

Exploring How Engineering Students Respond to Challenges While Working in Global Virtual Teams

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Abstract—This Research Full Paper aims to understand student experiences on global virtual teams in depth by exploring the challenges that students face, how they approach them, and how they assess their response to overcoming these challenges. During the COVID-19 pandemic, intercultural learning opportunities such as study abroad were limited, and many universities implemented global virtual team projects as an alternative approach to developing intercultural skills. Prior research of these programs has focused on identifying best practices, challenges, and learning outcomes, but has provided few insights into students' experiences in these projects. To explore these experiences, we collected written reflections from 65 students participating in global virtual team projects in the middle and at the end of the semester. We analyzed these data using a thematic analysis approach. We identified three main types of challenges that students experienced: group cohesion, communication, and project management. Students approached these challenges by making changes at the personal and the team level. Most notably, students tended to take a positive view of their approaches to addressing the challenges by suggesting that they found a solution, had a positive learning experience, or identified skills they wanted to improve in future projects. The results of this study can inform the design of global virtual project courses and encourage conversations about team conflict and how to address it while working in virtual cross-cultural environments.

Keywords—*Virtual teams, Reflection, Student experience, Team dynamics, Qualitative thematic analysis*

I. INTRODUCTION

Due to the increasingly global nature of engineering work, it is important that engineering graduates be equipped with skills that enable them to work successfully in cross-cultural teams. To work in such environments, engineers need to navigate boundaries of culture, time, language, varied perspectives, and working styles [1] and therefore, must be given opportunities to develop these skill sets before they graduate. Global virtual teams present an avenue for students to develop these skills while pursuing their engineering degrees without having to study abroad, which improves accessibility to these experiences for a greater number of engineering students [2]. Although global virtual teams are a promising approach to prepare global engineers, challenges related to cultural differences, language barriers, team conflicts, and

project management need to be addressed when coordinating these kinds of experiences [1], [3], [4]. Thus far, much of the research in this space focuses on navigating through these challenges from the perspective of program organizers or instructors [5]–[7]. Therefore, the purpose of this study is to understand student perspectives on the challenges they experience while working in global virtual teams and the approaches they use to address these challenges. To explore this topic, we addressed the following research questions (RQ):

1. What challenges do students identify while working in global virtual engineering teams?
2. How do students work to address these challenges?
3. How do students assess their responses to the challenges?

II. LITERATURE REVIEW

Engineering problems are globally situated, and engineers often work in globally distributed teams to solve these problems. To tackle such problems, engineers require the skills to work successfully with people from various technological, social, and cultural backgrounds. Engineers working on such problems are often located at different geographical locations and thus work collaboratively in global virtual teams [8]. To create similar experiences for students, universities have introduced virtual team experiences, especially during the COVID-19 pandemic. Prior research on global virtual teams in the classroom setting has indicated that they can support building cohesiveness in virtual peer teams, the development of students' professional networking skills, presentation skills, communication skills, intercultural skills, team management, and also help them gain a holistic perspective about their major/profession [8]–[12]. Such experiences can improve students' intercultural maturity and prepare them to work in diverse global settings [6].

Although global virtual teams can provide a platform for students to develop their professional, intercultural, and technical skills, they have their own set of considerable challenges. Instructors teaching courses that incorporate global virtual team projects have identified challenges related to cultural differences, preferred styles of teamwork, interpersonal issues (e.g., trust or motivation), personality conflicts, and project management issues (e.g., unequal workloads and

scheduling) [1], [3], [12]. Moreover, students in global virtual teams often need to work across different time zones, thereby increasing scheduling difficulties [1], [10]. Additionally, the study by Anagnos et al. [9] revealed that students from similar cultural/geographic backgrounds prefer using familiar online or technology resources instead of learning new platforms. They also found that many groups lacked structure in their project teamwork, which could be addressed by identifying a well-defined set of goals. Finally, cultural differences such as cultural stereotypes, communication styles, dialects, prejudices, power relations, and conflicting cultural practices were also identified as challenges faced by cross-cultural teams [11], [14], [15].

A range of best practices for coordinating global virtual team projects have been developed to overcome these challenges, including instructional practices, use of technology, and training. One approach is to adjust the instructional and pedagogy aspects of the course to include more guidance in the form of team procedures, roles, instruction virtual communication technology, incorporating scaffolding for positive team dynamics [5], [6], and class discussions or instruction [7] on cross-cultural collaborations [8]. Others have found it helpful to incorporate teacher training on digital literacy skills to help address challenges related to communication and the use of online platforms [16]. The use of technology such as online communication platforms can also help create effective learning environments [5] and foster developmental relationships using online practices [17]. A study by Cramton and Hinds [18] on global teams found that prompting individuals to share cultural dialects can be useful in overcoming tensions in interpersonal communication and organizational control. Providing cross-cultural training can also help overcome cross-cultural communication barriers and team member relationships [19]. Many of the studies on global virtual teams have made recommendations for improving these experiences based on suggestions from instructors or researchers. Thus far, there has been a little emphasis placed on understanding students' experience of the challenges they face and how they navigate them. Therefore, the purpose of this study is to understand student perspectives on the challenges they experience while working in global virtual teams and the approaches they use to address these challenges. The significance of this study lies in understanding how students approached these challenges so that we can better support them through this process.

III. METHODS

This study uses a qualitative research method to understand the challenges identified by students, how they approached these challenges, and their self-assessment of their approach while working on a global design project (GDP) in virtual teams. Our data were collected from a GDP course that is a part of an international engineering program (GEARE) at Purdue University. This program is available to undergraduate engineering students from all disciplines, and which typically requires international travel experiences. Due to the COVID-19 pandemic, these travel experiences were canceled for several semesters, and the GDP course was introduced to provide international experiences to students in the absence of travel abroad. In this course, students at Purdue University are placed in teams with students at collaborating universities abroad to work together on design projects that last the entire semester.

Students are provided with training in teamwork and cross-cultural communication strategies during class sessions, in alignment with the best practices identified in the literature.

A. Participants

In Spring 2021, 69 students participated in the semester-long GDP course from three universities – one in the United States, one in Ecuador, and one in Mexico. All participating students were undergraduate engineering students from various disciplines. Most of the students outside of the United States did not have English as their native language. Students from the U.S. university had taken a semester-long intercultural competency course, while the students from the other universities did not have any training beyond what was provided through the GDP course. Out of the 69 students, 65 students agreed to participate in this study, which was approved by the Institutional Review Board of Purdue University. The students were divided into six teams, each focusing on a different global design project. In this study, we focused on three project teams as students from these teams completed all the reflections (start, middle, and end semester). The three teams consisted of: 18 students from the U.S. university, 6 from the Mexican university, and 5 from the Ecuadorian university.

B. Data collection

Students were asked to complete individual written reflections at the start, middle, and end of the semester. The student reflections focused on the individual and team experiences of students while they worked in global virtual teams. The prompt for each reflection was provided in both English and Spanish and students were encouraged to reflect in the language in which they felt most comfortable. The start of the semester reflection asked students to share their prior experiences of working in cross-cultural teams and their goals for the project; because these topics are not relevant to this study, we did not analyze them for this paper (see [2] for an analysis of these reflections). Our analysis focused on the middle and end of semester reflections, the prompts for which are shown below.

Mid-Semester Reflection Prompts:

1. Tell the story about one specific experience on the team project that has been significant for your learning. This could be something that went well, was challenging, or helped you develop a different perspective. Explain what happened, how you responded, and what you learned from the experience (e.g., knowledge, skills, behaviors, perspectives).
2. Look back at your goals from the start of the semester. How have you been making progress in those areas? Are there other unanticipated areas where you have been learning? What changes could you make to improve your learning going forward?

End-of-Semester Reflection Prompts:

1. Same as Question 1 of mid-semester reflection
2. In addition to the learning mentioned as a part of the first question, what other knowledge, skills, behaviors, or perspectives have you learned related to working on a team project, working on a cross-cultural team, and/or working in a virtual environment?

3. What areas for growth can you identify that you want to continue working on in your: Next group project? Next cross-cultural experience?
4. Lastly, think about your team as a whole. What did the team do well? What areas for improvement might you identify if the team was going to work on another project together? (Which is typical in many work settings)

C. Data Analysis

To address our three research questions, we conducted a thematic analysis [20] to understand the major themes that emerged from student reflections. Thematic analysis is a qualitative analysis technique that aims to identify, analyze and report themes embedded within the data [20]. Our thematic analysis was driven by the research questions for this study, where unique themes were identified to address each research question. We followed the phases of thematic analysis as described by Braun and Clarke [20]. In the familiarizing with the data phase, our team of four researchers documented notes and ideas by reading student reflections. In the next step, the student reflections were divided among the four researchers, and initial codes were generated from the data set. Each researcher then identified potential themes that emerged from their coding. These potential themes were shared and discussed by the group of researchers and a final set of themes was generated during these discussions. As a group we developed definitions for each theme and then re-coded the data with the final set of themes and subthemes, as presented in the Results.

IV. RESULTS

In this section, the results of the thematic analysis of students' reflections are presented. The themes reveal the various challenges faced by students (RQ1), how they responded to the challenges (RQ2), and how they assessed the success of their response (RQ3). The results for each research question are presented in the sections below. We summarize the themes and subthemes, and number of participants mentioning (Frequency) the theme in Table I.

TABLE I. THEMES AND SUBTHEMES PREVAILING FROM REFLECTIONS

RQ	Themes, Frequency, and Subthemes from Student Reflections		
	Theme	Freq.	Subthemes
RQ1	Group Cohesion	15	Feeling excluded, Team biases and conflicts, Different working styles
	Communication	20	Language barrier, Discomfort with communication, Lack of communication
	Project Management	14	Time management/scheduling, Assigning roles, Division/completion of work
RQ2	Personal Changes	17	Empathy and increased self-awareness, Adaptability, Take on a new role
	Team Changes	17	Assigning roles and expectations, Time management/ communication structures, Use of technology
RQ3	Found a Solution	16	No subtheme
	Learning Experience	13	No subtheme
	Work on in the Future	15	No subtheme

A. Research Question 1: What challenges do students identify while working in global virtual engineering teams?

Our first research question explored the typical challenges that students identify as an individual or as a team while working in global virtual teams. This analysis revealed three themes: *Group Cohesion*, *Communication*, and *Project Management*.

1) Group Cohesion

One of the prominent challenges indicated in student reflections was their lack of *Group Cohesion*. We defined *group cohesion* as behavior that group members had toward each other. As we analyzed individual student reflections, we noticed patterns in the way students discussed their group dynamics such as biases that students had, tensions and differences that they experienced, and how they felt as a part of the group. Based on the analysis of student reflections, *group cohesion* could further be categorized into three subthemes: *feeling excluded*, *team biases and conflicts*, and *different working styles*.

The first subtheme captures how some students described *feeling excluded* while working in global virtual teams. Feelings of exclusion occurred for students who struggled to actively participate in group meetings, either because others were dominating the decision-making or because of a language barrier. Some students felt that exclusion happened more easily in the virtual setting as compared to regular team projects, as described by one student:

"I felt a little excluded as I wasn't ingrained by tasks, but we finally managed to come to an agreement. In addition to all this, it was difficult to have to work remotely. Even if we supported each other, suddenly I could not feel part of the project. I would have liked to be there." [Par. 7]

Another subtheme related to *Group Cohesion* that prevailed was *team biases and conflicts*. Team bias refers to the tendency of members to give preferential treatment whereas conflict in teams implies disagreement and confrontation between group members. Biases that students experienced included not trusting teammates with work/tasks and internal biases from previous team experiences. Analyzing team conflicts, we observed that common causes of tension occurred when students missed team meetings and when their personal goals did not align with group deliverables. A student reflecting on team confrontation said:

"The biggest problem in our team was the conflict between personal initiative and only working on deliverables that the teachers gave us. Firstly, the personal objectives were different. While for some people the grade didn't matter, to others it had a great significance." [Par. 17]

The third subtheme, *different working styles*, occurred frequently in student reflections because students from different cultural backgrounds may prefer different working styles. A participant described their surprise at the differences in working styles by mentioning:

"The first thing that I noticed is a little trivial, but it surprised me, and that was that fact that using Google docs for collaboration wasn't a common thing for the Ecuadorian students. This surprised me because I think this is the only thing that I have used to collaborate in a couple of years and it never occurred to me that it may not be used in other places." [Par. 30]

In addition to differences in technology preferences, students also identified differences in problem-solving styles and preference for collaborative or individual work for assigned tasks. In summary, we observed that *feeling excluded, team biases and conflicts, and different working styles* are common challenges that can hinder the development of *Group Cohesion*.

2) Communication

Many studies on global virtual teams suggest that communication is one of the most prominent challenges. A similar finding was observed while analyzing student reflections in this study. *Communication* as a theme broadly accounts for the interactions (verbal or text) that take place in teams. Along with the main theme of *Communication*, three other subthemes were identified from the thematic analysis: *language barrier, discomfort with communication, and lack of communication*.

The first subtheme identified that the *language barrier* within the global virtual teams presented a challenge for students, as highlighted in previous studies. A student reflected:

"One key example I would turn to that would explain this idea is the barrier created through language. Because I don't have a strong Spanish understanding, it makes it difficult to accurately explain some of my thought processes to some of the members in my group. During the first few meetings with my team, I struggled with getting some of my points across, and would definitely say that my team had some issues with moving forward in our tasks." [Par. 13]

The second subtheme, *discomfort with communication*, focused on the students' hesitancy to speak up in meetings or share their opinions while interacting with teammates. Students experiencing communication discomfort tended to stay quiet during team meetings and were fearful of how they may come across to their teammates. In some cases, this discomfort was connected to the language barrier, but other students described being shy or lacking confidence in their ideas. For example, one student observed that it was easier to let more talkative students dominate the conversation, saying:

"Often it is easier to allow this than to constantly ask quieter members for their input or try to bring everyone else up to speed. It is easy to say and believe that everyone's input is important, but often it is hard to implement that idea practically." [Par. 28]

The third subtheme emphasizes the *lack of communication* between team members. This subtheme refers to instances

where team members were not clear about what was expected from them because the team had failed to establish successful lines of communication. Noting the lack of participation of a few group members, a student specified:

"While planning our team project, I prefer to believe that we had communication issues. On the day we planned to meet I stayed up waiting for hours constantly texting the group waiting for a response from the team members, but none was provided. The day before the presentation one of the members texted the group in order to complete the task but, again, no one but myself responded. We both then proceeded to compile and present our answers to the class without the other group members and still not knowing what the situation was with the other members of our team" [Par. 5]

In summary, similar to earlier research on global virtual teams, we found that *Communication* is a common challenge, within which students can specifically struggle with navigating a *language barrier, discomfort with communication, and lack of communication*.

3) Project Management

The third type of challenge that we identified in the student reflections were challenges related to *Project Management*. The theme of *Project Management* in the context of this study looks at logistical and administrative aspects of the project that impact team success. Within this broader definition, students specifically highlighted challenges in time management, scheduling meetings across different time zones, assigning roles to team members, and unequal workload distribution. The theme of *Project Management* can therefore be divided into three subthemes: *time management/scheduling, assigning roles, and division/completion of work*.

The first subtheme, *time management/scheduling*, describes the issues that global virtual teams faced related to finding suitable meeting times, making continuous progress on project tasks, and meeting deadlines for project deliverables. A student discussing a weakness of their team remarked:

"One of our major weakness is the lack of deadline awareness. This usually results in last minute communication. Thus our team ends up rushing on the assignment last minute and as a result, we often fail to go thoroughly over the instructions and directions." [Par. 6]

The second subtheme, *assigning roles*, refers to the challenge of assigning roles to team members that would suit their technical strengths. As described earlier, communication is a common challenge for global virtual teams, and one potential outcome of a lack of communication is that students are unclear what their role is related to project deliverables. In particular, unclear role assignments can lead to multiple (or zero) team members working on a specific subtask of the project. Referring to such an incident, a student mentioned:

"An example of this is that both [Name 1] and I ended up doing the same task, because we wanted to contribute something to our presentation while [Name 2] worked calculations in MATLAB. Had we communicated better on who should do what, this issue would not have arisen." [Par. 3]

The third subtheme of *Project Management* that we found was unequal *division/completion of work*. This subtheme occurred when team members felt that they were completing either more or less than their fair share of the project. In many cases, this unequal distribution of labor was connected to ineffective time management and/or communication, where students felt they had to take on additional tasks to make sure they got done while other students were unclear of their responsibilities. In some cases, students felt that the required tasks were challenging to distribute evenly, such as completing a design or running a set of calculations. For example, one student commented that:

"One unanticipated challenge that our group has faced is in distributing work equally. I can tell that everyone in the group is eager to help and wants to contribute, but sometimes it is most prudent for one person to run calculations while others are sidelined a bit." [Par. 3]

In summary, we found that *Project Management* is a common challenge for global virtual teams, specifically in terms of *time management/scheduling, assigning roles, and division/completion of work*. Although many similar challenges arise in non-virtual team projects, students commented that these challenges were exacerbated by the virtual nature of the project. The additional variables of a language barrier, working style differences, and multiple time zones were also noted as contributing to challenges with project management.

B. Research Question 2: How do students work to address these challenges?

Our second research question sought to explore how students worked to address the challenges they faced while working on global virtual (cross-cultural) teams. The analysis revealed that students made changes at the personal and the team level to approach the challenges they encountered.

1) Personal Changes

When students described their response to challenges at the individual level, we classified these responses as *Personal Changes*. Personal changes were found to be both attitudinal and behavioral. Attitudinal changes were observed in students who described an increase in personal awareness that led to an empathic approach to problem-solving. In many cases, these attitudinal changes also led students to adapt their individual behavior to improve group dynamics.

One of the subthemes within the *Personal Changes* theme is that students began to demonstrate *empathy and increased self-awareness* in how they approached challenges. One student described their experience managing challenges with language differences while working on a group presentation in this way:

"I was ultimately happy and relieved in the end to take the time when looking back despite the longer length to plan out the presentation and order of content because to me, that signaled strong communication and working actively with others despite the differences in culture, environment, and language to come together. For instance, if I were to look at the situation of planning the presentation over from Francisco's shoes, he might really appreciate the time to go over these fine details so we can all be included in the discussion even if it takes another moment to state an idea or more ideas to collaborate on subjects." [Par. 2]

Through facing the challenge with language barriers on their team, this student became more aware of the importance of perspective-taking which demonstrates an empathic quality used to approach the challenge. The student recognized that despite the longer time to complete technical tasks, there was value in ensuring that all members of the team understood each other and could communicate ideas that contributed to the work.

The second subtheme within the *Personal Changes* theme was *adaptability*. This subtheme captures instances where students adapted their behavior as a result of increased awareness of their team dynamics. In many cases, the empathic attitudes students began to demonstrate influenced the adapted behavior. One example of this can be seen in the following student, who reflected on their role in supporting an inclusive team environment:

"I make sure to adjust my speech and behavior to be more welcoming to anyone who may feel anxious in such an environment. For example, I avoid idioms, which may be overkill, but I do so to minimize confusion and to communicate effectively." [Par. 1]

In the above excerpt, we see this student describe how they adjusted the way they communicated with their team to ensure all members were included in conversations. This student highlights how they made a *Personal Change* by adjusting their way of communication to approach the language challenges they experienced working in cross-cultural teams.

The final subtheme within the *Personal Changes* theme is instances where students made personal decisions to *take on new roles* in response to the challenges they identified related their team's effectiveness. This subtheme generally occurred when a student observed that a key role or responsibility was not being accomplished within the team, often related to either project management or communication. For example, the following student responded to a specific incident within their team by identifying the need for a leader, saying:

"This experience taught me that I have to be more alert on communication, especially when online social platforms are the only possible way of communicating in these times. [...] there should be a leader that makes sure that the

weekly meetings are held and that each team member shows up. Starting this week, I have decided to take this role and make sure that the meetings take place and everyone is on top of their tasks.” [Par. 6]

In summary, the theme of *Personal Changes* describes cases where students reflected on their attitudes and behaviors and chose make changes at the individual level either to make their teammates feel comfortable and included, or to improve the effectiveness of the team and meeting their deliverables. Three common changes that we identified in the student journals were demonstrating *empathy and increased self-awareness*, practicing *adaptability*, or choosing to *take on a new role*.

2) *Team Changes*

The second theme that emerged in response to the second research question was the changes that students made as a team in order to approach the challenges they faced. We identified three common types of *Team Changes* that global virtual teams used to respond to the challenges they faced: *assigning roles and expectations*, *creating time management and/or communication structures*, and *adapting their use of technology* to meet the needs of the broader team.

The first subtheme within the *Team Changes* theme was *assigning roles and expectations*. This subtheme describes teams who responded to challenges or incidents of conflict by making the team roles and expectations more explicit to create accountability structures within their team. For example, one student describes how their team responded to a change in team members that caused some confusion:

“To help remedy this situation, we were able to have a meeting with most of the group to give background into our project and answer any questions that the new members might have. By doing this, we were able to establish a basic sense of how the team might operate and start to foster a sense of teamwork among us. After this, it was full steam ahead as we needed to prepare our wing for testing.” [Par. 4]

In the above excerpt, the student describes how their team responded to having new members added partway through the semester by holding a specific meeting to ensure all members of the team understood the project goals. Setting aside time helped ensure that everyone was clear on the roles and expectations within the team, and as a result the team was able to work more effectively and productively.

The second subtheme within the *Team Changes* theme was establishing *time management and communication structures*. As discussed earlier, the virtual nature of the course added additional complications to scheduling which students needed to manage in order to complete the project tasks as a team. As a result, several students commented on how their teams needed to adapt their team processes in the middle of the semester to be more explicit and create more structure to ensure that tasks and communication were being handled effectively. For example, one student explained:

“However, after the first midterm presentation, we quickly realized the issue we were having and addressed the issue by communicating with one another and meeting up on a regular basis. This helped us speed up our progress and get things done as a team. The second midterm presentation was definitely better than the first one as we were able to get a lot of the required calculations done.” [Par. 6]

In this case, the team’s first group presentation did not go the way they wanted it to, so they decided to make some changes in their meeting schedule and communication plan to ensure that future work would be higher quality.

The *use of technology* was another subtheme that emerged as an area of *Team Changes*. As the teams operated virtually, many students described initial and unexpected challenges in determining what collaborative software tools will be effective not only for communication but for completing project work as well. Additionally, teams discovered that using technology creatively could help overcome language barrier challenges because it was often easier to communicate and understand ideas via written text and graphics instead of verbally. As one student describes:

“As time went on, we were able to rely more on the use of screen sharing, visual indicators, and the use of translating tools (online dictionaries, members who were strong in translation, [etc.]).” [Par. 13]

This student’s comments reflect the approach adopted by many of the teams to manage the language challenges that occurred when they used only voice to communicate. Students realized that visualization tools and language translators were effective ways to ensure all members of the team were able to contribute to conversations about project work.

In summary, the theme of *Team Changes* describes cases where teams worked together to respond to challenges by making collective changes in how the team operated. Three common changes that we identified in the student journals were *assigning roles and expectations*, *creating time management and/or communication structures*, and *adapting their use of technology* to meet the needs of the broader team.

C. *Research Question 3: How do students assess their response to the challenges?*

Our third research question examines how students assessed their responses to challenges. In exploring this question, we were interested in whether students felt that their approach had been successful and what tone they used in discussing their challenges by the end of the semester. We identified three ways that students assessed their response to challenges: 1) they felt that they had *Found a Solution*, 2) they described the challenge as a *Learning Experience*, or 3) they described how the challenge had identified an area they needed to *Work on in the Future*.

Students who felt that they had *Found a Solution* to the challenge that they faced reported that the issues they had

identified individually or as a team had been resolved successfully through the response they had implemented. In the following example, one student talks about how they solved a problem with some of the teammates who felt excluded because of the remote teamwork:

“Across the board all members actively sought to be involved in one way or another. I am pleased with this result, because I do personally believe that the previous issue was a failure on the part of [Student Name] and I to properly make sure everyone in the team felt included, which I think is one of the unique issues that can arise with remote work (and amplified by the language barrier/etc.).” [Par. 3]

This theme represents cases where students clearly stated that their approach had worked and that they were happy with the outcome. These stories tended to be completely positive in the sense that students reported success without discussing any lingering or additional issues that came up after their initial response to the challenge.

Another way in which students assessed their responses to challenges was by describing the situation as a *Learning Experience* where they focused on a key learning outcome that they could apply to future projects. For example, one student talks about how the challenge they faced has been an opportunity to work on their communication skills, saying:

“Despite the challenge, I feel that it has been beneficial; by improving my communication skills in a low-stakes environment while I am still completing my studies, I will be better able to handle such situations when I encounter them in the real world. Even though the class has only been ongoing for roughly eight weeks, I already feel that my communication has improved and that our group is able to better work together as all our skills have improved.” [Par. 4]

Other students mentioned learning skills related to working across a language barrier, improving their time management skills, or collaborating effectively in a virtual environment. In these examples, students did not report that the challenge had been resolved within this particular project, in fact, they generally did not comment on the final outcome of the challenge at all. Instead, these students took a potentially negative situation and described it as a positive learning opportunity that would help them in the future. In a sense, they were focusing on the “success” of having learned something useful.

The third type of assessment that students made was that they identified something they needed to *Work on in the Future*. Although this theme is similar to the previous one, in these cases, students focused on skills they had not yet developed or approaches they had not yet tried rather than reporting a learning outcome already achieved. For example, several students discussed ideas for how they would like to improve either their intercultural or teamwork skills on future team projects, such as in this example:

“In the future, I need to try and grow to be more understanding and comfortable with different perceptions of time and when work will be completed due to the large differences in perception of time across various cultures. This is applicable for group projects as well as cross-cultural experiences because the perception of time exists in nearly every part of life, it is important to always be aware of how others perceive time and the differences that might exists between your perceptions.” [Par. 4]

Additionally, both Spanish and English-speaking students also highlighted their desire to have more intercultural experiences so that they can improve their intercultural skills and their ability to improve their second language, as described by this student:

“Además, me gustaría poder estar nuevamente en una experiencia intercultural para poder trabajar en mi capacidad de interacción con otras personas dentro de un proyecto y al mismo tiempo mejorar mi nivel del idioma inglés.” (original) [Par. 33]

“In addition, I would like to be able to be in an intercultural experience again to be able to work on my ability to interact with other people within a project and at the same time to improve my English.” (Translated from Spanish)

This theme where students described something they needed to *Work on in the Future* was the closest that students in our study got to suggesting that their challenges had not been resolved. These students acknowledged that they still had areas where they needed to develop, and more experiences would be necessary to develop the skills they would need to be successful in their careers. Nevertheless, these students did not discuss whether the original challenge they had identified had been resolved, similar to the students from the second theme. In both cases, students chose to focus on the future in a positive light rather than explaining the full outcome of the situation they had identified in the current project.

D. Example from One Participant

In the previous sections, we provided quotes from a range of students to demonstrate how these themes appeared across student reflections. In Table 2, we highlight how the themes can fit together within a single narrative by showing how several of the themes across all three research questions appeared together in the reflections from Participant 25.

TABLE 2. THEMES FROM REFLECTIONS OF PARTICIPANT 25

Themes	Quote
RQ1 – Group Cohesion (feeling excluded)	“Often the same people would respond in group chat which meant that many people were not sharing their opinion.”
RQ1 – Project Management (assigning roles)	“When working on the solar dryer and weather analysis presentation a couple weeks ago, there were some challenges with coordinating the work.

Themes	Quote
	Most of us were confused on the role we were supposed to complete for the presentation.”
RQ2 – Personal Changes (empathy)	“Even though I was more comfortable with the situation, I had empathy for my ESPOL counterparts who were taking a class in their non-native language.”
RQ2 – Team Changes (use of technology)	“We learned that our Ecuadorian counterparts were not comfortable with those tools. Instead, they preferred to use WhatsApp and Word online. We then adapted to use those tools.”
RQ3 – Learning Experience	“This might be a small example, but it showed me that by changing even a small detail, you can go a long way to making someone else feel valued and welcome.”
RQ3 – Work on in the Future	“However, I think in the future, I should ensure that other members of the team feel needed and have something to work on.”

V. LIMITATIONS

One of the limitations of the course was that each team was working on a different/unique global design project and thus there were variations in challenges and experiences of student teams. In addition, the time students spent on the end-of-semester student reflections may be less than the mid-semester reflections as the end-of-semester reflections were collected during a period when students had a considerable workload. Lastly, challenges due to the COVID-19 pandemic likely impacted the student teams in different ways that may not be fully captured through the reflection assignments of this course.

VI. DISCUSSION

Our study explored the experiences of engineering students working in global virtual teams to understand what challenges they faced, how they approached these challenges, and how they assessed the success of their approaches. Our findings for RQ1 (identifying challenges) aligned closely with previous studies on this subject. In particular, our themes of *Communication* and *Project Management* reflect challenges that were identified in multiple studies [1], [3], [4], [8]. Although earlier studies have identified teamwork-related challenges in global virtual teams, our theme of *Group Cohesion* revealed new perspectives on the experiences of students when teams do not function effectively. Rather than focusing on the logistical issues of teamwork, this theme captures how students feel disconnected with teammates due to lack of communication, conflict, or differences in working styles. These disconnects occur in virtual teams due to lack of opportunities to build personal connections [3], [8].

In response to RQ2 (student approaches to challenges), we found that some students made *Personal Changes* to their behavior in response to challenges while others engaged in *Team Changes*, a more collaborative approach. At a personal level, students focused on their development of empathy, adaptability, or better communication skills. In some cases, students chose to take on a new role within the team to try to address a challenge they identified. At the team level, students made adjustments to team roles, expectations, time management, or communication practices to address challenges. It was notable that, in our data, when students identified a challenge, they nearly always described some sort of approach to address that challenge. We are curious if this is because students typically work to address challenges promptly, or whether the act of reflecting on these

challenges caused students to realize that something needed to be done. Students often shared approaches they anticipated using going forward, which suggests that reflection may have encouraged them to consider how to address their challenges.

Our findings for RQ3 (student assessment of their approach) indicate that students tend to assess their response to challenges in one of three ways. First, they often reported that they had *Found a Solution* that worked and their challenge had been successfully addressed. Second, some students focused on their own *Learning Experience* from working through the challenge, presenting the experience in a positive light even though it may have been difficult. Finally, many students discussed how the challenge had revealed something they wanted to *Work on in the Future*, identifying skills or teamwork practices they want to implement in their next team project. Students did not always discuss their assessment of their approach to addressing challenges, but we observed that when they did present an assessment it was nearly always positive in tone. There were no examples in our data of a student writing about how they tried an approach and it failed to address the issue. Similarly, even in cases where the student identified something to continue working on, it was often written as a positive outcome. We wonder if this indicates discomfort of the students to discuss issues that were not resolved, or where they tried and failed to resolve a conflict. They may have felt pressure in an assignment to indicate anything other than success to the instructor (although they seemed fairly open about the challenges they faced). Future work could explore this question in more detail.

Based on our results, we recommend that instructors invest time at the beginning and throughout the team project to guide teams with strategies for working through challenges. Although the GDP course provided general guidance on teamwork and cross-cultural collaboration, it would have been helpful to include specific conversations on conflict and ways to address it. Our study also suggests that asking students to reflect on their team experiences can increase awareness of their actions and identify areas for improvement. Prior studies found that developing a team-contract can help overcome common team challenges [8]. Our findings support this recommendation and suggest that teams must revisit these contracts throughout the semester. In particular, most teams in our study found themselves re-evaluating team roles, communication strategies, and project management structure between start and mid-semester. Requiring students to make such adjustments could support student learning about the need for continuous improvement in their team processes. Further, based on the lack of student reports on failures to address challenges in our study, we suggest that instructors could discuss failure openly and encourage students and teams to reflect on cases where they tried a teamwork approach that did not work. Such discussions can help students become comfortable with discussing failure, lead to more honest conversations within teams, and the help identify successful strategies for moving forward.

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