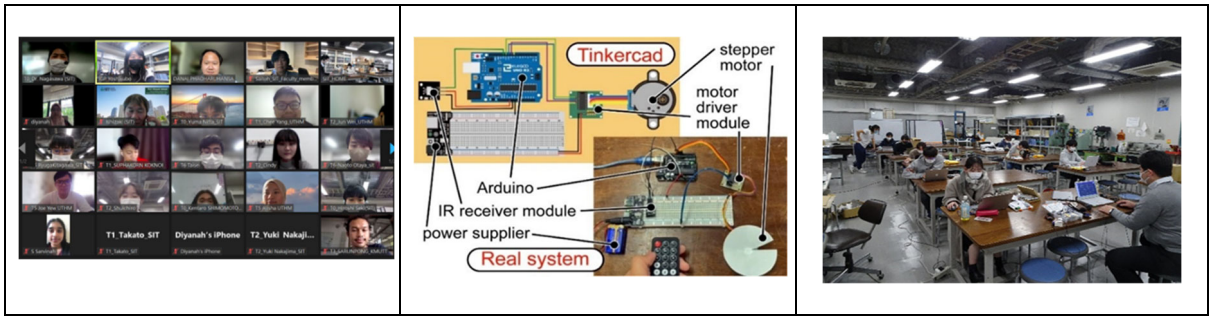

Figure 1-1: Online Robotics workshop in AY2021

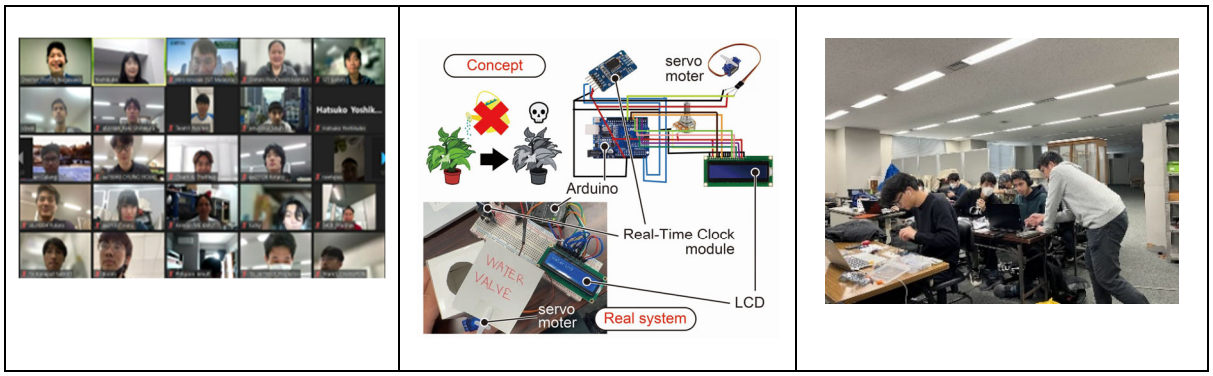

Figure 1-2: Online Robotics workshop in AY2022

The workshop, in large part due to its interdisciplinary and international nature, has comprised an important part of SIT's efforts to enhance equity and create opportunity in engineering education. Within the context of SIT's programs and courses, an 'Interdisciplinary Program' is defined as a learning experience for which participation is not limited to robotics majors or to students of any particular major. As demonstrated below, participants' majors varied, and included a diverse mix of science and engineering subjects.

Table 1: Participants by study majors in the AY2021 and AY2022 workshop

Study major	AY2021 workshop	AY2022 workshop
Automotive Engineering	0	2
Computer Science	0	1
Electrical and Electronic Engineering	12	0
Electronic Engineering	3	2
Engineering Science and Mechanics	1	1
Environmental System	1	0
Information and communications Engir	0	1
Information Engineering	1	0
Material Science and Engineering	1	0
Mechanical Engineering	5	15
Total	18	22

The Online Robotics workshop offers content that stimulates intellectual interest in both the sciences and the humanities. It is interdisciplinary both in its content - incorporating history and humanities modules - and in the composition of its participants. And equally importantly, it promotes equity through its expected outcomes of building students' cultural awareness and aiding their acquisition of collaboration skills across international boundaries.

Each year, the workshop welcomes about twenty-five students. Below are the expected learning outcomes for this year's Online Robotics workshop:

1. To provide participants with an education in robotics and engineering, using the Arduino and TinkerCad toolkits.
2. For overseas participants to receive an introduction to the one-semester study abroad programs and laboratory internship options at our institution.
3. For overseas participants to gain an understanding of Japanese culture and its unique impact on the field of robotics.
4. For Japanese students to learn more about their own culture and history.

The MGUDS-S

Since the 2019 academic year, the MGUDS-S tool has been the standard method used at SIT to evaluate all the online study abroad programs conducted at our institution. It was created by Prof. Marie Miville at Columbia University in the United States [1], [2], with a Japanese version later being developed by Oda et al [3]. It consists of a 15-question written survey, with responses scored on a 6-point Likert scale. The MGUDS-S tool is free of charge to use, and has consistently proven itself to be an effective assessment system, both in American higher education and in universities worldwide [4], [5]. It outputs an 'overall score' and three sub-scores, which are as follows:

1. ‘Diversity of Contact (DC)’ - the behavioral aspect, measuring study participants’ interest and willingness to engage in activities with people from diverse backgrounds.
2. ‘Relativistic Appreciation (RA)’ - the cognitive aspect, measuring participants’ recognition of the value diversity adds to one’s life and their respect for cultural differences.
3. ‘Comfort with Difference (CD)’ - the affective aspect, measuring the extent to which participants ‘feel comfortable’ interacting with people from diverse backgrounds.

The mean average of the scores for each of these measures is referred to as the subject’s ‘global competence’ score’.

Issues with SIT’s Online gPBLs identified in AY2020, and resultant innovations applied for the AY2021 Online Robotics workshop

In previous studies, Global Project-based Learnings (gPBLs) have been shown to be effective from both quantitative and qualitative perspectives [6], [7]. However, several issues with the gPBL format have also been identified [8], [9]. When our university conducted an institutional survey of the online programs which were implemented in AY2021, the results were surprising and contrary to our expectations. The participants in the short-term, online English Language training programs showed a greater increase in their ‘global competence’ scores than the online gPBL participants. More precisely, there was actually no statistically-significant observed change (when scores were averaged across all students) to the gPBL participants’ total global competence scores [10]. What are the possible reasons for this outcome?

Below are the major systematic issues previously identified with the interdisciplinary robotics workshop which ran in AY2020 - could these issues be affecting the university’s other online gPBLs as well?

1. Participants’ lack of previous subject knowledge, especially in the fields of robotics and computer programming.
2. Participants’ lack of English language skills for, particularly for Japanese participants.
3. Difficulty in adapting to living in a different culture; this is seen to affect both Japanese and overseas students.

In an attempt to counter the above three factors, several innovations were applied for the AY2021 Online Robotics workshop. The workshop was divided into two parts, ‘Phase 1’ and ‘Phase 2’. Phase 1 has a duration of fifteen hours over five days, is only for Japanese

students, and focuses on letting them practice self-introductions and learn how to make effective presentations in English.

Phase 2 has a duration of 32 hours over five days, and is attended by all students taking the online gPBL program, whether they are from Japan or from overseas. The first day of Phase 2 has a time allocation of eight hours and is devoted to humanities subjects; it features lectures aimed at developing cross-cultural understanding and collaboration skills. The remaining 24 hours of Phase 2, spread over the other four days, are solely focused on robotics and computer programming; day 2 focuses on fairly basic programming skills such as the use of TinkerCad, and days 3, 4, and 5 are spent on the program's main robotics project. As such, out of the total 47 hours of workshop contact time, roughly 50% is allocated to robotics content and 50% is allocated to humanities content.

After these changes were introduced for AY2021, a program evaluation was conducted with the aid of the MGUDS-S assessment tool [11]. There were twenty-four students taking this Online Robotics workshop in AY2021, and the number of those who responded to the survey was 13. The results of measuring the students' total global competence scores pre- and post- program showed a slight increase from 67.15 in the pre-program survey to 68.38 in the post-program survey, on a total scale of 90 (Table 2).

When broken down into separate measures for 'DC', 'RA', and 'CD', the average pre-program scores for the participants were 25.23, 26.46, and 15.46 respectively on a scale of 30.00, and their post-program scores were 28.00, 28.00 and 12.38 respectively. The biggest increase was for 'DC' ('Diversity of Contact'), with an observed increase also occurring in students' scores for 'RA' ('Relativistic Appreciation'). Post-survey scores for 'CD' ('Comfort with Difference') were actually lower than those measured at pre-survey – this was a common tendency across all our institute's online gPBL programs in AY2021 [10].

Table 2: Assessment of participants' global competencies
in the AY2021 Online Robotics workshop

n=13	Pre-survey	Post-survey	
MGUDS-S three sub-scales	Mean	Mean	Change
Diversity of Contact (DC)	25.23	28.00	2.77
Relativistic Appreciation (RA)	26.46	28.00	1.54
Comfort with Difference (CD)	15.46	12.38	-3.08
Total score	67.15	68.38	1.23

To sum up, the study authors concluded that result for the AY2021 Online Robotics workshop suggests the following points:

1) The innovations applied to the AY2021 online workshop seemed to have had some effect, but the combination of the low number of respondents and the fairly small increase in students' average global competence scores at post-test meant that a firm causative increase could not be clearly identified. In order to confirm the effectiveness of the innovations we have made, a study involving a larger number of students will be required - and for the AY2023 we intend to roll out the new assessment tools to cover all of the university's gPBL courses.
2) The lower 'CD' scores observed at post-survey might be the key to further study - as this trend was observed for a larger number of students across the university's whole gPBL offering.

Research objectives

In this paper, we investigate if there are further identifiable issues which can be found with the design and format of the Online Robotics workshop. Our research questions ('RQs') for this paper are as follows:

1. Can the MGUDS-S assessment tool be used to investigate weaknesses in the current design and format of the online gPBL programs?
2. Do MGUDS-S scores actually have a stronger correlation with students' 'self-described' satisfaction than the traditional 'how would you rate this course out of 5' Likert-scale satisfaction questions?
3. Can Slack-based evaluation provide a more effective way to keep track of participants' engagement in the group work activities that form part of the online gPBL program, and hence be used to improve the overall effectiveness of the online gPBL?

Methodology 1: Using MGUDS-S to investigate possible weaknesses of SIT's online gPBLs

Our institution has combined the MGUDS-S assessment tool with our own student satisfaction survey (Table 3); drawing on both of these we have devised what we refer to as an 'overall global competence / satisfaction assessment framework'. Our student satisfaction questionnaire consists of a 6-question written survey, with responses scored on a 5-point Likert scale as follows:

Table 3: SIT's student satisfaction questionnaire combined with the MGUDS-S

1)	Are you satisfied with the study abroad program, in terms of the support you have received from university faculty and staff?
2)	Are you satisfied with the study abroad program, in terms of the opportunities for collaboration delivered by the course format, and the other students' willingness to collaborate?
3)	Are you satisfied with the study abroad program, in terms of the facilities offered for online learning?
4)	Are you satisfied with the study abroad program, in terms of the course length and how well the length of the course matched the amount of content covered?
5)	Are you satisfied with the study abroad program as a whole?
6)	6)Please describe in your own words your opinions and impressions regarding the study abroad program you have taken part in. In particular, please feel free to mention any thoughts or feelings you had about the program which are not covered in the questions above.

What our paper proposes is that our new 'combined' assessment framework can be used not only as a global competence assessment tool but also to investigate the link between student course satisfaction (particularly the views expressed by students in the 'open feedback' section in question 6 shown above) and post-program total global competence scores. We should be able to find out whether those students whose MGUDS-S scores increased throughout the course tended to also give positive 'satisfaction survey' feedback, and similarly whether students whose MGUDS-S scores decreased tended to give negative feedback. Do MGUDS-S scores actually have a stronger correlation with students' 'self-described' satisfaction than the traditional 'how would you rate this program out of 5' Likert-scale satisfaction questions?

Below are excerpts from the feedback of students whose post-test total global competence scores were lower than their pre-test ones, describing how they felt about the group work in the Online Robotics workshop:

Table 4: Excerpts from the student feedback in the AY2021 Online Robotics workshop

1)	"There was one team in which three out of four team members were absent".
2)	"I felt sad and felt that it was unfair that my team members were absent for most of the group work and showed up only on the day of the presentation."
3)	"I felt my English skills were not good enough."

As can be seen from these comments, the most prominent issue was that some students were not satisfied with the nature of the group projects in the online gPBLs - this was the most common item of negative feedback. In particular, it seems that different students had

varying expectations and attitudes in terms of how they wanted to approach the group work and how much effort they were willing to put into it. This led to friction and dissatisfaction, which may have been a key caused of the near-zero growth in students' average global competence scores.

As might be expected, there does appear to be a loose correlation between students' positive or negative Likert-scale feedback and the sentiments they expressed in the 'open feedback' section on the student satisfaction survey. However, it should be noted that only half of the students actually gave feedback in the open section, and only a single student gave a rating of less than 'somewhat satisfied' for any aspect of the course which they were asked to rate on a Likert scale. Contrastingly, of the students who did make comments in the open feedback section, several of them expressed negative sentiments overall. Therefore it seems we cannot really draw any firm link or quantitative correlation between the Likert-scale feedback scores which students gave the program, and the views they expressed when asked to rate the program in their own words. As well as the lack of 'open' feedback from some students, another factor making it difficult to obtain meaningful data from these traditional forms of feedback is that many students tend to automatically give positive scores ('Satisfied' or 'Very Much Satisfied') when asked to give ratings on a Likert scale'.

On the other hand, when we look at students' MGUDS-S scores before and after the course, and then look again at the open feedback students expressed in their comments, we can see that of the 5 students whose MGUDS-S scores declined, 3 of them expressed negative sentiments about the course and only 1 made positive remarks in the open feedback section. This looks more like a potentially meaningful correlation, and we believe that with data from more students (when this methodology is applied at a larger scale in future programs), there is more likely to be a significant, meaningful correlation between these two measures: 'open feedback' and 'pre- and post-program MGUDS-S scores'. Since our assessment tools deliver a definitive global competence score for every student, tracking and analysing the other forms of feedback received from those students whose global competence scores decrease over the course may be a better way to identify weaknesses in the course format. One remaining challenge is to find a way to incentivise far more students to leave substantial 'open feedback' comments, so that the feedback data set to be compared and linked to students global competence scores is as complete as possible.

Methodology 2: Using the Slack collaboration platform

Now it is clear that 'lack of student engagement' is one of the main weaknesses of the online gPBLs, which might have caused almost zero growth in the total global competence

scores of the institutional online gPBLs' survey for AY2021. What steps can be taken to measure participants' engagement to improve the online gPBLs and to make them more effective? First and foremost, communication in group work is just as essential as it would be in a traditional 'face to face' program. Being in the same place encourages all team members to participate and contribute. Online gPBLs lose this physical presence, non-verbal communication, and responsibility to actively participate. Using whiteboards for drawing or sharing diagrams and formulas help, but verbal communication still plays an integral role in online gPBLs.

A possible solution would be to monitor student participation while letting participants know the evaluation criteria. This will ensure that group projects are progressing as intended by the format and that learning processes are being followed and learning outcomes achieved. However, the online format makes it more challenging for program organizers alone to make sure that students are actually communicating with each other.

The positive educational effects of online communication tools such as Slack and WhatsApp have already been pointed out by many studies [12], [13], [14], [15], [16]. But most of these studies have only focused on the usefulness of these tools for fostering communication among students in the classroom, rather than on their potential usefulness as course evaluation tools. In the following section, the Slack platform which was used by the 'Online Robotics Workshop' participants to communicate with each other about their group work will be examined, to determine its effectiveness as a tool for assessing student engagement in a group activity. With this technology-based tracking method, there is no need to assign human facilitators to constantly monitor group activities, as communication over Slack channels can instead be automatically recorded for later analysis. As 'engagement score' contributes to students' final grades, students were strongly encouraged to put as much of their intra-group communication as possible in the group Slack channel which we provide for them.

Analysis of students' engagement in online group work and discussion using the Slack messaging platform

The first action in the study was to put together a 'Slack evaluation development team' consisting of five students (two master's course students and three undergraduates) all selected from the body of students taking Robotics courses at SIT. These students all have recent, first-hand experience of using Slack for group work, discussion and collaboration. The professors running the study and these students then had a thorough brainstorming session on how best to establish effective measures for assessing student engagement in

group work, by analysing a range of different actions and activities on the Slack messaging tool. A key idea that emerged was to categorise every instance of a student's activity on Slack into one of three levels, with (A) being the highest (suggesting a high level of engagement in the project) and (C) being the lowest as follows:

1. Group A includes:

- Words and actions essential to the progress of the group work.
- Words and actions that contribute to the group activities, such as sharing circuits produced by Tinkercad and sharing references regarding their project.
- Expressions of ideas and opinions which directly contribute to or influence the direction of the group project.
- Providing program code.
- Video clips of the work produced by the group.

2. Group B includes:

- Any comments which cannot be clearly categorised into either Group A or Group C.
- Comments which our assessors judged had facilitated the progress of group work, without directly triggering a 'next step' in the project. For example, just expressing encouragement to other group members.

3. Group C includes:

- Casual conversation unrelated to the project, emoji, and other reactions as well as simple 'yes' / 'no' type responses.
- Sharing Zoom links, Google slides, etc.
- Posting presentation materials in the group chat (as all students have access to these already).
- Statements with no identifiable meaning.
- Repetition of a statement the same or very similar to one the student had already made.
- 'Negative' statements which might demotivate the team.

Two of the undergraduate Research Assistants selected from the aforementioned 'Slack evaluation development team' were put in charge of Slack analysis and categorizing students' verbal communications under the supervision of the program organizer. Table 5 below compares the assessed levels of engagement in group work of AY 2021 workshop participants and AY 2022 workshop participants. In AY2021, the total number of Slack comments posted by participants over the course of a 5-day workshop was 465, whereas in AY2022 the participants posted 1042 comments in total. Dividing these numbers by the number of

workshop participants (20 and 23 respectively) shows that the number of posts per participant nearly doubled from 23.25 in the AY2021 workshop to 45.30 in the AY2022 workshop.

These results strongly suggest that the introduction of a defined evaluation method (in this case Slack), in combination with making students aware of exactly how their group work will be assessed and evaluated, can play an important role in influencing participants' motivation and level of engagement in group projects'.

Table 5: Comparing the post number on Slack per participants between the AY2021 and the AY2022 workshop

Year	Post number	Number of participants	post number per participant
2021	465	20	23.25
2022	1042	23	**45.30**

Figure 2 below compares students' daily engagement on Slack between the AY2021 and the AY2022 workshops. 'Daily engagement' is defined as the total number of messages sent on this slack channel, which constitutes the y-axis of the graph. The first day showed the lowest level of engagement, with engagement hitting its peak on the third day which was the day of the mid-term presentation. Interestingly, after the mid-term presentation the engagement level went back down. This was an unexpected outcome as we had anticipated that students' engagement levels would be at their highest on the day before the final presentation.

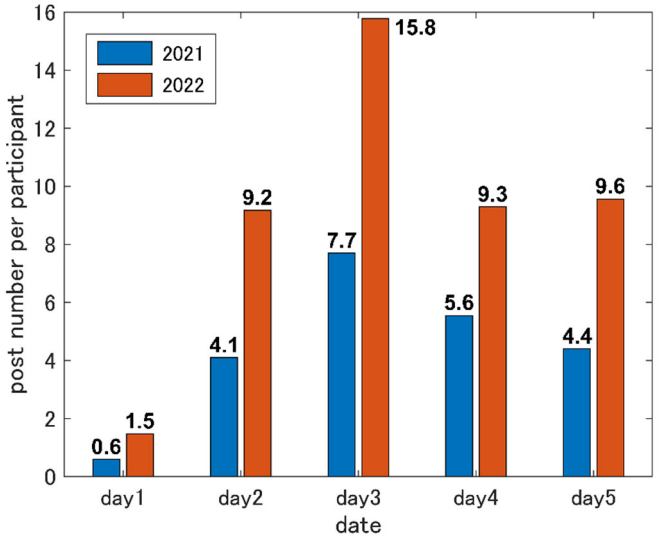

Figure 2: Comparing students' daily engagement on Slack between the AY2021 and the AY2022 workshops.

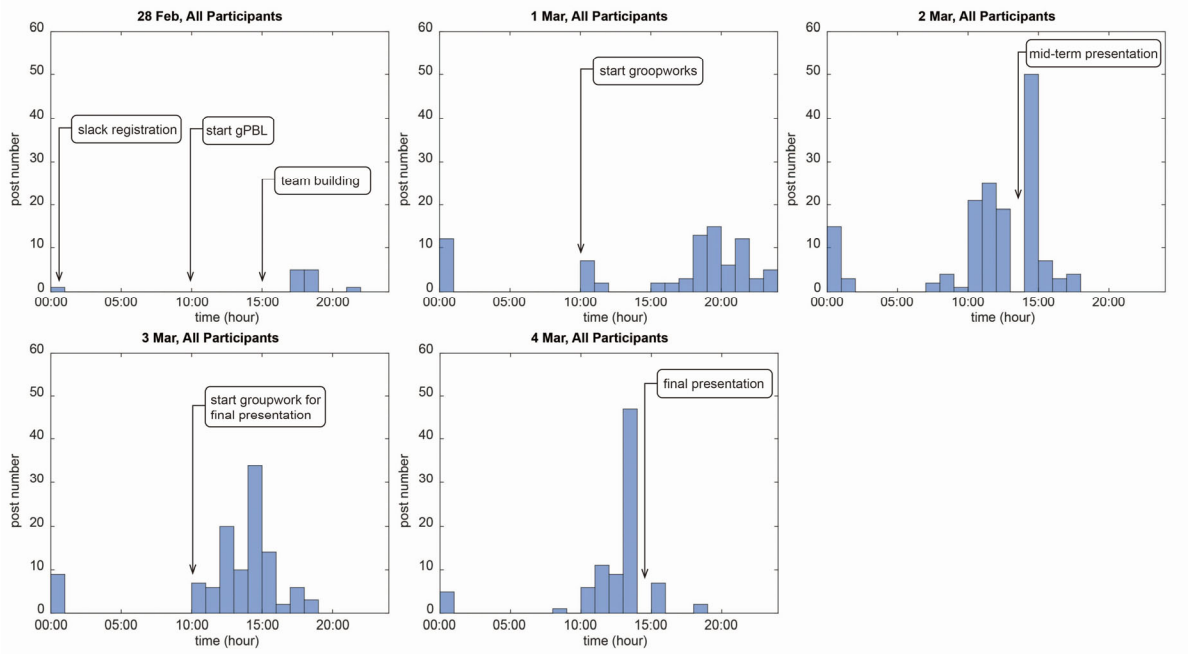

Figure 3-1: The hourly engagement pattern of all participants, on each day throughout the week of the AY2021 workshop

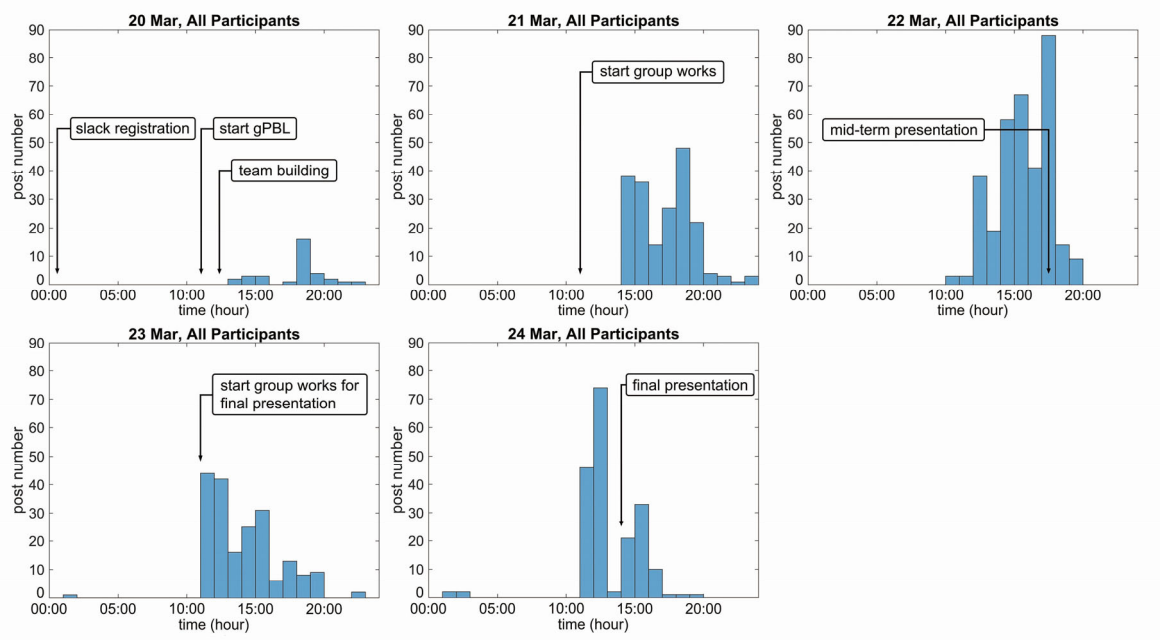

Figure 3-2: The hourly engagement pattern of all participants on each day throughout the week of the AY2022 workshop

The graphs in figures 3-1 and 3-2 above show the hourly engagement pattern, again based on the 'total' engagement of all participants in the group's Slack channel, on each day of the 5-day workshop in AY2021 and AY2022. As mentioned above, although the number of

messages per participant nearly doubled from 23.25 in the AY2021 workshop to 45.30 in the AY2022 workshop, the ‘trend line’ of activity over time looks very similar due to the fact that the program content itself was almost the same. For example, in both years the level of activity on Slack was at its lowest on the first day of the workshop, and peaked on the third day.

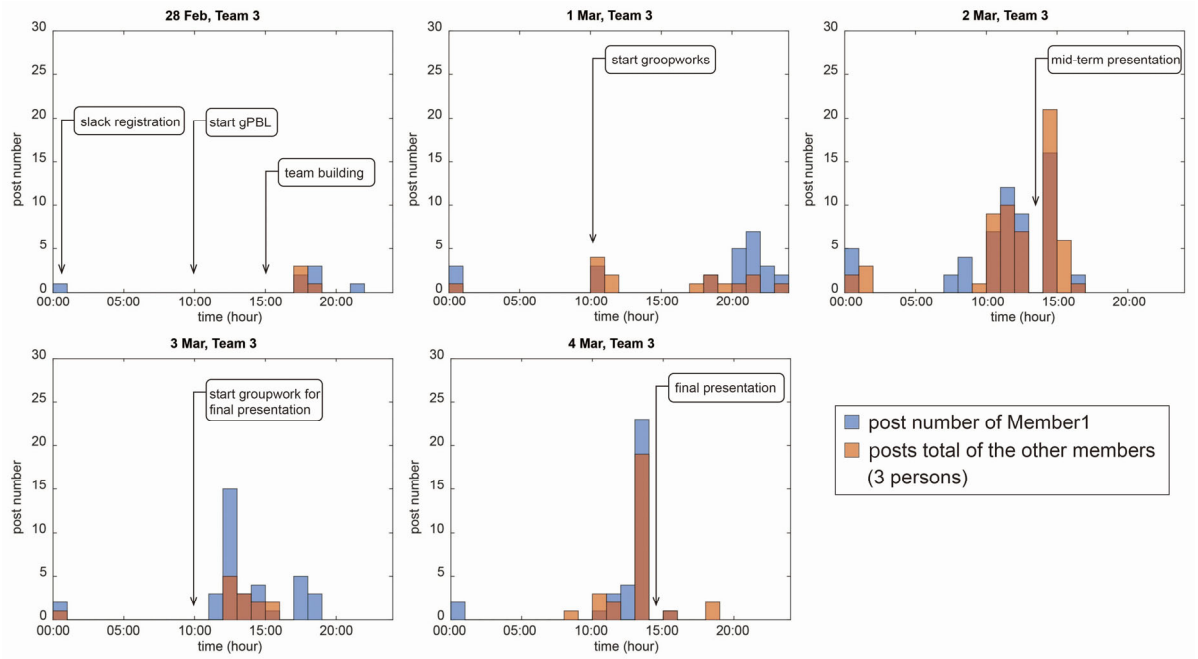

Figure 4-1: The hourly engagement pattern of ‘Student A’, whose global competence score showed a decrease after the workshop in the AY2021 *Note that these are ‘stacked’ bar charts so the y-axis value represents the total number of posts (in a particular hour) made by ‘Member 1’ and the rest of the group collectively.

The graphs in figure 4-1 above show the hourly engagement pattern on each day of the AY2021 workshop of an individual student (‘Student A’) whose global competence score showed a decrease after the workshop. The graphs also show the hourly engagement patterns of the other members of her working group. Student A is one of the students who commented negatively in the open feedback section in question 6 of the student satisfaction survey (see Tables 3 and 4 above); Student A is indicated in blue on the graph. These graphs demonstrate that Student A’s level of activity on Slack (defined as number of messages sent) was approximately three times greater than the ‘collective’ activity of the other members of her group, with the difference being greatest on the day before the final presentation (day 5).

Moving on to a similar example from the AY2022 workshop, the graphs in figure 4-2 down below show the hourly engagement pattern on each day of the workshop of another

student (‘Student B’) whose global competence score decreased after the workshop, and also show the engagement patterns of the other members of his working group. Student B is indicated in blue on the graph. These graphs demonstrate that Student B’s level of activity on Slack was approximately two times greater than the ‘collective’ activity of the other members of his group on the days of the mid-workshop presentation and of the final presentation (days 3 and 5).

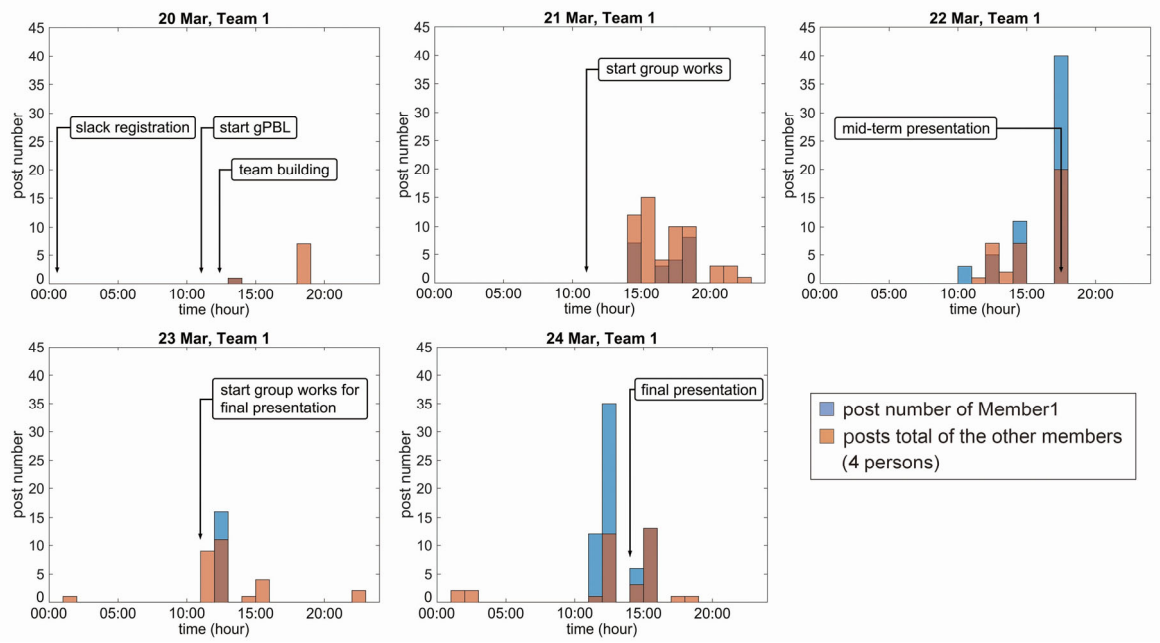

Figure 4-2 The hourly engagement pattern of another student, ‘Student B’, whose global competence score showed a decrease after the AY2022 workshop

Next, the graphs in figure 5-1 below show the percentage (on each day of the AY2021 workshop) of total group engagement that came from ‘Student A’ described in figure 4-1, and also the percentage that came from each of her fellow group members.

The x-axis in figure 5-1 categorises students’ Slack communication into three different types, with ‘A’ being the ‘highest’ level (relating to the exchange of information crucial to group progress) and ‘C’ being the ‘lowest’ level (including one-word messages indicating agreement, posting of external links, and other nonessential communication). Student A is labelled as ‘Member 1’ in blue in the graph; it can clearly be seen that her engagement accounts for over half of the total communication within the group on any given day, and also over half the communication at any particular level. This strongly suggests that within her working group she was contributing most of the work to the project - certainly more than any other member, and possibly an outright majority of group work.

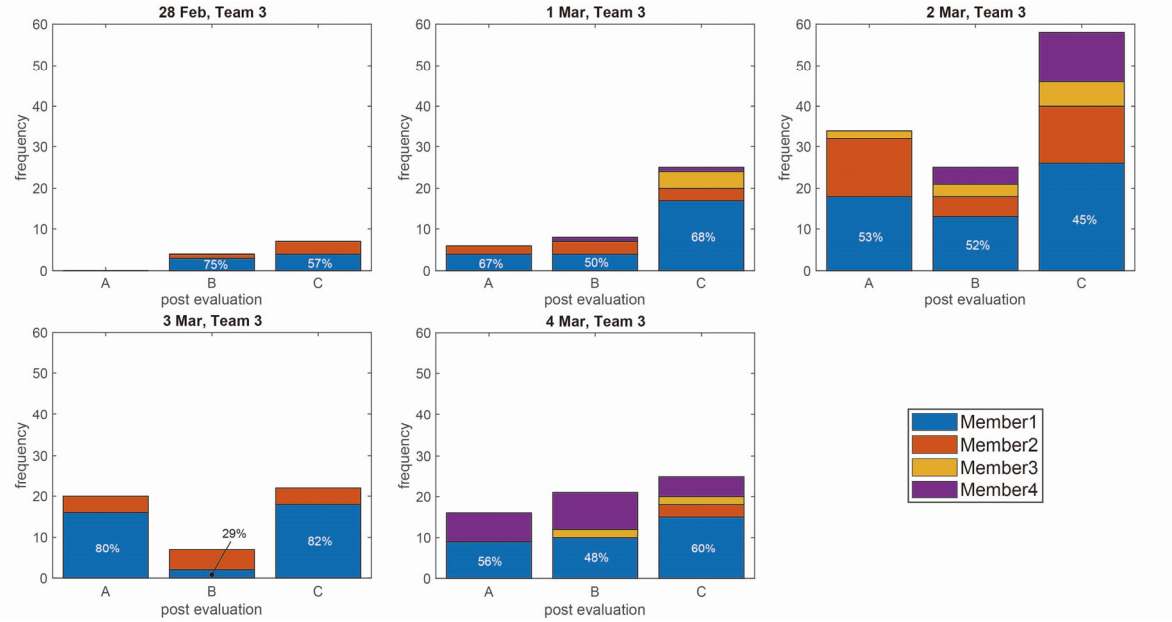

Figure 5-1: The percentage, on each day of the workshop, of total group engagement that came from 'Student A' described in figure 4-1, and also the percentage for each of her fellow group members in the AY2021 workshop

If we look more closely at the data from March 3rd (Day 4) in figure 5-1 we can see that Student A's engagement accounted for approximately 80% of all intra-group communication. All group members were supposed to be actively involved in preparation on the day before the final presentation, but members 3 and 4 made no comments on Slack at all. Another student 'Member 2' (indicated in red on the graph) did show a small amount of participation. It was also observed that on Day 5, the day of the final presentation, 'Member 4' (who had sent no Slack messages on the previous day) suddenly became an active participant in the group's online communication. His engagement level on Day 5 accounted for approximately 44% of all group communication. However, when we checked the actual contents of his comments on Slack, we found out that Member 4 did not actually understand the task he had been assigned within his group. Therefore he was receiving thorough guidance from Member 1 (=Student A), which caused Member 4's engagement level to rise suddenly on the final presentation day.

In contrast, we can also see from figure 5-1 that Member 2, who worked with Member 1 (Student A) on March 3rd, did not speak much on March 4th which was the final presentation day. It was reported later that Member 2 had fallen ill and been taken to hospital on that day. All these factors may have contributed to Student A's item of negative feedback shown in

Table 4 above, “I felt sad and that it was unfair that my team members were absent for most of the group work and showed up only on the day of the presentation.” As such, the Slack data has provided us with more than enough evidence that this student’s feedback, which was critical of her colleagues’ engagement in the group project, was indeed plausible.

The graphs in figure 5-2 below also show the percentage, on each day of the AY2022 workshop, of total group engagement that came from ‘Student B’ described in figures 4-2, and also the percentage for each of his fellow group members. Student B is shown as ‘Member 1’ in blue in this graph; it can clearly be seen that on the mid-workshop presentation and final presentation days, his engagement accounted for over 66% of the group’s total communication. This strongly suggests that within his working group he was contributing most of the work to the project - certainly more than any other member - in a similar manner to ‘Student A’ in the AY2021 workshop as shown in figure 5-1.

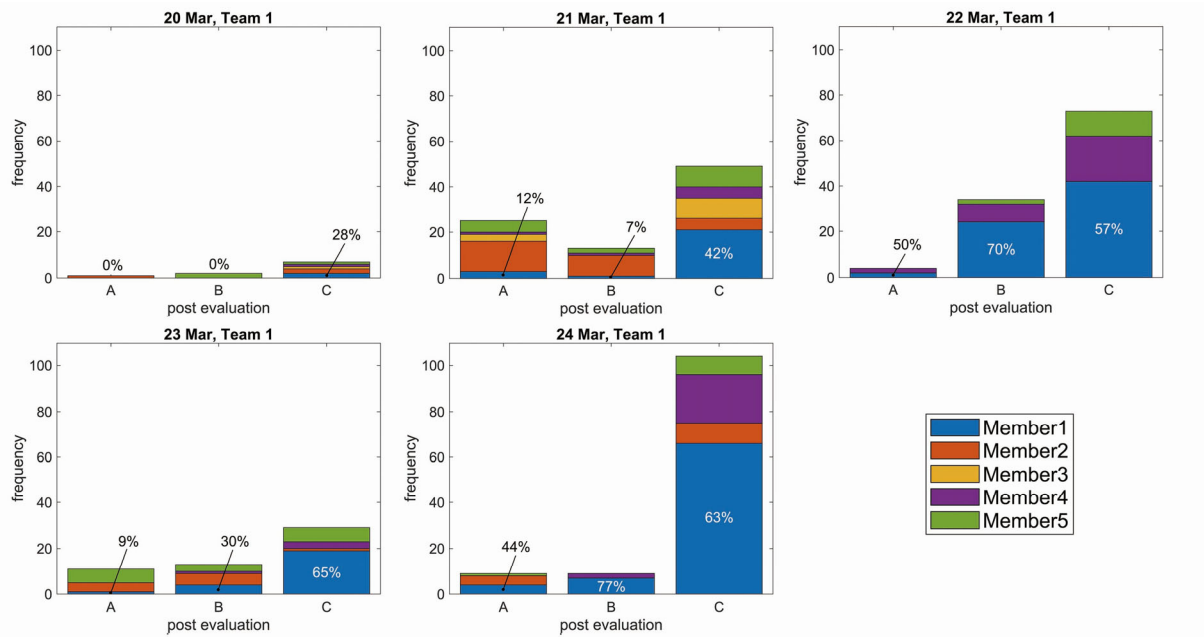

Figure 5-2: The percentage, on each day of the workshop, of total group engagement that came from ‘Student B’ described in figure 4-2, and also the percentage for each of his fellow group members in the AY2022 workshop

What has been observed from these assessments is that Slack-based evaluation enables easy analysis of the level of engagement in online group work being displayed by individual students and by the whole student body for the course in question. It can also be used to look in more detail at the engagement of just those students whose global competence scores decreased - rather than increasing as expected - between the pre-course and post-course

assessments. Similarly, we can analyse the engagement level of students whose scores increased the most, or of students selected by any particular criteria.

More detailed analyses of data gathered from Slack will be collated and presented in our future paper. However, it should also be noted that Slack-based evaluation is only effective for online programs and 'hybrid' or 'HyFlex' (combined online / face-to-face) programs such as ours; naturally an online tool like this does not offer any way to trace students' face-to-face communication in a classroom setting, which is the main type of communication taking place in many 'traditional' face-to-face programs.

Conclusions and further study

In this paper, the following two assessment tools were introduced to find out whether they can be effectively used to investigate pedagogical issues in SIT's Online Robotics workshop:

- A new 'combined' global competence / student satisfaction assessment framework, formed by combining the MGUDS-S assessment tool and our own student satisfaction survey. This framework was successfully used to evaluate participants' global competence and also to investigate any systematic issues that may exist with the online gPBLs.
- A new method of assessing students' level of engagement in online group work, based on analysis of students' individual activity and total group activity within the 'Slack' collaboration platform.

Looking at the AY2021 and AY2022 workshops after these new methodologies were applied, we have reached the following conclusions which can also serve as answers to the research questions asked by this paper:

1. The aforementioned combined assessment framework can be used not only as an assessment tool for students' abilities, but can also be used to investigate the link between the views expressed in the 'open feedback' section in the student satisfaction survey and the positive (or negative) change in their global competence scores. In this way, weaknesses in the program can be pinpointed and explored in more detail (RQ1).
2. The results of the studies carried out on the AY2021 and AY2022 Online Robotics workshops suggest a potentially meaningful correlation between the students' MGUDS-S scores before and after the workshop and the student feedback received in the 'open feedback' section (RQ2). With the aid of data from more students when this methodology is applied at a larger scale in future programs, the study authors expect that there is more

likely to be a significant, meaningful correlation between these two metrics, 'open feedback' and 'MGUDS-S scores pre-and post-program'.

3. The effectiveness of Slack engagement evaluation as an online group project assessment tool was confirmed through the pilot assessment in the AY2021 workshop and the assessment in AY2023. The number of posts per participant over Slack nearly doubled from 23.25 in the AY2021 workshop to 45.30 in the AY2022 workshop. These results strongly suggest that the introduction of a defined evaluation method (in this case Slack), in combination with making students aware of exactly how their group work will be assessed and evaluated, can play an important role in influencing participants' motivation and level of engagement in group projects'.

4. Since it enables easy monitoring and quantitative analysis of student engagement levels, 'Slack-based evaluation' has a strong potential to increase students' motivation to engage with the program at all points throughout the course. Resultantly, introducing this methodology should enhance the overall strength of the online gPBL format (RQ3).

In conclusion, in the research for this paper we observed the effectiveness of the combination of our new global competence assessment framework, the established MGUDS-S framework, and our new Slack-based method of assessing students' level of engagement in online group work. The study authors believe that the findings of this paper can serve as a good reference point for academics and administrators looking to enhance the overall strength of online gPBLs and similar programs under the 'new normal' of a world living with COVID-19. However, the following points do need to be explored further:

1) Since this Online Robotics workshop was conducted in a 'HyFlex' format, most SIT students spent a substantial amount of time in the classroom, and were therefore able to communicate with their group colleagues face-to-face in a way that would not be recorded by Slack or any other online tool. Therefore a certain portion of student communication, including intra-group communication, were inevitably absent from the data which went into our study.
2) Slack evaluation is only effective for online programs and hybrid (mixed online / face-to-face) programs, referred to within our department as 'HyFlex'. It is likely to be difficult to apply this methodology to traditional face-to-face programs, where engagement would instead need to be tracked through analysis of students' in-person verbal communication.

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References

[1] M. L. Miville, P. Holloway, C. Gelso, R. Pannu, et al., "Appreciating Similarities and Valuing Differences: The Miville-Guzman Universality-Diversity Scale," Journal of Counseling Psychology, vol. 46, no. 3, pp. 291-307, July 1999, DOI: 10.1037/0022-0167.46.3.291

[2] J. N. Fuertes, M. L. Miville, J. J. Mohr, W. E. Sedlacek and D. Gretchen, "Factor Structure and Short-form of the Miville-Guzman Universality-Diversity Scale," Measurement and Evaluation in Counseling and Development, vol. 33, no. 3, pp.157-169, 2000, DOI:10.1080/07481756.2000.12069007

[3] S. Oda, "Development and Evaluation of Global Competency for Science and Engineering Personnel," Ph.D. dissertation, Shibaura Institute of Technology, Kou, 246, 2019.

[4] K. Kegel and C. DeBlaere, "Universal-diverse orientation in Asian international students: Confirmatory factor analysis of the Miville-Guzman Universality-Diversity Scale, Short Form," Cultural Diversity and Ethnic Minority Psychology, vol. 20, no. 3, pp.469-474, July 2014, DOI: 10.1037/a0034746.

[5] D. Lang, M. Handley, A. M. Erdman, J. J. Park and M. Tsakalerou, "Intercultural Competency Differences between U.S. and Central Asian students in an Engineering Across Cultures and Nations Graduate Course," Conference paper of 2019 ASEE Annual Conference & Exposition, Tampa, Florida, June 2019, DOI: 10.18260/1-2-33005

[6] N. Avsheniuk, O. Lutsenko, O. Lutsenko, N. Seminikhyna and T. Svyrydiuk, "Fostering Intercultural Communicative Competence and Student Autonomy through Project-Based Learning," *AWEJ Special Issue on Communication and Language in Virtual Spaces*, pp.130-143, January 2023, DOI: 10.24093/awej/comm1.10

[7] T. Fortune, S. Borkovic, A. Bhopti, R. Somoza, H. Chan Nhan and S. Rangwala, "Transformative Learning Through International Project-Based Learning in the Global South: Applying a Students-as-Partners Lens to a "High-Impact" Capstone," *Journal of Studies in International Education*, vol. 23, no. 1, pp.49-65, November 2018, DOI: 10.1177/1028315318814571

[8] P. P. Srinivasa, N.C. Niranjan and B.R. Shrinivasa, “Project Based Learning (PBL): Issues Faced by Faculty for its Effective Implementation,” *Journal of Engineering Education Transformations*, vol. 31, no. 3, pp.9-16, January 2018, DOI: 10.16920/jeet/2018/v31i3/120743

[9] T. Yokemura and M. Inoue, “A Method to Solve PBL Issues and to Improve Project Management Competencies of Students,” *Management Studies*, vol. 6, no. 3, pp.147-166, May-June 2018, DOI: 10.17265/2328-2185/2018.03.001

[10] H. Yoshikubo, S. Aihara, M. Inoue, A. Yamazaki, N.Loader, H. Ishizaki and M. Tachibana, “Assessment of Online Study Abroad Programs from the Students’ Perspectives,” *Journal of JSEE*, vol. 71 no.1, pp.17-25, January 2023, DOI: 10.4307/jsee.71.1_18

[11] H. Yoshikubo, S. Nagasawa, N. Ibrahim, H. Ishizaki, and M. Tachibana, “Interdisciplinary Online Robotics Workshop: Pedagogical Issues and Innovations,” *Journal of JSEE*, vol. 71, no. 1, pp. 26-34, January 2023, DOI: 10.4307/jsee.71.1_27

[12] S. Müller, “How Slack Facilitates Communication and Collaboration in Seminars and Project-Based Courses,” *Journal of Educational Technology Systems*, vol. 51, no. 3, pp.1-14, January 2023, DOI: 10.1177/00472395231151910

[13] F. R. Kates, S. K. Samuels, J. B. Case, and M. Dujowich, “Lessons Learned from a Pilot Study Implementing a Team-Based Messaging Application (Slack) to Improve Communication and Teamwork in Veterinary Medical Education,” *Journal of Veterinary Medical Education*, vol.47 no.1, pp.18-26, February 2020, DOI: 10.3138/jvme.0717-091r2

[14] Y. Heryandi, I. Said, and R. Herlina, “Online Teaching in Writing by Means of Slack Application,” *Journal of English Education and Teaching*, vol. 4, no. 1, pp.49-68, March 2020, DOI: 10.33369/jeet.4.1.49-68

[15] D. Bouhnik, and M. Deshen, “WhatsApp Goes to School: Mobile Instant Messaging between Teachers and Students,” *Journal of Information Technology Education: Research*, vol. 13, pp.217-231, 2014, DOI: 10.28945/2051

[16] S. Dahdal, “Using the WhatsApp Social Media Application for Active Learning,” *Journal of Educational Technology Systems*, vol. 49, no. 2, May 2020, DOI: 10.1177/0047239520928307