Global Software Engineering Education: Students' Experiences during the Pandemic

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***Abstract*—Software engineering projects are increasingly conducted by globally distributed teams. Students need to learn intercultural and distributed project management skills to face the challenges involved in working together online with team members in other countries. Travel and contact restrictions during the pandemic make it impossible to spend a semester abroad to gain international experience. A collaborative class in global software engineering, conducted by two universities, one in Japan and one in Germany, is described. Additional hurdles caused by the pandemic and possible methods to overcome these difficulties are described from the perspective of the students who took part in this course.**

***Keywords*—distance, education, global, software engineering**

I. Introduction

Travel restrictions and social distancing requirements introduced to combat the spread of the COVID-19 virus have caused major upheavals in every aspect of life worldwide. Educational institutions are no exception. Both students and instructors had to adapt to hybrid and distance modes of learning and teaching, almost immediately, without adequate lead time to prepare appropriate pedagogic constructs.

The skills that students learn to adapt to remote learning during their university studies can be of great help later on in their professional careers. Modern software engineers need to be able to collaborate online with project partners who are geographically distributed around the globe, often without the chance to actually meet in person. These skills in distributed project management and intercultural communication can be learned during a course that simulates a global software development project.

This work describes such a collaborative, geographically distributed course to teach global software engineering at the master's degree level. During the fall/winter semester of 2021/2022, two universities held a course together: the Ritsumeikan University in Japan and the Nuremberg Institute of Technology in Germany. This course was conducted in a hybrid format, simultaneously in-person and online.

The goal of this research is to determine whether a course in global software engineering held cooperatively by two universities in two countries can help students to learn the distributed project management and intercultural communication skills necessary to work on international software development projects. The hypotheses which will be investigated in this work are:

- H1. Fixed tasks, roles, and responsibilities, such as project manager, communications manager, and developer, are assigned within the team.
- H2. Online tools serve as a tool for communication and different time zones influence the organization within the team.
- H3. English and programming skills improve.
- H4. Global software engineering allows participants to get to know the partner culture better.

Section II of this paper, Related Work, gives a brief overview of some of the relevant literature on this topic. Section III Methodology describes the organization of the course in global software engineering and the methods used to collect data for this study. Section IV presents the results from the perspective of the students at the Ritsumeikan University in Japan and the Nuremberg Institute of Technology in Germany and discusses possible limitations. Section V presents conclusions and ideas for future work.

II. Related Work

A. Engineering Education During the Pandemic

A number of authors have conducted inquiries into the subject of e-learning and distance education during the pandemic. Traditional universities, which had conducted face-to-face lectures for decades, were forced to switch to remote education, seemingly overnight. Due to the lack of adequate time or resources necessary to adapt to distance education, many educators and students initially felt quite overwhelmed, especially women and parents with young children [1].

Manuscript received January 5, 2024; revised March 10, 2024; accepted May 20, 2024; published July 12, 2024.

Grodotzki *et al.* [2] conducted a survey of engineering students at a German university. Both students as well as educators initially had major difficulties in adapting to online learning and teaching. Even after finding acceptable methods to conduct online lectures, finding a way to conduct hands-on laboratory exercises still remained a challenge. Rasudov and Korunets [3] address the problem of teaching engineers to work with hardware not available at home. They propose the implementation of a digital twin concept for industrial equipment. This could not only be used for remote learning during the pandemic, but also to aid professional training even after the pandemic is over.

Changes in remote education during the pandemic experienced by students in Romania were studied by Manea *et al.* [4]. In contrast to the previous studies summarized here, their students cited both personal and educational advantages to remote instruction. Online lecture videos gave students the possibility to stop, rewind, and repeat lectures. This enabled them to review concepts that they did not understand the first time, which greatly increased their understanding. Students also greatly appreciated the opportunity to watch lectures at any time, from any place. Personal benefits included saving time and money by not having to travel to the university every day and also an increase in flexibility and comfort when watching lectures at home in the evenings.

A literature review on the use of lecture capture technology during the pandemic conducted by Biscan *et al.* [5] resulted in mixed opinions. Traditional, in-person lectures in pre-pandemic times gave instructors the opportunity to adapt their teaching to student's individual needs. Direct visual feedback of students' facial expressions was no longer available during static, pre-recorded lectures. Successful learning outcomes correlated highly with students' own intrinsic levels of self-motivation. They expressed the concern that during the pandemic, the gap between highly motivated, high achieving students and those lacking motivation and self-discipline would widen even further.

Kanij and Grundy discuss an ad hoc adaptation of an in-person course in software engineering in Australia to an online format [6]. They describe the transition period as stressful for both students and instructors due to the limited communication available. Major challenges were identified in encouraging student engagement, asynchronous learning, hands on learning, and assessments. Limitations to distance education were identified, such as the need for high-speed internet connections and access to an adequate computer. Students without such resources may experience an increase in the digital divide compared to those with financial means.

A survey of student satisfaction with e-learning conducted in Turkey [7] found that students used video recordings intensively and found them quite useful, although students found the face-to-face lectures before the pandemic more useful than digital live lectures. Students also showed initiative by using external online resources to improve their learning performance. In comparison to previous in-person settings, students felt they received significantly less support from instructors and fewer interactions with classmates online. They rated instructor support, interaction and collaboration with other students, and student autonomy as necessary factors to achieve high quality in e-learning.

Experiences in adapting an in-person course on software engineering to an online format were described by Barr *et al.* [8]. First, they simply streamed their existing lectures in their entirety. This resulted in rapidly diminishing concentration levels among their students, due to so-called "Zoom fatigue". By breaking up these longer lectures into shorter units and then mixing these with other learning methods, they achieved better results. Apart from these cognitive aspects, they also reported that students expressed experiencing increasing levels of uncertainty and anxiety during the pandemic. The importance of supporting students' social and psychological well-being during contact restrictions was emphasized.

Park *et al.* [9] found that the efficacy and efficiency of distance learning can be greatly influenced by students' emotional experiences. They advocate that addressing not only the intellectual requirements, but also the essential emotional needs of students should be viewed as the responsibility of the entire educational community.

In addition to these psychological and social aspects, Talanquer *et al.* [10] caution against simply returning to the previous state of education once the pandemic is over. The recommend taking advantage of this major structural break to reflect on what is being taught to students and why each topic is taught. This sudden change in the status quo can serve as a motivator to explore new methods to better facilitate the student learning experience.

B. Cultural Dimensions of Global Software Engineering

Hofstede was one of the first researchers to conduct a statistical analysis of variations of cultural dimensions in IT professionals in different countries [11]. Hofstede's model defines six major dimensions that characterize cultural groups:

- Power distance: Attitudes toward hierarchy, status, and unequal distributions of power
- Individualism vs. collectivism: The relative strength of ties between an individual and groups
- Masculinity vs. femininity: Values of assertiveness and achievement vs. social cooperation
- Uncertainty avoidance: Feeling threatened by ambiguous or unknown situations
- Long-term vs. short-term orientation: Importance of preparing for the future instead of valuing the present
- Indulgence vs. restraint: Free expression and gratification of wants vs. control by social norms

Alanoosy *et al.* [12] studied the effect of cultural dimensions on requirements engineering. They conducted a systematic literature review of papers from five digital databases. They identified 16 characteristics that

influence requirements engineering activities. They found that in countries with a high power distance, such as Thailand, decisions were made by stakeholders with high authority, such as managers. Subordinate employees avoided making decisions, because this could lead to conflict with managers. Respect was shown to older software customers and to older requirements engineers. In countries with low power distance, such as Australia, subordinates felt comfortable to identify requirements and to improve the requirements engineering process.

In collectivist cultures, they found that building relationships with clients helped to better understand users' needs during the requirements elicitation process. One disadvantage found was that requirements engineers would often accept new requirements just to maintain friendships with clients, even if this meant modifying the entire architecture of the software [12].

Communication with teams from non-collectivist cultures can prove difficult, because requirements are sometimes not explicitly mentioned. Differences in shared meanings and a lack of shared context can lead to omissions or misunderstandings during requirements elicitation [13].

Ayed *et al*. [14] found that cultural dimensions play a role in the level of acceptance of agile software development practices. They collected data on software development from three countries: Belgium, Malaysia, and Singapore. These data were analyzed according to Hofstede's cultural dimensions [11]. They found countries with different scores on cultural dimensions have significantly different acceptance levels of agile software development principles. Countries with high scores on power distance also showed a high level of team commitment, and management buy-in, but a low acceptance of empowerment, transparency, cohesion, and process improvement.

Garousi *et al*. [15] studied software engineering practices in Turkey. They found that a majority (53%) of software engineers still use the waterfall life-cycle model. Only 34% stated that they preferred agile development models. This may possibly be explained by high scores for power distance and uncertainty avoidance, combined with low scores for individualism found by Hofstede for Turkey [11]. A high score for power distance tends to correlate with hierarchical structures, rather than the self-organization inherent to agile projects. Uncertainty avoidance could also explain the avoidance of agile methods, which view change as good and do not guarantee a certain outcome at the end of the project.

III. Methodology

A. Organization and Structure of the Course

As part of master's degree programs, students from the Universities of Ritsumeikan in Japan and the Nuremberg Institute of Technology Georg Simon Ohm in Nuremberg, Germany enrolled the seminar "Global Software Engineering" in the fall/winter semester of 2021/2022.

Each group of students was required to comply with the study regulations of their home universities, each with different frameworks of course requirements. While the students from Ritsumeikan had one 90-minute course per week, the students from the Nuremberg Institute of Technology were required to participate in two 90-minute sessions. In the first part of the 90 minutes, both universities held a joint session on Zoom. Software development basics were explained and the status of all projects was discussed. Participants of the Nuremberg Institute of Technology had an additional 90-minute session via MS Teams. Also, the grading regulations of the two universities differed. Students from Ritsumeikan University had a midterm presentation, which was one third of the total grade, and a final presentation, which was two thirds of the total grade. The students from Nuremberg Institute of Technology, on the other hand, had to give a final presentation, which accounted for one third of the overall grade, and a written paper, which accounted for two thirds of the overall grade.

Another difference lies in the technical equipment of the two universities. Ritsumeikan University has a high number of international students who are taught through distance learning methods. Therefore, they have state-of-the-art video conferencing systems. The Nuremberg Institute of Technology traditionally teaches face-to-face classes, mostly in German, because few international students are enrolled. The Computer Science Department did not have classrooms specially equipped with videoconferencing technology. After the initial face-to-face lectures, as the infection rates increased, some students decided to participate remotely from home. Many of these students complained of slow internet connections. Due to poor audio and video quality, students had to turn their cameras off to save bandwidth. Ritsumeikan University students who were physically present in Japan were required to participate in person. Those who were still in their home countries waiting for their visas took part remotely and were asked to keep their cameras on permanently.

At the first joint meeting, all of the course participants, including the professors, introduced themselves. Afterward, teams of students were formed to work together on a software project. While the Japanese students were assigned by their professor, the students from the Nuremberg Institute of Technology were allowed to self-organize to form their own groups independently.

Of a total of 27 participants in the course, three groups were formed, each with five students from the German university and about four students from the Japanese university. The task of each group was to come up with a creative idea to develop software based on artificial intelligence to detect anti-social behavior. Anti-social behavior was defined as inappropriate behavior within a specific culture. For example, while it may be acceptable to wear street shoes in the house in Germany, this behavior would be frowned upon in Japan.

The organization of the software project and its implementation was left to the individual teams themselves and took place outside of the 90-minute class time. At the end of the semester, each of the three cross-

site groups presented their project idea and system design, and demonstrated a prototype of their software.

B. Data Collection

Based on the research questions and hypotheses, an online survey was created for all of the course participants. The respondents are the students from Ritsumeikan University in Kyoto, Japan, and the Nuremberg Institute of Technology Georg Simon Ohm in Germany, who participated in the course "Global Software Engineering" in the fall/winter semester of 2021/2022. After the survey was completed, the data obtained was processed, the responses validated, and the response rates analyzed. The data was examined with the help of the hypotheses with the goal of answering the research questions. With the help of the online survey tool "SoSci Survey", each participant received a questionnaire with a total of 31 questions. The structure of the questionnaire is based on challenges, their solution, and a subsequent outlook for improvement in the future. Questions were asked in the format of "What were the challenges in the project?" or "How did you solve them?

IV. Results

A. Japanese Students

The participants from Ritsumeikan University were mainly international students from China, Vietnam, and Ukraine. They were all predominantly male, aged 21–27. The majority of the respondents stated that this was their first global project.

Due to the fact that most of the participants were foreign students, they are open to gain international experience. Due to the pandemic, it was not possible to enter Japan. This severely limited their overseas experience to online classes from home.

All of the participants stated that their project went well. The reasons for this were listed as good project implementation and communication within the team, which was characterized by a high level of motivation, active behavior, and professionalism. In addition, there were good team leaders (one in Germany and one in Japan) who supervised the group throughout the project.

Nevertheless, all of them say that they faced challenges: a lack of activity from some team members, an unbalanced distribution of work within the team, the global distance and associated time zone differences, cultural differences, the technology that was used, and internet connection issues.

Furthermore, language posed an additional challenge. At the beginning of the survey, students were asked to self-evaluate their English skills. These estimates varied widely, from poor to good, which may explain why language was listed as one of the major challenges.

An additional cultural challenge is the different software development practices of the European and Asian cultures.

As shown in Table I, Ritsumeikan students expressed little disagreement within their international group meetings and tended to follow instructions without argument. Due to different levels of English proficiency, some students seemed to hold back during discussions. Few translation tools were used and they tended to communicate within their student group in their native languages. In future projects, the Ritsumeikan students plan to learn more English "key words", in order to participate more actively in meetings and discussions. To compensate for inactive team members, they plan to work overtime and form smaller groups. To improve communication, they will try to smile more and the team leader will take charge of cross-team communication. In future projects, the students wish to choose their own group members independently and apply more of the solution approaches right from the beginning.

At the end of the semester, the students from Ritsumeikan University stated that they had improved their programming skills.

TABLE I. Survey Results Japan

Question	Answers Japan
Why did the project run well?	Much communication, motivation, good leader, active and professional, teamwork, good group distribution
What challenges did you have?	Inactive members, distance, language, technology, internet issues, different time zones and cultures, unbalanced distribution of work, different software development practices between Europe and Asia
How did you solve the challenges?	Talking to the team leader, communication, smile, team leader centralized the communication, balanced the difference, discussed and agreed upon common practices for the whole team, divided into smaller sub-teams, overworked to compensate task hours left by the inactive members
What challenges did you have during communication?	Bad English skills, good people took over the tasks so not much more was added, internet issues
How did you solve the challenges?	Asked others, followed and obey
How would you do it differently in the future?	Learn keywords in advance, catch up on knowledge, and contribute more

B. German Students

The participants of the Nuremberg Institute of Technology were exclusively from Germany, predominantly male and 21–27 years old. For the majority of the students, this was their first global project.

A small proportion of the respondents had planned to spend a semester abroad, but did not do so due to the pandemic. Because of the unknown nature of the virus at that time, it was safer to stay in Germany. In addition, there were monetary aspects, since it was not possible to give up one's student job.

As shown in Table II, all but one participant stated that the project went well. Reasons for this were also good team leaders, a sufficient number of team members to be able to implement the project and good cooperation within the team. The latter is due to the fact that tasks were well distributed, team members contributed equally, a clear distribution of roles could be seen, and at least one

good and communicative person participated from the Japanese side. The regular meetings showed the current project's progress and problems. Nevertheless, one participant stated that communication was poor and that not every team member was equally involved. This was also reflected in the challenges identified, as there were students who did not answer messages, did not participate equally in the project, and participated only silently in meetings. Furthermore, team members needed more time to work on tasks, so not every team member contributed work of the same quality. Due to the international time difference between Japan and Germany (7–8 hours), it was difficult to organize team meetings.

TABLE II. SURVEY RESULTS GERMANY

Question	Answers Germany
Why did the project run well?	Good leadership, lot of manpower, cooperation, grade pressure, regular meetings, good discussions, good work split, one communicative person from Japan, productivity
Why did the project run badly?	Communication, involving every team member
What challenges did you have?	Members needed more time for tasks, communication, appointment planning, no participation, time difference, no answers to messages, quiet in meetings, meeting schedules, time zones, language barriers, motivation, uneven workload, integration, responsibility, getting everyone to contribute a similar amount with similar quality
How did you solve the challenges?	Add deadlines, easier task assignments, meet in smaller groups, work asynchronously, talk to the Japanese teammates, meet on weekends, directly writing, group speaker, speak to German members on how to better address the Japanese, work harder with German team members
What challenges did you have during communication?	Some team members were very quiet or didn´t reply to messages, bad internet connection and English skills, very quiet Asian teammates, found good times for meetings where everyone could participate, internet issues
How did you solve the challenges?	Talking to the most communicative person in the group, repeating the sentences, asking them direct questions, and delegating tasks, more work for German team, meeting in the morning for Germans and afternoon for Japanese, smaller groups, chatting, slowly talking, writing English, assigning tasks, asking questions direct and delegating tasks, repeating sentences
How would you do it differently in the future?	Try to make them participate more actively

To solve these challenges, people were addressed directly by name during meetings, assigned easier tasks, and other team members were asked to try to directly involve specific group members more. In addition, meetings were held asynchronously in smaller groups, and deadlines were set for the entire group. Instead of working with the Japanese students to find a solution, solutions were sought within the German half of the team, which worked together more intensively.

In the future, these challenges will be avoided at the beginning by arranging regular team meetings throughout the project, assigning clearer roles, and developing a clear communication strategy.

Some of the challenges in communication were due to internet problems and finding time for the team meetings. Students from the Nuremberg Institute of Technology blamed further problems in communication on the perceived low level of English skills of the students from Ritsumeikan University. This may explain why they were perceived as silent and rather agreeable in meetings. It was only in offline chats that they communicated their ideas in writing, which later resulted in discussions.

In order to solve the communication challenges between off-site groups and to involve individual students more, meetings for German students are held in the morning and for Japanese students in the evening, divided into small groups. German students tried to solve problems associated with deficits in English by speaking more slowly, repeating sentences more often, and asking questions directly to one person. A lot of small talk was used to create a more pleasant atmosphere. Again, however, more attempts were made to communicate among the German team members, in order to achieve better results.

In the future, it is planned to increase the involvement of all team members in the project and to apply more of the solution approaches at the beginning of the project.

The majority of all participants consider their English and programming skills to be good to very good, which is why they were not able to significantly improve their performance. Google Translate and DeepL were used as translation tools to support the communication flow.

C. Discussion

All interviewees reported that they have become better acquainted with team members from another culture, both in improving their communication skills and working methods.

For the majority, the project went well, but there were many challenges to overcome, which enabled them to learn quite a bit. The most frequently mentioned problem of different time zones in Japan and Germany was solved through good organization and team management. The use of cloud-based, online tools, such as MS Teams, Trello, or Discord also supported asynchronous communication across time zones. The online teaching of the pandemic period has greatly facilitated the use of these tools, as all participants are already familiar with these technologies.

Self-reflectively, students are aware of their shortcomings. The Japanese students note that they contributed little to the discussion during meetings, due to a lack of English proficiency. On their next global project, they will try to improve their communication by learning more "key words" in advance, such as technical terms.

The German students said that on their next international project, they will try to better support and incorporate the team members from other cultures.

During this course, they made the mistake of not working more intensively with their off-site team members. By focusing solely on getting a good grade, they left the Japanese half of their team members out. This type of behavior corresponds with the high scores for the cultural dimensions of masculinity and individualism found by Hofstede [11]. Cultures that exhibit a high level of masculinity tend to value achievement over cooperation. A high score on individualism would lead each student to try to maximize their own grade, rather than concentrate on what's best for the entire group. This directly contradicts the goal of the course. Cross-site teams were formed to require students to find ways to work constructively with team members from another country.

The research question can be answered adequately based on the hypotheses that have been established.

H1 was confirmed. The role of each team member is firmly assigned, so that there is a leader from each side for each team, the German and Japanese sides. The leader took over the organizational functions and introduced the presentations. The remaining members were responsible for the implementation of the project and the clear distribution of tasks, to make milestones more measurable.

H2 was mainly implemented by the German participants in order to communicate better. The Ritsumeikan students hardly used translation tools, which definitely would have been an advantage for them when communicating in meetings with the Germans. The "key words" they plan to learn for the next global project could also have been used in this course.

H3 does not apply to the German students, since they already indicated at the beginning of the course that they considered their English and programming skills to be good to very good and have hardly improved. The Ritsumeikan students reported that they improved both their programming and their English skills.

H4 applied fully to both sides, as all of the participants stated that they had become better acquainted with another culture.

All of the participants faced challenges due to their different levels of English and programming skills. A major challenge that remained unsolved was how to motivate inactive team members. Team leaders divided the work into smaller groups, requiring participants to complete fixed tasks that were suited to their level of programming skills.

The aspiration to gain cultural experience in a semester abroad is significantly limited by the pandemic. While the Ritsumeikan students were not allowed to enter Japan due to travel restrictions, the German students purposely did not start a semester abroad because they felt safer at home.

D. Limitations

The experiences reported during the Global Software Engineering course described here are subject to a number of limitations, which are explained below.

Due to the circumstances that a majority of the participants are international students, these results cannot be generalized to Japanese students.

In addition, the survey was conducted anonymously online, so not all course participants took part. Those who did choose to take part actively self-selected themselves. Those who chose not to take part could have all had the same specific reasons for declining and thus similar answers. The possibility that this self-selection could lead to biased answers makes it impossible to test the results for statistical significance. The responses collected still have value in providing impulses for future improvements.

The course requirements of the two universities differed. While Ritsumeikan students were graded on their midterm presentation and final presentation, with the addition that the best project gets the better grade, students at the Nuremberg Institute of Technology did not have this additional competitive reward and were graded on their final presentation and report. This could motivate the Japanese students to focus more on the midterm presentation in the first part of the semester, while the German students would be motivated to focus more on the project report and the final presentation.

V. Conclusion and Future Work

In conclusion, this experiment demonstrated that a distributed, cooperative course in global software engineering can be held in a hybrid format, even during a pandemic. Project-based learning with a partner university in another country with a different culture can bring many advantages. The digital simulation of a global software engineering project can help students get to know other cultures better, without leaving their home countries. It also helped them improve their English skills and their programming skills. The responsibility of organizing a distributed software development project and learning to communicate online with international partners who they have never met in person gave the students experience that can be useful in other future global projects.

Future work will hopefully include adding additional universities from other countries, with other cultures, to the cooperative course.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Annette Kott contributed to the sections on methods, results, and discussion; Patricia Brockmann contributed to the abstract, the introduction, and the section on related work; Moritz Marutschke and Victor Kryssanov contributed to the section on results from the Japanese students; all of the authors contributed to the conclusions, reviewed and approved the final version of the paper.

Acknowledgment

The authors thank the German Academic Exchange (DAAD), the Ritsumeikan University, and the Nuremberg Institute of Technology for their support on this project.

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