



COMMUNICATION CHALLENGES IN DISTRIBUTED STUDENT PROJECTS

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Conference Key Areas: *Engineering skills*

Keywords: *Communication challenges, virtual teams, distributed software development, student projects, case study*

ABSTRACT

Student projects have been widely adopted in software engineering education. Project teams are composed of students in the same institution, and students can meet and communicate face-to-face regularly. The Covid-19 pandemic, however, forced the student projects to rapidly transition to remote mode and adapt to the virtual team. Virtual teams in distributed environments face challenges due to distance factors that separate collaborators from each other. This study aims at investigating the communication challenges student teams encountered and managed to overcome. We report on an analysis of data collected from reports and interviews in the software project course delivered in fall 2020. There were 57 participants, forming 10 project teams in the study. The results show that remote work negatively affects the social aspects of project teams, especially early communication difficulties in a project. The teams were able to handle most identified challenges but had less interest in tackling those that they did not see as a risk to project completion, which would have most likely caused problems in real-world projects. This study improves understanding of communication challenges in student project teams and the findings serve as a resource for course teachers to design student project courses in the context of virtual teams.

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1 INTRODUCTION

The recent COVID-19 pandemic has forced many software development teams and developers to remote work instead of working in the traditional office environment. For many software development teams, this sudden shift has changed how team members communicate their work [1]. Similar changes happened also to students' software development projects in universities. Lectures were given remotely, groups had their internal meetings virtually, intensive usage of collaboration and communication tools was forced, and customers and course staff participated remotely in review meetings and other project activities.

The goal of this study is to identify challenges, especially the communication challenges in student projects in which students are forced to rapidly transition to a remote mode and adapt to the virtual team in software development projects. The research questions that guided our study are as follows: *What are the communication-related challenges identified in the students' virtual teams for software development?* and *How are the challenges tackled in virtual teams?*

The rest of the paper is organized as follows. In Section 2 we give an overview of communication in virtual teams. Section 3 covers background information of the case study and describes how data was collected and analyzed. Findings are given in Section 4. The last section concludes the work. This paper is based on a master's thesis [2] of the first author.

2 COMMUNICATION IN VIRTUAL TEAMS

Software development is highly collaborative work. To be successful, adequate communication is needed. Lack of communication or poor communication practices can be a significant factor in project failure. Especially in distributed environments where face-to-face communication is limited, effective communication practices become even more important.

In distributed software development, software products are developed by teams with members from different sites [3]. Virtual teams can be defined as geographically distributed collaborations that rely on technology to communicate and cooperate [4]. Based on the definition, virtual teams can be the opposite of collocated teams. Members of a virtual team are distributed across separate sites, but they work on the same tasks as a team [5]. In distributed projects, there can be one or more virtual teams with distributed members [6].

Communication challenges are constraints that decrease the efficiency and effectiveness of communication, and consequently, they can negatively affect the project's success [7]. Alzoubi and others [7] conducted a systematic literature review on communication challenges in globally distributed agile software development to identify communication challenges and solutions to them. They identified a total of 17 communication challenges and categorized them into six distinct categories: distance differences, team configuration, project characteristics, customer communication, organizational factors, and human factors.

Distance differences refer to geographical and temporal distances between team members. Team configuration is related to team size, team structure, and member changes in the team. Project characteristics cover project domain, project architecture, and project type. Customer communication refers to communication between the team and the customer's representatives. Organizational culture, project management processes, communication tools, and infrastructure characterize organizational factors. Human factors refer to personal differences like language, national culture norms, values, and style of communication, and personal attitudes and skills.

Agile software development can be understood as software development that follows the values and principles defined in the Agile Manifesto [8]. Software development projects in industry and university education are nowadays mainly done using some agile software development model or framework, like Scrum [9]. Calefato and Ebert [10] give an overview of collaboration tools used in agile distributed projects, and Ahmad and others [11] give a systematic mapping study on communication channels and practices in agile software development.

3 CASE STUDY: VIRTUAL STUDENT PROJECTS FOR SOFTWARE DEVELOPMENT

3.1 Study context

To answer the research questions, we studied the software project courses implemented at Tampere University in Finland in fall 2020. The course aims at training students the basic skills and competence for software development. Although the study was done with the computer science students, the content of the course was essentially the same as described by Sten and others [12]. The course forms an essential part of the bachelor's degree studies in computer science and computing. In the course, students worked in a team of approximately six members to develop a software system or improve an existing application for real clients. Students typically take the course during the 3rd year of their studies, and therefore, have at least basic skills and knowledge of the techniques and process of software development. For some students, the course also serves as their first experience in solving a real problem in teams. Besides, each team has a master's degree student who acts as a project manager. Project managers have gained a basic understanding of software product and process management in the software project course and other prerequisite studies. The project course lasts 4 months. The development process applied by the project teams can be generally considered agile [8] and iterative.

3.2 Data collection and analysis

There were 57 participants in the course, and 10 teams were formed. Seven teams had six members and the rest had five members. Two of the teams were international and their working language was English, and the rest teams had only Finnish speaking students. The primary channel for data collection was reports required in the course. A final report was for each team to summarize the project



performance and the retrospective. Ideally, the entire team participated in preparing the report. In addition, personal reports were required for every individual to report his/her personal discoveries about the learning and the process of the teamwork in the middle of the project and at the end of it. Open-ended questions such as communication challenges the project teams or individuals encountered and how they reacted were used to elicit feedback from the course participants in both types of reports. The final reports were returned by all 10 teams and the personal reports by 56 out of 57 participants.

All project managers of the teams were invited to participate in voluntary interviews. At the end of the course in January and February 2021, semi-structured interviews were conducted with four project managers. The interview lasted between 45 minutes to 75 minutes. Our purpose was to identify challenges that were not necessarily noticed by the project teams. Besides the questions asked in the reports, challenges identified from the literature were also discussed to determine whether the project team has faced such problems or not.

The course participants were informed that the questions would be used for research purposes, and that it is voluntary to answer the questions. The projects were anonymized using an alphabetical identifier. The course participants were referred to as team members or project managers. The course teacher collected and pre-processed the reports by making only the relevant data accessible for analysis. The open coding technique [13] was applied to interpret and analyze the answers based on the perceived similarity and the common challenge categories identified by Alzoubi and others [7].

4 RESULTS AND DISCUSSION

The COVID-19 pandemic has forced teachers and students to rush into the virtual events of teaching and learning, with inadequate preparation for the unique demands the virtual events post. When the software project course was implemented in fall 2020, students still have limited experience in working in a virtual team. The teams were able to decide their communication practices. They managed to organize regular virtual meetings with team members, project clients, and the course teacher. Most meetings last 30-60 minutes, while others reported that sometimes weekly meetings lasted for several hours. Besides, four teams also arranged coding sessions for members to work on tasks together or at least have a possibility to communicate with others while working on individual tasks. The teams relied on text-based communication tools for daily communication. Synchronous communication was possible but often limited because students often had different schedules and were online at different times.

The teams managed to communicate during the project and experienced different challenges. When 44 out of 56 students seemed to agree that there was enough communication in their teams, as shown in Fig. 1, more than half of the students still would have preferred more face-to-face communication, as shown in Fig. 2.

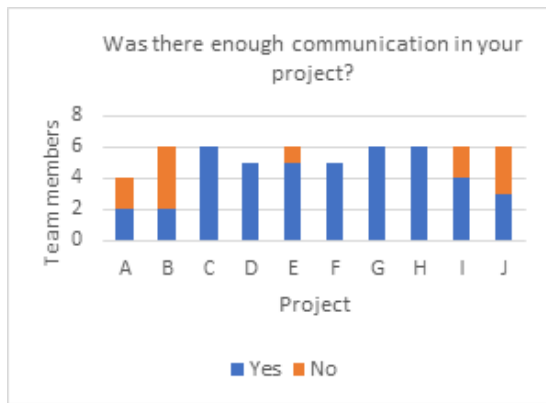


Fig. 1. Sufficiency of communication during the project.

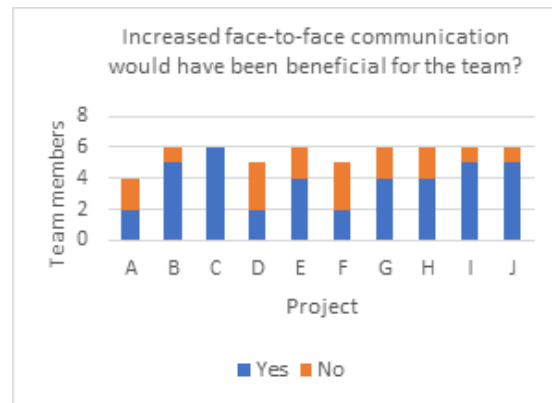


Fig. 2. Would face-to-face communication has been beneficial for the team?

All teams found appropriate communication tools according to their needs and prior experience. The most used communication tool was Slack (used by four teams). Discord and Telegram were used by three teams, and WhatsApp by two teams. The online meetings were held on Zoom (used by four teams), Google Meet (by three teams), Microsoft Teams (by two teams), or Discord (by two teams). Most teams used more than one tool. Some teams used different tools for team meetings and client meetings. For instance, Team C used Zoom for client meetings and Discord for team meetings, while Team J used Zoom for team meetings and Google Meet for client meetings. In the report, it is unclear which tool Team A used for organizing meetings. This may be a signal of insufficient communication within Team A, as reflected in Fig. 1. In addition, some teams used an instant messenger, e.g. WhatsApp or Telegram as a reliable way of reaching their team member before they got used to the use of Slack, their primary communication tool.

4.1 Challenges in students' virtual team projects

There were 91 challenges reported in the 56 personal reports. Fig. 3 illustrates the challenges and their distribution in projects.

The most identified challenges are related to team members' skills, reported by 25 students in 9 project teams. They were related to the team's familiarity with the tools or technologies used in the project. Some students also reported skill differences between team members and a steep learning curve of knowledge or skills, especially at the beginning of a project. In addition, 13 members from three teams reported technical problems in project implementation; however, these are related to a particular domain and implementation technologies of the given project.

Time management and scheduling form the next common challenge, reported by 14 students in 8 teams. They were described as procrastination issues such as leaving too much work to the end of a project, inadequate time to finish all features, etc. Many projects had a slow start which led to an unbalanced workload at the later stage. In addition, challenges for team members in different time zones were reported by Project I, and members in Projects D, G, I, and J faced challenges in balancing their studies or full-time work with the project schedule.

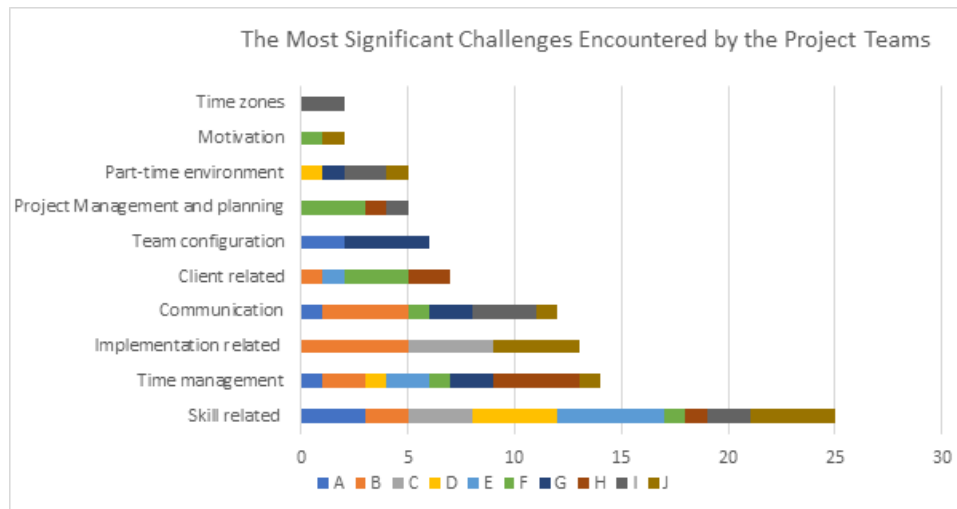


Fig. 3. Challenges identified in personal reports. The chart shows the challenges on the Y-axis and the no. of answers on the X-axis. The color represents the respective team, as indicated in the chart's legend.

Communication challenges were reported by 12 students in 6 teams, among which two teams (B and I) had significant communication challenges, as they were reported by most of the team members. The other four teams have only one or two members reporting such challenges. On the other hand, students in Projects A and G reported team configuration challenges, such as members quitting the project, teams being merged, and the project manager missing at the beginning of a project. These may partly cause communication difficulties. Also, some students reported the issue of misunderstanding project requirements, which implies the challenge of communicating with the clients and understanding their needs.

Besides, three teams have difficulties with project planning, scope management, and project management. These are related to the project managers' competence and skills and are also affected by how smoothly the team communicated with the client above the project objectives and requirements.

4.2 Tackling the challenges

Communication challenges were identified by synthesizing findings in the project team's final reports, personal reports, and interviews with project managers. We adopted the communication challenges and categories presented by Alzoubi and other [7] to summarize the identified challenges, their causes, recognized consequences, and the project teams' solutions in Table 1. The findings show that remote work decreased the feelings of social connection and team cohesion. Even though every team reported they had regular meetings, there are questions regarding the quality and ease of communications. Herein, differences in schedules and differences in skills were the most common challenges.

The difference in team members' schedules was reported in eight teams. It was one typical distance factor causing challenges like delays in communication and difficulties in arranging meetings, as one team mentioned in the final report, "*the main problem was: agile projects need frequent communication. Meanwhile, students do not like to be bothered frequently*". Even though the temporal distance

was a common challenge, the teams managed to handle it in various ways, e.g. introducing the 24-hour rule of reading and responding to the posted messages, suggesting members turn on the new message notification in communication tools, being aware of team members' availability to schedule regular meetings in advance, sharing meeting notes, etc.

Table 1. Communication challenges reported by project teams and their solutions. The parentheses include teams that recognized the challenges but did not mention solutions.

(env. – environment, comm. – communication, TM – team member, PJM – project manager)

Category	Cause	Consequence	Solutions	Teams Affected
Geographical distance	Lack face-to-face meetings	Eliminates spontaneous interaction in demo or development env. setting	screen sharing and other tools in online meetings	E, (A)
	Lack of informal comm.	Lack of team cohesion	Improved over time	B, C
	Limited access to project-specific tools	Lack of shared knowledge	Tool demo using videos or shared screen	C
Temporal distance	Different schedules	Delays in communication	24-hour rule, message notification	A, B, E, G, J
		Difficulties in scheduling meetings	scheduling regular meetings in advance	B, C, D, E, F
		TMs absent in meetings	Meeting notes	B
	Different time zones	Difficulties in scheduling meetings	-	I
Comm. tools	Unfamiliarity with tools	Passive/inefficient use of tools	Using alternatives	B, C, E, J
	No use of webcams	Less social cues	-	B, H, J
	Prefer text over voice comm.	More difficult to comm.	-	H, J
	Inefficient use of task boards	Reduced comm. and awareness	Increasing TM's involvement with task board	E, F, (B, H)
	Using multiple tools	Difficult to keep track of all comm. channels	-	F
Customer comm.	Insufficient/miscomm. with the client	Assumptions about requirements or goals	Regular meetings with clients	B, F, (A, H)
Team comm.	TMs were unfamiliar with each other	Early comm. problems	Improved over time, PJM as a role model of active communication	B, C, E
	TMs quit & teams merge	Early comm. problems	Addressing problems in meetings	G, (A)
	Lack of task-related communication	Lack of task awareness, assumptions have to be made	Task boards (e.g. Trello), task dependency model, more meetings for project progress	C, F, A
	Lack of meeting agenda	Inefficient meetings	Adding agenda	C
Human factors	Different learning goals	Not following comm. protocol	-	B, J
	Different skills	Poor understanding or explaining technical concepts	Giving TMs tasks matching their skills	B, C, E, (F)
		Dominated/passive TMs	Involving less active TMs by asking their opinions	C, J, A
	Different language skills	Misunderstandings, passive comm.	-	(H, I A)



Besides, human factors related challenges were identified almost in all projects and were caused by factors such as language differences, the passiveness of team members, skill differences, and the members' motivations or goals. Among which skill differences were the most common ones leading to problems such as difficulties in explaining or understanding technical concepts, experienced team members dominating communication, and misunderstandings. Encouraging communication was the common strategy used by the teams. Specifically, two teams mentioned their strategies such as assigning tasks that match the member's skills and always asking for everyone's opinions during the meeting. However, most teams did not mention any specific solutions to the problems related to skill differences, implying the difficulties and low motivation for the teams to overcome such challenges.

It is remarkable how the virtual teams have adapted so quickly to remote working on the project and that the virtual team setting and limited face-to-face communication did not cause significant communication challenges for most teams. The availability of face-to-face interaction would have made communication smooth and mitigated the difficulties brought at the beginning of a project when team members were not familiar with each other and the team-building efforts had to take place virtually. Face-to-face interaction would have eased the demonstration of code and tools and avoided some technical problems brought by the communication tools. However, most of the communication challenges would have likely remained even if face-to-face interaction was possible. Some teams even seemed to prefer the remote setting due to its benefits, such as, saving time commuting to face-to-face meetings.

The teams solved the encountered challenges reactively. Also, the agile practices adopted by every team, like review meetings, regular team meetings, task boards, etc. helped to communicate and manage project tasks. Typically, the recognized problems were addressed in meetings and the team would decide how to deal with them; while some others were only recognized retrospectively and mentioned in the reports, like those presented in the parentheses in Table 1. The teams were able to handle the most crucial challenges to complete their project. However, the less significant communication problems were often ignored, if they did not see them as a threat to the project's success. For instance, none of the teams used webcams actively, although visual cues can help team members better read each other's emotions in a meeting. The decision of no use of webcam may be related to the team members' personal preferences or technical problems like the webcam not working, poor internet connection, etc. but the teams did not initiate any actions to improve the social cues in communication.

5 CONCLUSIONS

Software development projects are often complex, and they require sufficient communication which is not always easy to achieve. Communication becomes even more difficult in virtual teams in which face-to-face interaction is limited. This study identified communication challenges and their solutions based on software projects worked by university students. Our findings show that remote work negatively affects



the social aspects of project teams, especially early communication difficulties in the project. The teams were able to handle most of the recognized challenges in one way or another. The common agile practices like review meetings, regular team meetings, task boards, etc. helped communicate tasks within the team and between the team and the customer. For these teams, communication was mostly a minor challenge, and challenges related to individual's knowledge and skills, project time management, implementation techniques, etc. impacted more on project conducting. The unsolved communication problems were mainly related to human factors. Considering that students might have different motivations to take the project course, we see that the project teams have less interest in tackling challenges that they did see as a risk to project completion. This might have been sufficient for a student project, but in real-world settings, their practices would have potentially caused more significant problems.

In virtual student projects, although most teams found ways to meet regularly, the quality and ease of communication remain challenging. Effective communication helps build trust and enhance understanding. When designing a student project course, it is important to emphasize the learning objectives and provide sufficient guidance to help project managers and their teams organize meetings at the beginning of the project and discuss with team members not only the tasks and roles of team members but also the recommended practices and tools in communication, and expectations such as use of cameras by remote participants, trust, prompt responses, regular meeting hours, etc.

This study identified many communication challenges that are relevant to university student projects. However, not all the possible challenges could be identified. Students with limited experience may not be aware of all the problems that affect their projects. Our next step is to further investigate the challenges with data collected using different methods from similar projects. This will certainly enrich the understanding of the communication challenges and provide effective guidance for designing student project courses in the context of virtual teams.

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