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RESEARCH ARTICLE

# Adopting Scrum in Hybrid Settings, in a University Course Project: Reflections and Recommendations

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**ABSTRACT** Agile software development (ASD) methods such as Scrum promote collocated team collaboration. However, adopting Scrum in hybrid work environments can pose challenges. Therefore, understanding the positive aspects and challenges of adopting Scrum in hybrid settings and the relevant agile tools and practices is important. Software engineering education should also prepare students with the necessary knowledge and skills for implementing ASD methods in hybrid settings. This study provides insight into implementing Scrum in a hybrid setting, in a course project, discussing its positive aspects, challenges, and relevant project management and communication tools. We used a questionnaire to collect feedback from 12 scrum teams, made up of 59 master's degree students at the University of Oulu, who developed student well-being prototypes in four sprints. We applied thematic analysis to analyze the teams' feedback. We found 16 challenges, 12 positive aspects, and varying ASD practices and tools. Key challenges included scheduling conflicts, communication issues, and estimating efforts. Discord and Microsoft Teams were popular for communication, while JIRA and Trello were favored for agile project management. This study complements software engineering literature with new empirical findings. It reveals practices and tools applicable to software practitioners and start-up teams for effectively adopting scrum in hybrid settings. It also contributes by illustrating the adoption of scrum course projects in hybrid settings and providing recommendations to enhance the design of similar courses. It identifies research gaps, such as the need for tools and practices to improve collaboration and the potential of asynchronous chats in hybrid environments.

**INDEX TERMS** Agile software development, hybrid work, scrum, software engineering education.

## I. INTRODUCTION

Agile software development (ASD) describes iterative and incremental software development methods that are founded on the values and principles of the agile manifesto [1]. ASD promotes close collaboration with customers, minimal documentation, quick delivery of software, and welcomes late requirements change [1]. Scrum, Extreme Programming (XP), and Feature-Driven Development (FDD) are examples of ASD methods [2] ASD methods such as Scrum are widely adopted in the software industry [3]. This is due to their capability for quick delivery of software, ease of managing priorities, improved predictability, and enhanced software quality and management [3], [4]. In this regard, universities offering software engineering education have also been striving to equip students with relevant knowledge and skills on ASD methods, tools, and practices.

One of the twelve principles of the Agile Manifesto highlights the importance of face-to-face communication for efficient and effective communication [1]. However, following the COVID-19 pandemic, hybrid working has become common [5]. Hybrid working describes collaboration and meetings where multiple collocated and remote participants engage in synchronous and asynchronous interactions to handle their work. Considering ASD methods such as Scrum and their emphasis on collocated team collaboration [1], it is important to investigate how they intertwine with hybrid working. For example, what are the potential challenges that

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teams may experience when applying Scrum in hybrid work settings? What are the positive aspects of utilizing Scrum in hybrid work settings? What type of agile project management and communication tools can teams use in such settings? These questions are also relevant for software engineering education, where students apply Scrum in software projects in hybrid work settings. Answering such questions can help gain insight into the practicalities of Scrum in hybrid settings and improve the design of courses that apply Scrum projects in hybrid settings.

The software engineering literature reveals that there are studies reporting the lessons learned from teaching ASD methods in university settings [6], [7], [8], [9], [10], [11], [12], [13]. These studies report experiences from applying Scrum in course projects, the challenges in teaching ASD methods, and provide recommendations for teaching ASD methods such as Scrum and XP in university settings [6], [10], [14], [15]. Many of these studies reflect lessons learned from contact teaching and do not rely on knowledge gained from teaching ASD in remote and hybrid settings. Studies investigating the adoption of scrum in remote and hybrid work settings within university course projects are lacking [16]. Therefore, our study aims to fill the gap in the limited availability of empirical evidence on adopting scrum in hybrid settings in university course projects.

In this study, we report our findings from teaching university students ASD, where the students applied Scrum in hybrid settings to develop prototypes of a student well-being application. 59 master's degree students studying Software Engineering and Information Systems at the University of Oulu, organized in 12 scrum teams and took part in a course project consisting of four weekly sprints. We use feedback collected from these teams using a questionnaire study to report on their experiences in applying scrum ceremonies in hybrid settings, the challenges they met, and the project management and communication tools they used. We also provide recommendations that help enhance the design of courses applying Scrum in hybrid settings. Our research defines the following six research objectives and questions.

The first objective is gathering the reflections of scrum teams in adopting scrum ceremonies in a hybrid setting within a course project. It is addressed through Q1.

**Q1. What are the reflections of scrum teams adopting scrum ceremonies in a hybrid setting in a course project?**

The second objective aims to synthesize evidence on the challenges of adopting scrum ceremonies in hybrid work settings within a course project. This objective is addressed through Q2.

**Q2. What are the challenges of adopting scrum ceremonies in hybrid settings in a course project?**

The third objective is to synthesize the positive aspects of adopting scrum ceremonies in hybrid work settings within a course project. It is addressed through Q3.

**Q3. What are the positive aspects of adopting scrum ceremonies in hybrid settings in a course project?**

The fourth objective is to gather evidence on agile project management tools used by the scrum teams in hybrid settings, the corresponding challenges, and the positive aspects of using the tools in a course project. Q4 addresses this objective.

**Q4. What agile project management tools did the scrum teams use in their projects, and what were the challenges and positive aspects of using these tools?**

The fifth objective is to gather evidence on the communication tools adopted by the scrum teams in a hybrid setting and the challenges and positive aspects they experienced when using the tools. Q5 addresses this objective.

**Q5. What communication tools did the scrum teams use in their projects, and what were the challenges and positive aspects of using the tools?**

The sixth objective aims to gather lessons learned on using scrum boards in a hybrid setting by scrum teams in a course project. It is addressed by answering Q6.

**Q6. What are the experiences of the teams regarding the use of scrum boards?**

We found that how each team adopted the scrum ceremonies varied (e.g., in terms of frequency of handling daily scrums and how they applied the scrum ceremonies and scrum boards). The scrum teams faced challenges from scheduling conflicts, the absence of members and the lack of commitment, and poor communication infrastructure (e.g., audio and internet) when organizing the scrum ceremonies. There were also challenges from effort estimations, unbalanced work allocation, and unfamiliarity with tools. The scrum teams reported that the scrum ceremonies helped them get visibility of their work in progress and contributed to enhancing team collaboration and work coordination. The scrum teams applied tools such as Discord and Microsoft Teams for communication and Jira and Trello for agile project management.

Our work complements existing literature by providing empirical knowledge on adopting Scrum in course projects in hybrid settings. It presents practices and tools that software practitioners can use to facilitate the adoption of Scrum in hybrid settings. Our study illustrates the adoption of scrum in hybrid settings in a course project and offers recommendations to enhance the design and implementation of similar courses. Furthermore, it identifies potential research gaps, such as exploring the use of asynchronous chats as a substitute for daily scrum meetings and the need for tools and practices that improve collaboration and coordination of scrum projects in hybrid and distributed settings.

The rest of the paper is organized as follows. Section II presents related work on studies that report experiences from teaching ASD in university settings. Section III presents the course design. Section IV provides the research method used for data collection and analysis in the study. Section V presents the findings of the study. Section VI discusses the implications of the findings, the threats to validity, and future research. Section VII provides the conclusion.

## II. RELATED WORK

Hybrid work settings pose challenges for teams using ASD methods like scrum, as they may experience slower and more difficult communication and miss out on the informal social aspects that facilitate ASD [17]. Course projects offer opportunities to get insight into the implementation of ASD in hybrid settings. The scientific literature reveals that there are studies reporting teaching of ASD in university settings [6], [7], [9], [10], [12], [15], [18], [19]. These studies mainly report lessons learned and provide recommendations for teaching ASD methods through course projects in universities. Most of them do not consider hybrid settings.

Mahnic [6] presents the lessons learned from teaching Scrum in a capstone course project at the University of Ljubljana, Slovenia. The author also provides recommendations for teaching ASD in universities, such as clarifying the role of product owners, scrum masters, the notion of 'Done,' and user stories. However, the study is based on a course project that was carried out in face-to-face settings and does not consider hybrid work settings.

Similarly, Anslow and Maurer [7] report their lessons learned from teaching ASD in a course project where students developed a web application in groups. The students were taught and applied Scrum and XP in their course projects. The authors identified that students had difficulties in scoping user stories and tasks, self-organizing their teams, and challenges from unbalanced workload among team members when doing their course project.

Devedzic and Milenkovic [8] report their experiences of teaching ASD in different universities. The authors found that in course projects applying ASD, it is important to eliminate major difficulties early on. They also noted that keeping teams small and self-organized is necessary. Masood et al. [9] report the constraints that students faced when learning ASD practices when using Scrum in a course project at the University of Auckland. The authors also provide insights into the adaptations made by the students to overcome the constraints and provide recommendations for educators.

Similarly, Hsu et al. [10] share their experiences teaching Scrum to Feng Cha University students. Their findings show that students face difficulty in finding a fixed time for daily scrum meetings. Trello boards were seen as disadvantageous by the students since there were no connections between Trello tasks and the product backlog items, and maintaining priorities among tasks was difficult. Linden [13] reports their experience of adopting scrum for fostering self-regulated learning in programming courses carried out in in-person teaching. Frydenberg et al. [12] report on students' experience of building paper airplanes using scrum concepts.

Matthies et al. [11] report lessons learned from student projects applying Scrum and Kanban at the Swinburne University of Technology in remote settings. Regarding teamwork and the process, the authors found that the students faced challenges such as reduced implicit feedback, less interaction, and fewer options for offering help in virtual meetings. There were also challenges due to decreased focus, which arose from distractions in remote settings. They also found that the teams maintained high trust in each other. Table 1. Summarizes the findings of the related work.

**TABLE 1. Summary of related work.**

| Study | Study focus | Findings |
|---|---|---|
| Mahnic [6] | The study reports the lessons learned from teaching Scrum in a capstone project to undergraduate students. | The authors found that students' planning and estimation abilities improved during sprints, and that product owner role was crucial for success of the project. They recommend the need for clarifying notion of Done, and the role of product owner and scrum master. |
| Anslow and Maurer [7] | The study reports the lessons learned from teaching ASD (Scrum and XP) project course to undergraduate and graduate students. | The authors found that customer involvement was challenging, and students faced a high learning curve in estimating user stories. Undergraduate teams had problems with self-organization. |
| Devedzic and Milenkovic [8] | The paper focuses on reporting the lessons learned from teaching ASD to university students between 2002 and 2009. | The authors recommend short iterations for sprints. They also highlight the importance of assigning a scrum master and creating self-organized small scrum teams (4 – 5 students in a team). |
| Masood et al. [9] | The study reports the constraints students experienced when adopting agile practices in a university course and proposes recommendations. | Scheduling, collaborating with customers and product owners, and difficulty in estimations were reported as constraints. The authors reported virtual and physical daily stand-ups, the use of digital scrum boards, and bots sending daily reminders as useful for students. |
| Hsu et al. [10] | Reports the lessons learned from teaching Scrum in a university course, where 34 students organized in 5 teams applied Scrum. | The authors found the need for regular time for daily scrum and shared working space. They also found a team using Trello faced difficulty. |
| Matthies et al. [11] | Reports the lessons learned from teaching the application of Scrum and Kanban in a capstone course project in a remote setting. | They found challenges such as reduced implicit feedback, fewer social interactions, technical issues, and video call fatigue. Remote ASD enabled effective sprint planning, easier documentation, and focused virtual meetings. |

The studies mentioned above offer valuable insights into the implementation of Scrum and ASD in university settings. However, these studies do not provide sufficient knowledge on how to adopt Scrum in hybrid settings in university course projects. There is a need for research examining how remote

and hybrid settings impact ASD projects, particularly those implementing Scrum projects in university settings [17]. We fill this gap by reporting knowledge gained from adopting scrum in a course project, in a hybrid setting.

## III. COURSE DESIGN

This study is based on a Scrum course project task given as part of a master's degree course, *Professional Software Engineering Processes and Human Factors*, at the University of Oulu in Autumn 2022 (November and December 2022). The course aimed to equip students with knowledge and skills on software development process models and software process improvement and understanding the role of human factors in software development. The course involved lectures, exercises related to the lectures, and a course project task. The course was worth 5 ECTS, and it lasted for six weeks. The 5 ECTs comprised 135 hours of work, i.e., 56 hours of lectures and exercises and 69 hours of course project work. We used students' exercise submissions and course project work for course assessment.

Students were given lectures and exercises on three modules: software processes, human factors in software engineering, and software process improvement. They also carried out a course project task aimed at applying agile practices and tools using the Scrum method to develop student well-being application prototypes by working as a Scrum team.

Before the course project began, the students learned the module on software processes. A lecture focusing on software processes and discussing different software methods, including ASD, was given to the students. The students also had to read papers on software development processes and watch an interview video about software processes from an industry expert. Additionally, they carried out exercise tasks related to software processes.

*Course Project Organization*: for the course project, we created scrum teams by considering various aspects. We collected information on students' software engineering experience, ASD experience, gender, and cultural backgrounds (which country they came from) using an online form, https://forms.office.com/e/yW3DRn10s5. The students were notified about the purpose of data collection, and they provided their consent for the use of the collected data. We used the collected data to create scrum teams that are balanced in terms of their software engineering and ASD experiences and diversified considering the cultural backgrounds and genders of their team members.

*Team Composition:* We had 59 full-time and part-time master's degree students, and we organized them into 12 teams. We created 11 teams of five students and one team with four students (see section V for details). When creating the teams, we ensured that each team consisted of two students who reported experience with ASD. We also ensured that the teams were diversified in terms of their country of origin and gender.

After creating the scrum teams, we gave the students an introductory lecture on Scrum. The students were taught about scrum team organization, scrum ceremonies, and accountabilities. In this lecture, the students were also briefed on the practicalities of the project task and the workflow. We introduced the aim of the project task, briefed on potential agile project management and communication tools the teams may adopt, and expected project deliverables.

We informed the teams to assign scrum roles (accountabilities) explicitly among themselves and work as self-organized. Therefore, they handled organizing their work and setting the accountabilities among themselves. Each team assigned product owner, scrum master, and development team roles by themselves. The scrum teams also selected and used the development, testing, project management, and communication tools of their choice. In all scrum teams, the project members worked remotely and in hybrid from within Finland. In three teams, members were working from outside Finland, too.

*Course Project Task*: The course project task was aimed at applying agile practices and tools to develop prototypes of a student well-being application. The two teachers (the first and second authors) acted as customers in the course project task. The course project had four weekly sprints, which the teams used to build the prototypes. We provided the teams with a software description for a student well-being application (see appendix A- software requirements description). We gave them weekly instructions, held two sprint review meetings, and provided clarifications about the tasks during the sprint implementations. During the sprint review meetings, we gave the scrum teams feedback, which they needed to consider when developing the prototypes. The teams had to build prototypes and conduct usability testing of the well-being application's desktop, smartwatch, and mobile versions. Section V shows an overview of the development and testing tools and versions of the prototypes the teams developed.

*Course Project Assessment*: the course project was worth 50% of the total course grade. We used the teams' weekly deliverables and way of conducting the Scrum, developed prototypes and their final deliverable to evaluate their work. The scrum teams had to present their project work in a seminar, and answer questions related to their work. This was also used for the evaluation.

## IV. RESEARCH METHOD

In this study, we were interested in understanding how students adopt Scrum in hybrid settings in a course project and their experiences using agile project management and communication tools. We applied a questionnaire-based study to examine how 12 teams of 59 master's students at the University of Oulu applied scrum in a hybrid setting when developing software prototypes for a student well-being application.

### A. DATA COLLECTION

The first and second authors drafted, discussed, and refined the questionnaire used in this study before the course started.

We used a questionnaire to collect feedback on the scrum ceremonies and the communication and project management tools used by the 12 scrum teams. We also collected the teams' feedback on the positive aspects and challenges of adopting the scrum ceremonies, and related communication and agile project management tools. The data was collected using a questionnaire made in Excel spreadsheets from the 12 teams (see Appendix B) at the end of the last sprint. We followed the research ethics guidelines from the Ethics Committee of the Human Sciences of the University of Oulu when collecting and processing data. Our study did not require an ethical board review as it neither physically intervened with participants nor posed long-term mental harm and security risks.

Each team provided feedback by filling in the questionnaire in an Excel spreadsheet. Then, we collected the data using labels such as challenges of sprint planning meetings, positive aspects of sprint planning, adoption of sprint planning, etc. from each team's feedback. These labels were targeted at answering the research questions we defined in the introduction.

We then aggregated the data collected from all 12 teams using such labels into a spreadsheet. For example, the feedback on the challenges of adopting sprint planning meetings given by all 12 teams was aggregated into a spreadsheet. Likewise, the feedback on all other aspects was aggregated into a spreadsheet.

### B. DATA ANALYSIS

The data analysis followed in this study is mainly qualitative. Once we aggregated the feedback data on each aspect into a spreadsheet, we applied thematic analysis [20]. We used thematic analysis since it helped us analyze similarities and differences in the feedback and derive themes. When applying thematic analysis, we proceeded as follows. For instance, each team's feedback on the challenges of adopting sprint planning was collected under a label named *'challenges of adopting sprint planning.'* The feedback was aggregated into a spreadsheet. We then read the feedback from each team and labeled it with a code that explains the feedback. For example, feedback that stated, '*try to complete the task in a specified time*' as a challenge of adopting sprint planning by one group was coded as '*difficulty in completing planned task in time.*' We did the same for all other feedback. We then compared the different codes describing feedback on a specific aspect by all teams among each other.

During the comparison, we categorized codes that describe similar themes under one category. We refined the category names, too. For example, regarding the challenges of sprint planning, Fig.1 illustrates how the challenge *'difficulty in effort estimation'* is derived from those codes describing challenges related to sprint planning. We followed the same procedure to analyze the aggregated feedback data on all other aspects (e.g., positive aspects of the daily scrum, challenges of the daily scrum, positive aspects of the sprint review, challenges of the sprint retrospective). In the data analysis, some codes described non-recurrent feedback, i.e., feedback not forming themes. We report these codes as non-recurrent feedback in our results. For example, we had non-recurrent feedback on the positive aspects of sprint planning by one team, which is seen as a benefit, *'ease of task allocation and prioritization.*' This code is derived from the feedback *'Everyone had the possibility to review and vote for different features. Prioritization and allocation of tasks was easier among team members. Common engagement to tasks and priority was achieved.*'

In this study, we also used quantitative analysis to report the demographics of the scrum teams.

## V. RESULTS

This section addresses the study's research questions. It begins by giving an overview of the scrum teams' demography, the prototypes, and the tools used by the teams to develop the student well-being prototypes. It then explains the lessons learned about adopting scrum practices, i.e., sprint planning, daily scrum, sprint review, and sprint retrospective meetings. It also reflects on the agile project management tools and communication tools the teams applied in hybrid settings during the project. Additionally, it synthesizes the teams' experiences in using digital scrum boards in their project management. Fig. 2 shows an overview of the scrum process adopted in the course project.

### A. OVERVIEW OF SCRUM TEAMS AND THE PROTOTYPE DEVELOPMENT AND TESTING

The study is based on data collected from 59 full-time and part-time students organized into 12 scrum teams. Fig. 3 depicts an overview of the demographics of the participants. 75% (44) of the students were men and 25% (15) were women (see Fig. 3. a).

Among the 59 students, 63% (37) had their country of origin as Finland, while 37% (22) had a different country of origin (see Fig. 3.b). Before the start of the course project, 53% (31) reported that they had experience with ASD, and 47% (28) said they had no ASD experience (see Fig. 3.c). 61% (36) of students reported having experience in software development, while 39% (23) said they had no software development experience (see Fig. 3.d). All twelve teams were working in remote and hybrid settings. Among them, three teams (Teams H, K, and M) had one member each who was taking part remotely from China. The other nine Scrum teams had all their members working from locations within Finland. Table 2 shows an overview of the scrum teams' composition.

In the course project task, each team was expected to deliver prototypes for desktop, smartwatch, and mobile versions of the student well-being application. However, only 50% (six scrum teams) build three versions of the prototypes. 42 % (five scrum teams) managed to deliver desktop and mobile versions of the prototype, while 8 % (one team) had only the mobile version of the prototype.

| Group name | Challenges of adopting sprint planning | Code describing the challenge reported by each team | Theme that emerged by compairing the codes that were reported by each team |
|---|---|---|---|
| Group E | The estimation of capacity of team members to perform different tasks related to the features was a bit hard at the start. This got easier after the first sprint when we show how much time different things needed. | effort estimation by team members was difficult at the start | Difficulty in effort estimation |
| Group F | Try to complete the task in a specified time | difficulty in completing planned task in time | |
| Group G | Sprint planning could be improved by having everyone participate and think about what is needed and how much work it takes in more detail. | planning sprint tasks and related estimation needs improvement | |
| Group H | Sometimes miscommunication and estimation is not correct at first time, the product backlogs need to broken down to more smaller pieces | estimation is not correct at first time | |
| Group I | Difficult to estimate the work hour needed for the tasks. | Difficult to estimate the work hour needed for the tasks. | |

**FIGURE 1.** Illustration of thematic data analysis.

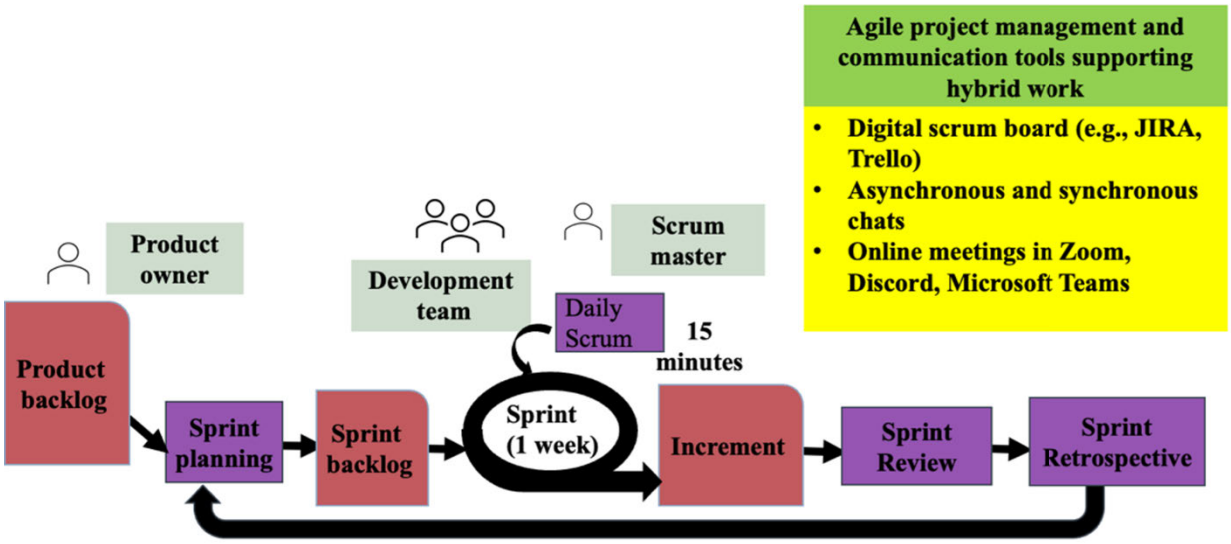


**FIGURE 2.** An overview of the scrum process in the course project.

When considering the prototype development tools, 92 % (eleven teams) used Figma to develop their prototypes. One of these teams used Canvas and another used draw.io. The remaining team used Axure Rp10 for prototype development. The scrum teams used usability testing tools and techniques suitable for testing the prototypes they developed. 25% (three teams) used Maze, and 8% (one team) used Uxtweak.com. 42% (five teams) applied usability testing with testers, 17% (two teams) used Nielson's heuristics, and 8% (one team) used the cognitive walkthrough technique. Table 3 summarizes the prototype versions developed by the teams, prototype development tools, usability testing tools, or techniques used by each team. The data was analyzed from the deliverables of each team.

### B. REFLECTIONS, CHALLENGES, AND POSITIVE ASPECTS OF APPLYING SCRUM IN HYBRID SETTINGS IN A UNIVERSITY COURSE PROJECT

**1. Reflections on adopting scrum ceremonies in hybrid settings in a course project (Q1)**

*Sprint Planning Meeting:* All teams explained that they held the sprint planning meeting in every sprint. These meetings were held in hybrid settings. The teams adopted the sprint planning meeting in various ways. 50% (six teams)

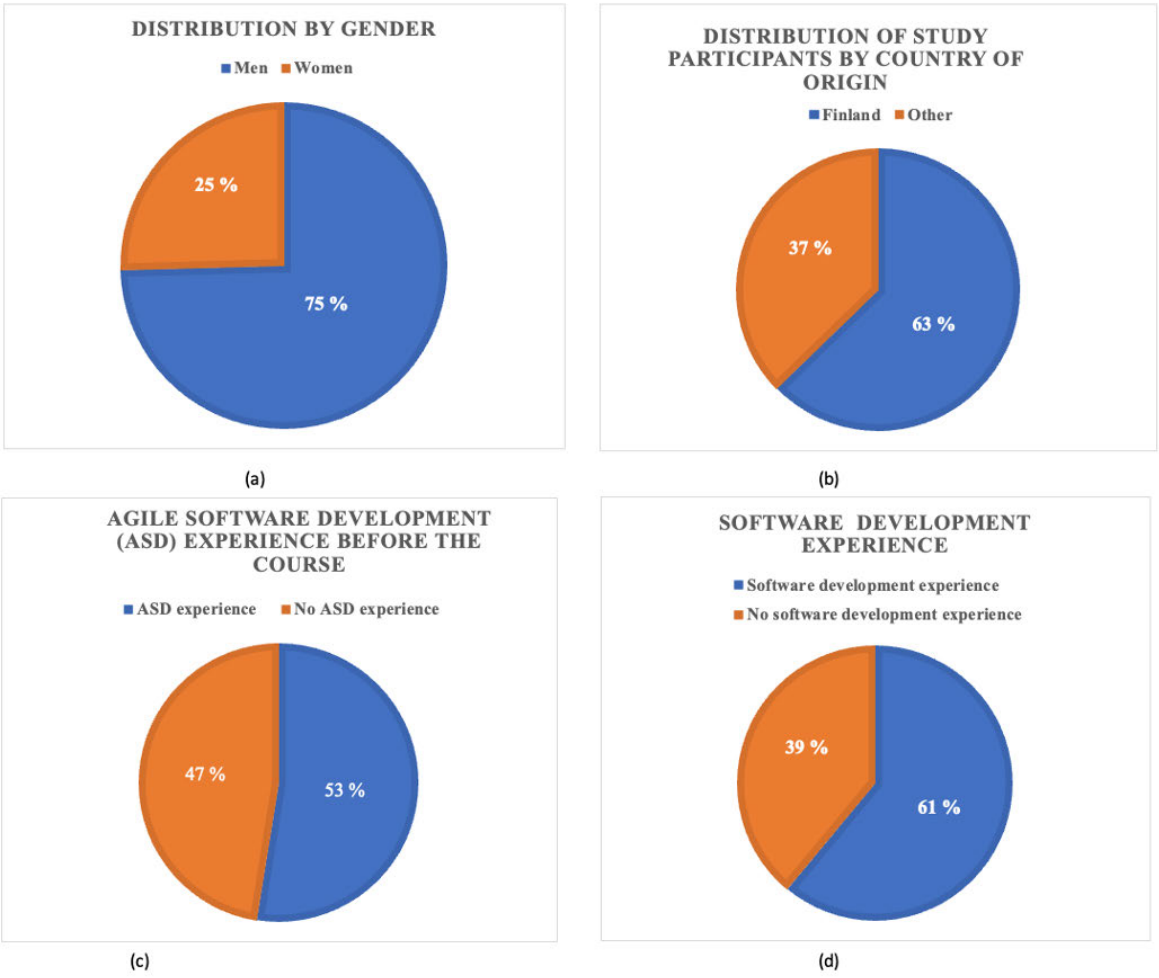


**FIGURE 3.** Demographics of the participants, (a) Distribution by gender, (b) Distribution by country of origin, (c) Prior ASD experience, and (d) Distribution by software development experience.

explained that they adopted the ceremony to find and create tasks for an upcoming sprint. They described that they estimated effort for the tasks in the meeting and prioritized them, too. One team elaborated that they also defined acceptance criteria for their tasks during the sprint planning event.

*Daily Scrum (Stand-up) Meetings:* 75% of the Scrum teams (nine) virtually hold the daily Scrum meetings. The frequency, meeting time, and channel or medium of the meeting varied among the teams. These teams used tools such as Discord, Microsoft Teams, and Zoom for the meetings. 17% (two teams) had asynchronous text chats among their members instead of daily stand-up meetings. 8% (one team) did not hold the daily scrum meeting. Instead, the team relied on the weekly scrum meetings they held on Discord. Among the nine teams holding the daily stand-ups, five teams had fixed timeslots daily for the meeting, and two had flexible time slots changing every day. However, one of the nine teams held only two to three daily scrum meetings and did not report whether they had fixed or flexible time slots. The two teams that held asynchronous chats and one that did not hold daily scrum meetings justified scheduling conflicts as a reason for not following the daily scrum meeting.

*Sprint Review:* Each team held two sprint review meetings with the customers, which were the course instructors. However, these sprint review sessions lasted only for 15 minutes. The teams held the third and fourth sprint review meetings without the customers. In the sprint review meetings, the teams reviewed the task completion, progress status, and feature implementations, and discussed the issues they met during the sprint. 17% (two teams) said they met and reviewed their backlog in preparation for the review meeting with the customer. 8% (one team) held an extended sprint review meeting, whereby the sprint review meeting was extended and held among team members after the meeting with the customer had ended. In the sprint reviews, where customers were not present the teams had to report their task completion, progress status and issues through e-mail to the customers. The customers also provided feedback to the teams through e-mail.

*Sprint Retrospective:* 83% (ten teams) reported holding weekly sprint retrospective meeting after the sprint review meetings. These teams used the meetings to improve upcoming sprint implementations. Among these ten teams, five explicitly said that they discussed what went well and bad in

**TABLE 2.** Overview of the composition of the scrum teams.

| Team | ID | Gender | Country of origin (Finland, Other) | Software dev. exp. | ASD exp. |
|---|---|---|---|---|---|
| A | P1 | Man | Finland | Yes | Yes |
| | P2 | Man | Other | No | No |
| | P3 | Woman | Finland | No | No |
| | P4 | Man | Finland | Yes | Yes |
| | P5 | Man | Other | Yes | Yes |
| B | P6 | Man | Finland | Yes | Yes |
| | P7 | Man | Other | No | No |
| | P8 | Woman | Finland | No | No |
| | P9 | Man | Other | Yes | No |
| | P10 | Man | Finland | Yes | Yes |
| C | P11 | Man | Finland | Yes | Yes |
| | P12 | Woman | Finland | No | Yes |
| | P13 | Man | Other | No | No |
| | P14 | Woman | Other | No | No |
| | P15 | Man | Finland | Yes | Yes |
| D | P16 | Man | Finland | Yes | Yes |
| | P17 | Woman | Other | Yes | No |
| | P18 | Woman | Finland | Yes | Yes |
| | P19 | Man | Finland | No | No |
| | P20 | Man | Finland | Yes | Yes |
| E | P21 | Man | Finland | Yes | Yes |
| | P22 | Woman | Finland | No | Yes |
| | P23 | Man | Other | No | No |
| | P24 | Woman | Other | No | No |
| | P25 | Man | Finland | Yes | Yes |
| F | P26 | Man | Finland | Yes | Yes |
| | P27 | Man | Other | Yes | Yes |
| | P28 | Woman | Finland | Yes | Yes |
| | P29 | Man | Finland | No | No |
| | P30 | Woman | Other | Yes | No |
| G | P31 | Man | Finland | No | No |
| | P32 | Man | Finland | Yes | Yes |
| | P33 | Man | Other | Yes | Yes |
| | P34 | Man | Finland | Yes | No |
| | P35 | Woman | Other | Yes | Yes |
| H | P36 | Woman | Other | Yes | No |
| | P37 | Man | Finland | Yes | Yes |
| | P38 | Man | Other | Yes | Yes |
| | P39 | Man | Finland | Yes | No |
| | P40 | Man | Finland | No | No |
| I | P41 | Man | Finland | Yes | Yes |
| | P42 | Man | Other | Yes | Yes |
| | P43 | Woman | Other | Yes | No |
| | P44 | Man | Finland | No | No |
| | P45 | Man | Finland | No | No |
| J | P46 | Man | Finland | Yes | No |
| | P47 | Man | Other | No | Yes |
| | P48 | Man | Finland | Yes | Yes |
| | P49 | Man | Finland | No | No |
| K | P50 | Man | Finland | Yes | Yes |
| | P51 | Man | Finland | No | No |
| | P52 | Woman | Other | No | No |
| | P53 | Man | Other | Yes | Yes |
| | P54 | Man | Finland | No | No |
| M | P55 | Woman | Other | Yes | Yes |
| | P56 | Man | Finland | No | No |
| | P57 | Man | Finland | Yes | Yes |
| | P58 | Man | Other | Yes | Yes |
| | P59 | Man | Finland | No | No |

**TABLE 3.** Overview of prototypes, development, and usability testing tools and techniques.

| Team | Student well-being application prototype versions developed by the team | Prototype development tool used by the team | Prototype testing used by the team |
|---|---|---|---|
| A | Desktop, Mobile and Smart watch | Figma | Usability testing with a tester, and observer |
| B | Desktop, Mobile and Smart watch | Figma | Usability testing with a tester |
| C | Desktop and Mobile | Figma | Usability testing with a tester |
| D | Mobile and smart watch | Figma | Testing was done with cognitive walkthrough |
| E | Desktop and Mobile | Figma for mock-ups, Draw.io for sequence diagram development | Maze tool |
| F | Desktop, Mobile and Smart watch | Figma, Canva | Usability testing with a tester |
| G | Desktop, Mobile and Smart watch | Figma | Nielsen's heuristics evaluation for usability testing |
| H | Desktop and Mobile | Figma | Nielsen's 10 Usability Heuristics |
| I | Desktop and Mobile | Axure RP10 | Uxtweak.com tool usability testing |
| J | Desktop and Mobile | Figma | Usability testing with a tester |
| K | Mobile | Figma | Maze |
| M | Desktop, Mobile and Smart watch | Figma | Maze |

the sprint implementation and determined action points for improving future sprint implementations.

Among the remaining 17% (two teams), one team reported they had only one scrum retrospective meeting. The other team did not report how often they held the meeting. However, they explicitly said that they used the meeting to assess the sprint implementation and find means of improving future sprint implementations. The scrum masters handled guiding the sprint retrospective meetings.

**2. Challenges of adopting scrum ceremonies in hybrid settings in a course project (Q2)**

In total, we found 16 challenges that can be mapped to the different scrum ceremonies. Table 4. maps these challenges along the different scrum ceremonies. We discuss the challenges related to each scrum ceremony below.

*Sprint Planning Meeting:* Regarding the challenges of sprint planning, the difficulty in effort estimation was the most recurrent challenge, being reported by 50% (six teams). 25% (three teams) reported challenges in hybrid meetings due to schedule conflicts and time zone differences. 17% (two

**TABLE 4. Mapping the challenges of adopting scrum in hybrid settings in a course project to scrum ceremonies.**

| Challenge | Sprint plan | Daily Scrum | Sprint review | Sprint Retrospective |
|---|---|---|---|---|
| 1. Difficulty in effort estimation | X | | | |
| 2. Schedule conflicts, differences in time zones | X | X | | X |
| 3. Difficult learning path at the beginning | X | | | |
| 4. Communication Infrastructure (audio devices, poor internet connectivity) | X | X | | |
| 5.Miscommunication on tasks | X | | | |
| 6. Imbalance in task allocation among team members | X | | | |
| 7. Keeping the meeting time-boxed | X | | | |
| 8. Language – heavy accent, not clear | | X | | |
| 9. Not following the meeting agenda | | X | | |
| 10. Insufficient feedback during the sprint review | | | X | |
| 11. Unfamiliarity and inexperience with tools and processes led to difficulties in the proper allocation of time and task | | | X | |
| 12. Absence of team members | | | X | X |
| 13. Deriving action items from sprint retrospective | | | | X |
| 14. Sprint duration was small | | | | X |
| 15. Sprint retrospective not scheduled properly | | | | X |
| 16. Lack of open discussion among team members | | | | X |

teams) reported difficulty in applying sprint planning at the project's outset. The scrum teams also reported non-recurrent challenges, such as challenges due to communication infrastructure (e.g., audio devices, and poor internet connectivity), imbalance in task allocation among team members, the difficulty in keeping the sprint plan meeting time-boxed and miscommunication on tasks which also resulted in incorrect effort estimations.

*Daily Scrum Meeting:* We found that there were challenges due to scheduling conflicts, communication tools, language accents, and lack of adherence to meeting agendas and purpose. Scheduling conflicts that made difficulties in arranging a common time for holding the meeting were reported by 75% (nine teams), while 25% (three teams) reported challenges with adherence to the daily scrum meeting goal and agenda. 17% (two teams) reported challenges due to communication medium and infrastructure. Language issues due to accent which was not easy to understand was reported as a problem by 8% (one of the teams).

*Sprint Review Meeting:* 42% (five teams) reported challenges due to insufficient feedback from the customer during the sprint review sessions. 17% (two teams) reported difficulties due to tools and processes, which arose from the unfamiliarity and inexperience with Scrum tools and the review meeting. The absence of team members in the sprint review meeting was reported as a challenge by 8% (one of the teams). 25% (three teams) reported no challenges, and one team did not respond to the question.

*Sprint Retrospective Meeting:* 45% (four teams) reported that the sprint durations, which lasted a week each, were too small and recommended longer sprints. 22% (two teams) reported facing challenges due to the lack of open discussion. There were non-recurring challenges such as not scheduling sprint retrospective meetings, failure to derive actionable items from the sprint retrospective meeting, and the absence of team members during the meeting. One team reported that the exercise format did not fully support the needs of remote, distributed students working and studying in different time zones. Two teams reported that they faced no challenges.

**3. Positive aspects of adopting scrum ceremonies in hybrid settings, in a course project (Q3)**

This section summarizes the positive aspects that the scrum teams reported on the adoption of the scrum ceremonies in their projects. In total, the teams reported 12 positive aspects or benefits regarding the adoption of scrum ceremonies. Table 5 presents a mapping of the reported positive aspects applying scrum ceremonies along the different scrum ceremonies.

*Sprint Planning Meeting:* 67% (eight teams) reported that the sprint planning meeting was beneficial for getting clarity on the sprint goal and tasks. 25% (three teams) reported that sprint planning helps ease task allocation and prioritization among team members. Additionally, two teams found that it helped in enhancing team collaboration. One team reported that sprint planning helped see the bigger picture of the project. Another reported that sprint planning contributed to sprint success.

*Daily Scrum Meeting:* 58% (seven teams) found that the daily scrum meetings were beneficial since they brought visibility to the work in progress and the tasks that everyone was doing. Other benefits of the daily Scrum meeting reported included effective communication (reported by 33% (four teams)), enhanced team collaboration and work coordination (reported by 25% (three teams), and support in finding impediments (reported by 25% (three teams).

*Sprint Review Meeting:* 58% (seven teams) reported that the meeting helped check the work in progress and served to show and review what has been done in a sprint and ensure work is done correctly. Five teams explained that it helped them get customer feedback, thus easing the planning of the upcoming sprints and possible improvements. Two teams reported that it helped them improve the sprint planning and effort estimations in the upcoming iterations. One team did

**TABLE 5. Mapping of positive aspects of scrum ceremonies in hybrid settings in a course project.**

| Positive aspects | Sprint planning | Daily Scrum | Sprint review | Sprint Retrospective |
|---|---|---|---|---|
| 1. Clarity on sprint goals and tasks | X | | | |
| 2. Eases task allocation and prioritization | X | | | |
| 3. Enhance team collaboration and work coordination | X | X | | |
| 4. Visualize the bigger picture of the project | X | | | |
| 5. Contributes to the success of the sprint | X | | | |
| 6. Visibility of the work in progress and tasks others are doing | | X | X | X |
| 7. Effective communication | | X | | |
| 8. Helps identify impediments | | X | | |
| 9. Helps monitor the work in progress | | | X | |
| 10. Get customer feedback | | | X | |
| 11. Improve upcoming sprint planning and effort estimations and implementations | | | X | X |
| 12. Apply what is taught in the lecture (theory) into practice | | | X | |

not respond to the question, while another said it helped them apply concepts taught in the lecture.

*Sprint Retrospective:* 75% (nine teams) reported that Sprint retrospective helped them improve their working in subsequent iterations. Six of these teams and one other team noted that it contributed to finding weaknesses in the sprint implementation. One team reported that the meeting also helped bring visibility into the entire project's progress among the team members. One team did not provide an answer.

### C. REFLECTIONS ON THE USE OF AGILE PROJECT MANAGEMENT TOOLS, COMMUNICATION TOOLS, AND SCRUM BOARDS

This section provides the reflections of the scrum teams on using agile project management and communication tools in their projects. Fig. 4 (a) and (b), respectively, show the distribution of the communication and project management tools used in the project work among the twelve scrum teams.

The section also reflects on the scrum teams' use of scrum boards.

**4. Agile project management tools used by the teams in hybrid settings and the challenges and positive aspects of using them (Q4)**

58% (seven teams) adopted Jira for project management, and 42% (five teams) Trello. One team that adopted JIRA also used Microsoft Teams to edit and share documents within the team. Another team that used JIRA used SharePoint to share documents. The level of adoption of the tools among the teams varied widely. This was affected by the teams' experience with the tools. The features of each project management tool also affected the way that the teams managed their projects. Experienced team members helped with the adoption of tools.

The teams that used JIRA reported that the scrum master and product owner led the project management (e.g., setting up the tools, creating sprint backlogs, creating tasks and tickets). These teams used JIRA to plan their tasks in sprint backlogs, estimate effort for tasks, create tickets for tasks and monitor the progress of their work. The teams that adopted Trello said self-learning, team members' collaboration, and video tutorials helped them learn how to use the tool. They used the Trello board for managing tasks and backlogs. Some teams created distinct backlogs for each sprint, while others worked with a sole product backlog.

*Challenges:* 33% (four teams) reported the complexity of Jira as a challenge. According to them, the availability of several features, difficulty in sharing the scrum board, and advanced features that were not easy to learn to inexperienced users contributed to the complexity. 25% (three teams) reported difficulty in arranging requirements at various levels of abstraction in the tools. Two teams reported limited feature availability in the free versions of the tools they used as a challenge. The neglect of documentation in the project management tool (Trello), constantly changing tasks, insufficient time to learn the tool, and difficulty in setting up SharePoint were each reported as challenges, too. Additionally, one team reported that they faced no challenge in using Trello as a project management tool.

*Positive Aspects:* 67% (eight teams) reported the capability for organizing, monitoring, and managing project tasks as a benefit of the project management tools. 58% (seven teams) reported the ease of using the tools as a positive aspect, explaining that it eased adopting the tools. These teams found the tools easy for assigning tasks, updating statuses, and customizing them to their processes. Five teams reported that the project management tools helped bring transparency to the work in progress among team members. They were able to see their tickets and monitor their work progress and how their project was progressing. Two teams reported that the tools helped them to achieve efficient collaboration.

**5. Communication tools used by the teams in hybrid settings, and the challenges and positive aspects of using them (Q5)**

58% (seven teams) adopted Discord for communication purposes. These teams explained that they used daily chats and voice channel meetings in Discord to schedule and hold their meetings. Three of these teams also explained that they used separate channels and threads in Discord to keep discussions isolated. Additionally, one of the seven teams that adopted Discord also used Zoom for hosting scrum meetings. 42% (five teams) adopted Microsoft Teams to hold different

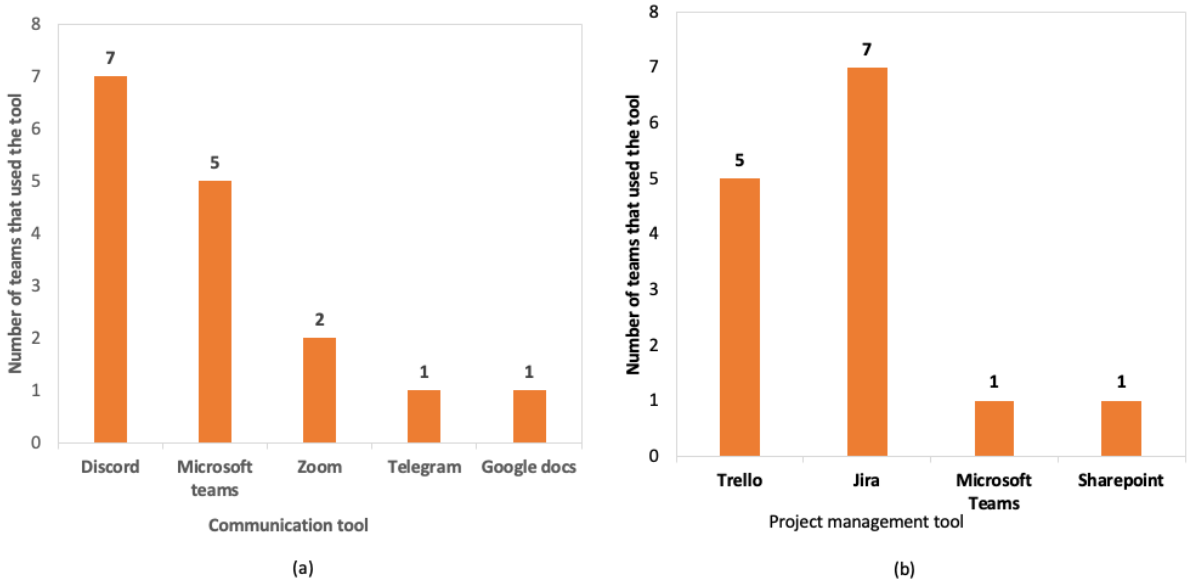


**FIGURE 4.** Distribution of tool usage by the Scrum teams (a) Communication tools and (b) project management tools.

meetings, co-working on documents, and sharing and managing documents. Among these five teams, one also adopted telegram and Google Docs, while another one adopted Zoom.

*Challenges:* Audio quality issues were reported by 33% (four teams) that adopted Discord. Two teams that adopted Microsoft Teams and Discord reported challenges due to missing messages and notifications among team members. 25% (three teams) reported no challenges. 8% (one team) reported Zoom's logging, tracking, and sharing restrictions as a challenge. According to the team, the Zoom version used by the students had limited features (e.g., it did not keep video recordings). Using Microsoft teams also required the students to have university accounts. This was seen as a challenge by one team. Additionally, another team reported the challenge of the extra effort and planning needed to set up Microsoft Teams since all members were not using the tool previously.

*Positive aspects:* 58% (seven teams) reported that Discord helped them to organize easy and effective communication in their teams. The ability to organize discussions on separate channels and keep track of conversations and topics was seen as an advantage. The tool also ensured quick responses and shortened delays, contributing to effective communication. 42% (five teams) adopting Microsoft Teams reported that they find the tool easy to use for meetings. They reported that the tool also helped them take notes and supported recording. One team that used Telegram, Google Docs, and Zoom also reported ease of use of the tools for communication.

**6. Reflections on the use of scrum boards (Q6)**

58% (seven teams) adopted JIRA for the Scrum board, while 42% (five teams) used Trello. These teams used the Scrum board to find and plan their tasks and monitor the progress of their work. Each team implemented the scrum boards by using different labeling that fit their development. Examples of labeling followed by the teams included: To Do, in progress, and done; Scheduled, in progress, and Done; Backlog, in progress, testing, Done; Backlog, In Progress, Code Review, Done. The scrum masters and product owners handled organizing the Scrum boards. However, scrum team members also took part in updating task descriptions and the status of tasks.

*Challenges:* 42% (five teams) reported that inexperience regarding the tool used for the scrum board made the task of using scrum boards challenging at the course project's outset; among these, four teams used JIRA, while one used Trello. Inexperience on Scrum practices and using the tools prevented the teams from applying the full features of the tools. 33% (four teams) reported a challenge due to a lack of prompt updates on tasks and their status by team members. Team members failed to document and update cards. 25% (three teams) also reported difficulty in creating tasks out of requirements (e.g., tasks and sub-tasks) and transferring and documenting them in the board. Two of these teams were using Trello, while one team used JIRA. Two teams reported a challenge due to vague descriptions of tasks in Trello, which were not detailed enough to understand. One team reported they faced no challenge.

*Positive Aspects:* 58% (seven teams) reported that the Scrum board brought visibility of the workload and task descriptions for their teams. 42% (five teams) reported the ability to monitor work progress. Four teams (two teams applying Trello and two teams applying JIRA) reported the ease of use of the scrum board for organizing, documenting, and sharing tasks among team members. One team reported that JIRA's notifications feature helped collaborations among team members. This was because the notification feature helped shorten delays regarding communication among team members. One team reported learning the skills regarding the tool and scrum as a benefit.

## VI. DISCUSSION

In this section, we discuss the findings of our study and provide recommendations for enhancing the design of course projects that apply Scrum in hybrid settings. We also compare our findings to related work, discuss the threats to validity, provide implications, and point out directions for future studies.

### A. ORGANIZING SCRUM CEREMONIES IN HYBRID SETTINGS IN COURSE PROJECTS

*Sprint planning:* The scrum teams found difficulty in effort estimation and scheduling conflicts for arranging sprint planning meetings as challenges of the sprint planning meeting. Effort estimation is a challenging task in ASD [21], and it has also been reported as a challenge in ASD course projects [6]. We acknowledge the challenge since experience and skills influence effort estimation ability. Regarding sprint planning, scheduling conflict was also reported as a challenge among the teams. Scheduling conflicts are also reported as challenges in remotely taught scrum projects [11].

**Recommendation** - One means of enhancing effort estimation is to include training on different estimation techniques in Scrum exercises. Training on effort estimations can help students and practitioners improve their task effort estimation abilities [21]. To overcome the challenges of scheduling conflicts in arranging sprint planning meetings, defining a precise time that is common to all members of the team will be helpful. This can be done, for instance, by allocating part of the weekly exercise sessions for the sprint planning meeting. Matthies et al. [11] also found that defining and following a precise time shared by team members is helpful for the proper arrangement of remote scrum meetings among students.

**Daily scrum meeting** – Seven teams arranged their daily scrum regularly through video meetings, while one held two-three daily scrum meetings. These observations show that teams can effectively hold virtual scrum meetings. Two other teams relied on daily asynchronous chats in Discord instead of daily scrum meetings. These teams were composed of members living, studying, and working in various locations and time zones. They justified their decision to adopt the daily Discord chats as a solution to overcome the challenge of scheduling conflicts. Will this also be a viable solution for small scrum teams that work in distributed settings with different time zones? Can scrum teams working in global software development (GSD), where teams work around the clock, from various locations, in distributed settings around the globe [22], utilize similar solutions? While this may be viable, we believe that it is necessary to systematically investigate the effectiveness of asynchronous chats replacing daily scrums. This can be one area that future studies can address. The teams that did not hold the daily scrum meetings had their members studying, working, and living in different time zones. We believe that the asynchronous chats could be adopted by such teams systematically.

**Recommendation**– When designing course projects that apply scrum projects in hybrid settings, measures should be taken to monitor that students apply the scrum ceremonies properly. Teachers should explicitly convey the importance of holding the scrum ceremonies regularly and correctly. In the beginning, teachers can also be present during the daily scrum meetings, observe how the students hold the meetings, and provide feedback and guidance.

Teams working in different time zones and distributed settings can experiment with using asynchronous chats as a substitute for daily scrum meetings. We recommend that this needs to be done systematically, with a shared understanding of the procedure, and should be led by the scrum master. Each member should state 'what they did, what they plan to do, and communicate any impediment they may have faced.' These need to be documented systematically and in a traceable way. Chatbots can also be customized to collect briefs on daily scrum meetings [9]. In cases where team members work in different time zones, this can be used as an alternative solution.

In-person meetings are seen to encourage team collaboration and coordination. Including them early on can help ease communication and collaboration and build team spirit, which is required for the success of teams working in hybrid settings. When starting the course project, we recommend that students begin with in-person scrum meetings, e.g., sprint planning and daily scrum meetings, then proceed with hybrid and remote sessions.

**Sprint Review**– Five teams perceived customers' feedback during the sprint review as insufficient. This was valid since the sprint review meetings lasted only for 15 minutes per team for each sprint. This was due to resource limitations. However, we tried to mitigate this by informing the teams that they should communicate with customers (course lecturers) through e-mail to clarify unclear requirements and to discuss other matters in detail. Product owners of some teams were actively communicating with the customers and clarifying the issues. We observed practices that contributed to effective sprint review meetings, such as in advance preparation for the sprint review meetings and extended review meetings among team members. We plan to increase customers' involvement in the sprint review meeting sessions in future course implementations. The absence of team members in the sprint review meetings was also a challenge in some teams. This has also happened in other scrum meetings.

**Recommendation**- The design of course projects applying scrum should consider allocating enough resources to ensure smooth implementation of the project and the achievement of the learning objectives. Teachers should allocate sufficient time for sprint review sessions with students. Students should also prepare for an effective sprint review meeting in advance. Product owners of the scrum teams should clarify requirements that may not have been clearly addressed in the sprint review session by communicating with the customers.

**Sprint retrospective –** open discussion in a hybrid setting was seen as challenging when holding the retrospective

meetings. One team reported that the project work was challenging due to the distributed team members having different time zones. While distributed teams working on the project task can give the students insights into real-life projects, we noticed that arranging teamwork for members working in different time zones is not easy.

*Recommendation*: Organizing scrum projects for students working in distributed and hybrid settings should take into consideration challenges that may arise from team members' diversified backgrounds (e.g., culture and experiences in software engineering). For example, achieving open communication can be difficult, especially when the teams work only on a four-week scrum project. This may be difficult since students must attend other courses too. Course projects can consider longer periods, with more weekly sprints, as students will have chances to know each other and collaborate better, enhancing the likelihood of open communication.

### B. USING AGILE PROJECT MANAGEMENT TOOLS, COMMUNICATION TOOLS, AND SCRUM BOARDS IN HYBRID SETTING IN COURSE PROJECTS APPLYING SCRUM

In this section, we present the implications of our findings regarding the use of agile project management tools, communication tools, and the application of the Scrum board.

*Agile Project Management Tools:* Jira and Trello were popular project management tools among the scrum teams. Additionally, the scrum teams complemented and managed their project work with tools such as Microsoft Teams and SharePoint. The presence of experienced team members helped with the adoption of the tools. Students with experience in ASD and project management tools like Jira helped their fellow team members adopt the tools and scrum practices.

The features of the project management tool also affected how the teams used the tools. For example, JIRA had more features to support scrum compared to Trello. JIRA had features for creating burndown chart reports and visualizing and monitoring their work progress. However, some teams reported these features as complex and challenging to learn. The availability of the features also varied based on the version (commercial and free trial versions). Other teams using Trello found the limited availability of such features to be a challenge.

*Recommendation:* We recommend providing initial training in setting up and using project management tools. Additionally, student projects can adopt alternative open-source agile project management tools such as taiga.io, which offer advanced features and are not restricted to free trials. Involving team members with experience in ASD is beneficial since they may have exposure and familiarity with agile project management tools and practices. They can help their teammates and facilitate the adoption of scrum and relevant tools.

*Communication Tools:* The teams were free to choose the communication tool that they used. Discord voice meetings and chats were popular communication choices among them. Microsoft Teams was the second most popular tool, while Zoom and Telegram were also used for communication. We also observed that these tools were used in agile projects organized in a university context [11]. A recent systematic literature review by Neumann and Bogdanov [16] reported Microsoft Teams, Zoom, Slack, and Google Hangouts are used for communication in remote ASD teams. The study found that Microsoft Teams was the most popular.

In our study, four teams that used Discord reported challenges due to audio quality issues such as unclear voice and inaccessible voice chats. The audio quality issues could have resulted from microphone issues and poor internet connectivity. Messages in long chat discussions were prone to be missed and forgotten easily by team members. Discord's feature of supporting separate discussions on different channels was seen as advantageous since it supported keeping discussions focused.

*Recommendation:* ASD promotes collocated team collaboration where teams meet and organize their work face-to-face [1]. When considering hybrid work settings, ensuring proper and quality communication infrastructure is important. Courses taught at universities and applying ASD in course projects in a hybrid setting should ensure that students have proper communication tools that help facilitate their learning. For example, investing in quality microphones that students can borrow and high-speed internet connections can contribute to enhancing scrum meetings and communication.

*Scrum board:* The findings revealed that each team adopted the scrum board to suit their software development process. While the use of the scrum board was identified as useful in enhancing the visibility of the work in progress among team members, inexperience with tool usage and failure to continuously update the status of the tasks on the scrum board were challenging. The features of the tools that were chosen for project management also affected how the board was utilized.

*Recommendation:* Similar student projects applying scrum board should consider providing training and guidance for students. Using free versions of proprietary project management software that may have limited features can hinder students' learning experience when applying Scrum. Therefore, it is important to consider open-source project management tools (e.g., Taiga.io), which offer added capabilities when applying scrum projects in university settings.

### C. DISCUSSION IN THE LIGHT OF RELATED WORK

The software engineering literature exhibits various studies reporting lessons learned from teaching ASD in university contexts [6], [7], [8], [9], [10], [11], [12], [13]. Except for [11], most of the studies base their findings on experiences gained from in-person teaching. Additionally, they don't investigate how scrum is adopted in hybrid settings in university course projects. Matthies et al. [11] report the challenges of teaching ASD using scrum and kanban in remote settings during the covid 19 pandemic. Our study synthesizes

the challenges and positive aspects of adopting scrum in hybrid settings in university course projects.

Regarding the challenges, we found that students faced challenges due to scheduling conflicts and differences in time zones since identifying common meeting times was difficult. Matthies et al. [11] also identified scheduling was challenging for students adopting scrum in remote settings. Although not in a hybrid context, Massod et al. [9] work reveals students faced similar challenges due to scheduling conflicts when adopting scrum in a university course project. We observe scheduling challenges exhibited in university course projects adopting scrum regardless of the context (remote, hybrid, or in-person). This occurs because students must participate in other courses, may work part-time, or have other commitments. In this regard, educators should proactively design courses with a plan to mitigate such challenges, for example, by defining fixed time slots for scrum ceremonies.

In our study, we found unique challenges of adopting scrum in hybrid settings in course projects, which are not reported in other studies. These include a team member's absence, the feeling of imbalanced task allocation among team members, difficulty in deriving action items from sprint retrospectives, and the lack of adherence to scrum meeting agendas. We believe ensuring students' commitment to course project participation and providing proper and adequate training on scrum can alleviate such challenges. When organizing a scrum course project in in-person settings, Hsu et al. [10] identified that students face challenges in getting a shared working space to arrange scrum meetings (e.g., daily scrum). In our study, we did not observe a similar challenge. However, we want to emphasize that educators should consider the importance of shared spaces when organizing scrum projects in in-person settings.

Effort estimation is crucial in ASD projects since overlooking estimations may lead ASD teams to incur technical debt [21]. It is also an important skill that ASD teams should develop. Difficulty in effort estimation was another challenge identified in our study. Studies such as [6], [7], and [9] also found that students faced challenges in effort estimation. This challenge is not unique to scrum projects adopted in hybrid settings and occurs in in-person scrum course projects. Therefore, scrum projects given in universities should provide proper and adequate training on effort estimation.

The Agile Manifesto promotes interactions and considers face-to-face conversation the most efficient and effective way of conveying information among agile teams [1]. Considering this, adopting ASD methods, such as scrum in remote and hybrid settings, can pose challenges. In our study, miscommunication on tasks was one of the challenges that scrum teams faced. There were challenges due to the lack of openness in discussions during sprint retrospectives. Matthies et al. [11] found that students adopting scrum in remote settings experienced decreased implicit feedback since there were no non-verbal clues in communication, unlike in face-to-face meetings. Cucolas and Russo [23] also identified openness as a challenge in software companies adopting Scrum remotely when compared to in-person retrospective meetings during the COVID-19 pandemic. Griffin [24] shows that the psychological safety of teams adopting scrum in remote settings may be impacted since everyone may also not have their webcam turned on, affecting open discussion in sprint retrospectives. Scrum teams can benefit from practices that encourage openness. For example, adopting video calls where all participants turn their webcams on, in hybrid settings can be beneficial since it can help scrum team members participate actively in scrum ceremonies.

Teams adopting scrum in remote and hybrid settings rely on communication and project management tools to collaborate and coordinate their work. In our study, scrum teams reported using communication tools such as Discord contributed to effective communication. Discord enables organizing distinct channels and threads to discuss different topics and shortening delays in response. Some scrum teams noted that JIRA notifications and scrum boards facilitated collaboration and communication. However, we also found that some students experienced challenges due to the lack of regular updates on documentation and missing project management tool notifications. Some students faced issues due to audio quality, internet connectivity, and audio devices affecting team communication and collaboration. Griffin [24] found similar challenges due to audio and video conferencing tools and network issues. Neuman and Bogdanov [16] found that some software practitioners who adopted ASD remotely in software companies perceived that communication worsened than in-person settings, while others found that it improved. While these findings may be context-dependent, they highlight the importance of allocating proper communication infrastructure. It is also essential to adopt practices that are tailored for hybrid settings and invest in proper training in relevant communication and project management tools both in educational and industrial settings.

In our study, one team identified time-boxing sprint planning meetings as difficult. Similar observations have been made in software teams adopting scrum in remote settings. Griffin [24] found that scrum teams struggle to adhere to the time boxes of daily scrums and sprint review meetings in remote settings. Cucolas and Russo [23] discovered daily scrum meetings took longer in remote settings compared to on-site settings in teams adopting scrum. The challenge of time-boxing scrum meetings occurs both in educational and company settings when adopting scrum in remote and hybrid settings. We believe that clarifying the goals of sprint ceremonies (e.g., daily stand-ups, sprint planning) and utilizing proper tools when applicable (e.g., chatbots and using asynchronous chats as substitutes for daily stand-up meetings) can contribute to minimizing time-boxing challenges.

Regarding the positive aspects, we found teams consider sprint planning to contribute to enhancing transparency, team collaboration and coordination, and sprint success. Likewise, daily scrums were found beneficial by bringing visibility to the work in progress, enhancing communication, and identifying impediments. Matthies et al. [11] show that students

who adopted scrum in remote settings reported benefits such as effective sprint planning, easier documentation, and focused virtual meetings. Neuman et al. [25] interviewed software practitioners adopting remote ASD and found they perceived transparency as improved compared to in-person ASD. The use of digital scrum boards, increased documentation, and communication channels were perceived to contribute to enhancing transparency [25]. We believe scum teams should adopt proper project management and communication tools, utilize optimal documentation, and tailor their ASD practices to fit their context to effectively adopt Scrum in hybrid settings.

Overall, we observe some similarities between our findings and studies reporting the adoption of ASD in university course projects, both in hybrid and in-person settings. For example, students in both settings share challenges due to scheduling conflicts, difficulty in effort estimation, and poor communication infrastructure. Some of the challenges we found are also exhibited in software companies adopting scrum and ASD in remote settings, e.g., communication and coordination challenges. Our work also complements existing knowledge by identifying new challenges, e.g., imbalanced task allocation and difficulty in deriving action from sprint retrospectives. Regarding the positive aspects, we found improved transparency, which was also reported both by students and practitioners adopting ASD in remote settings. Our work also uncovers practices for effectively adopting scrum in hybrid settings, e.g., using asynchronous chats as alternatives to daily scrums, using topic-specific channels on Discord to facilitate communication and discussion, and adopting video calls and promoting openness to enhance open discussion in sprint retrospective meetings. Additionally, we provide recommendations that enhance design and organization of scrum course projects in hybrid settings.

### D. THREATS TO VALIDITY

We adopted Runeson and Host [26] classification of validity threats to discuss the threats to validity and limitations in our study. We also discuss the mitigations we took to minimize the corresponding threats to validity.

**Construct validity** – Each team's experience in ASD and software engineering may have influenced how each team adopted Scrum in their projects. When creating the scrum teams, we used data on the students' backgrounds and experiences in ASD and software development. This helped us include students who reported experiences with ASD in each Scrum team and minimize the chances of having an unbalanced team composition. However, it is possible that course projects that use different forms of team composition and creation (e.g., allowing students to create their own groups) may have different experiences and results.

The fact that some students were taking additional courses simultaneously and others were working part-time while studying and taking part in the course may have affected their contribution and performance within the team. We acknowledge the limitations which may arise from such aspects.

**Internal validity** – It is possible that there might be factors that have been overlooked or that we are unaware of that have influenced the outcome of our study. However, we took the following measures to minimize the threats to internal validity. To minimize threats that may arise from using only one source of data, i.e., feedback data from the questionnaire, we used triangulation. We triangulated our findings using multiple sources. For example, notes we took during sprint review sessions and students' deliverables were used to cross-check data. The customers' absence in the third and fourth sprint review meetings poses a potential threat to internal validity. However, to minimize the threat, the scrum teams had to submit their sprint deliverable and update the status of their sprint to the customers through e-mail. The customers also provided feedback to the teams through e-mail.

Another limitation may come from the fact that the scrum teams have utilized different tools. The teams adopted the tools of their choice. It is possible that the teams chose different tools for various reasons. For example, some teams may have opted for tools they are more familiar with or have easy access. For example, our students have free access to Microsoft Teams, which may have influenced some teams to use it. We acknowledge that having all the scrum teams utilize similar project management, communication, and development tools may have varying outcomes.

**External validity -** refers to the generalizability of the study's findings. Although the generalizability of the findings is limited to the study's context, we believe that the findings of the study are partly applicable to similar contexts. For example, the findings on the importance of ensuring proper communication infrastructure for students and the need to consider potential scheduling conflicts among students when organizing scrum ceremonies are factors that apply to scrum projects that are organized in remote and hybrid settings.

**Reliability**– We collected data using Excel spreadsheets. To minimize threats from collecting irrelevant data, both authors designed and reviewed the spreadsheet used for collecting feedback. This helped ensure the collection of relevant feedback by the scrum teams. The first author conducted the data analysis. To minimize potential researcher bias in the data analysis, the second and third authors reviewed the results of the data analysis. Additionally, we used notes that we took during sprint review meetings, seminar presentations, and project work deliverables to triangulate the findings from our analysis. For example, we crosschecked the data collected on project management tools and challenges reported by the teams in the feedback with reports in the seminar presentation, as well as notes we took in our sprint review meetings.

### E. IMPLICATIONS FOR SOFTWARE ENGINEERING EDUCATION AND RESEARCH

Teaching students ASD at the university level is deemed as challenging [7], [9]. However, ASD course projects can

help students gain transferable skills that are needed by the software industry. The study's findings contribute to software engineering education by providing insights into aspects that educators need to consider when designing and teaching Scrum at the university level in hybrid settings. University teachers can learn about the potential factors that may affect the implementation of Scrum projects in hybrid settings (e.g., communication tools, issues that may arise from scheduling conflicts for handling scrum ceremonies, the importance of allocating enough resources to carry out the implementation, and importance of providing adequate feedback during sprint review meetings). Such knowledge is beneficial since it can help them take a proactive approach when designing their courses and facilitate the smooth implementation of Scrum projects in hybrid settings, which is a new normal.

For software engineering research, our findings provide empirical knowledge about running scrum projects in hybrid settings within educational settings. It also highlights potential research gaps, such as understanding and assessing the feasibility of using asynchronous chats as substitutes for daily scrum meetings in hybrid settings within scrum projects. Researchers can also explore ways to improve open discussions in sprint retrospective meetings in hybrid settings, a challenge we found common to both industrial and educational contexts. Communication and coordination are crucial in scrum teams adopting ASD in hybrid settings. In this respect, researchers can develop tools and practices to facilitate seamless communication and coordination of Scrum and ASD teams working in remote and hybrid environments.

### F. IMPLICATIONS FOR SOFTWARE PRACTITIONERS

The findings of our study are also applicable to software practitioners. In particular, the findings will be useful for small startup teams who are willing to establish scrum processes for their projects in hybrid settings and maybe working with limited resources. They can learn about the potential tools and practices that they can use to support their development process. For example, small, distributed scrum teams operating in different time zones can experiment with asynchronous chat meetings that are documented systematically as a substitute for daily scrum meetings. The challenges related to handling scrum ceremonies in hybrid settings can also provide them with aspects that they may need to consider (e.g., the need to ensure excellent communication tools and train them in effort estimation techniques). Practitioners can learn about the benefits of using tools such as Discord to facilitate collaboration in hybrid settings by organizing distinct channels and threads for different topics in their scrum project.

Some of the challenges identified in our work are also exhibited in software companies adopting scrum in remote and hybrid settings. For example, scrum teams operating in remote and hybrid settings may face challenges from the lack of open discussions during sprint retrospectives and difficulties in time-boxing scrum meetings. In such a scenario, they can use practices reported in our study, e.g., promoting a culture of openness, enforcing video calls, clarifying scrum ceremony goals and meeting agendas, and utilizing asynchronous chats to mitigate the challenges.

### G. FUTURE WORK

As future work, we consider extending our study in the following directions. First, we consider conducting an in-depth investigation of the topic by tailoring how we organize the scrum project. We aim to extend the sprints to five weeks, improve the time and resources we allocate in the sprint review meetings, and include training on effort estimation techniques. We also consider including mandatory in-person meetings for scrum teams at the outset. This is motivated by our observations in this study. We believe that extending the study in such a path will give us more insight into the practices and challenges of adopting Scrum in remote and hybrid settings.

We found that asynchronous chats have been used as substitutes for daily scrums. Researchers can investigate how asynchronous chats can be used as substitutes for daily scrum meetings in hybrid settings and GSD teams, where distributed members of small scrum teams work in different time zones.

In our study, the scrum teams were free to choose the tools they used in the course project. As a result, the lessons learned reflect findings from the scrum teams who used varying tools. Enforcing the scrum teams to use similar tools and techniques for prototype development and testing, communication, and agile project management could have varying outcomes. In this regard, we aim to explore the adoption of scrum in hybrid settings in course projects by restricting the choice of tools and techniques.

Knowledge sharing in remote and hybrid settings is difficult [27]. Our study reported inexperience with tools and processes and difficulty in the learning path as challenges. Practices and solutions encouraging knowledge sharing and team collaboration can enhance students' learning paths in hybrid settings. With the advent of large language models (LLMs) in different fields, we believe there's a potential for exploring their use in facilitating the adoption of Scrum in hybrid settings. In this regard, we aim to examine the potential of using LLMS to facilitate knowledge sharing and the adoption of scrum in hybrid settings. We also encourage other researchers to explore using LLMs to tackle such problems.

## VII. CONCLUSION

Software engineering education should cater to the needs of the software industry by helping students gain skills that are relevant to the industry and offering up-to-date education that is in line with current and future trends. In this study, we report lessons learned from a scrum course project organized in hybrid settings.

The study reveals students gained insight into Scrum, applied agile practices and tools, and successfully delivered software prototypes. They were able to achieve the learning

objectives we set. We found challenges such as difficulties in the estimation of efforts, and communication and coordination issues, which affect organizing effective scrum projects in hybrid settings. Our analysis indicates that some of these challenges are also common in the software industry and need attention both from academia and industry.

The study offers insight into the key aspects that teachers should consider when organizing scrum projects in hybrid university settings. It provides recommendations for improving the design and organization of scrum course projects in universities, specifically in hybrid settings.

Our study provides valuable information on agile project management and communication tools for practitioners and small startup teams considering implementing scrum in hybrid settings. It offers insight into the tools, their benefits, relevant practices, and potential challenges. We also identify future research areas, such as creating tools for better collaboration in hybrid settings and investigating asynchronous chats as alternatives for daily scrum meetings in such environments.

## APPENDIX A
## SOFTWARE REQUIREMENTS DESCRIPTION

"Student Well-being" is software for ensuring the well-being of university students. This well-being system is owned by YTHS. This software helps students to keep track of their physical health based on sleep quality, diet, workout or exercises by keeping YTHS engaged.

- With the help of this well-being system, YTHS can keep track of students' well-being, e.g., diet, sleep routine, physical workout or exercises or outdoor activities.
- The application can be installed on smartwatches and mobile phones. However, users should also be able to learn about their well-being status online. Therefore, a user can view his/her health well-being report.
- In case where a user is not continually active in using online report services, then his/her well-being status should be stored locally on his computer. This should be done through a desktop version of the software, thus allowing users to check their health and well-being reports whenever they wish. The desktop interface is always in sync with the latest reports/updates that are available on the web.
- If a user does not own a smartwatch or activity tracker, the well-being application should also provide compatibility with other wearable sensors.
- Smartwatches and activity trackers should also be able to notify the user about specific events. For example, notifications about monthly reports that are ready to be viewed and health examination calls notifications whenever required by YTHS. There should also be an option for reminders of appointments with general practitioners or specialists if a user has scheduled those.
- Users should also be able to customize the notifications, i.e., along with the default settings, users should be able to choose notifications from the list of services/reports provided by YTHS.

## APPENDIX B
## QUESTIONNAIRE

See Table 6.

**TABLE 6. Questionnaire.**

| **Group Name** | | | |
|---|---|---|---|
| Did your team members meet face-to-face at least once during the exercise project? (Yes/No) | | | |
| Practices | How did you adapt the practice in your context? | What is the positive aspect of it? | What were the challenges related to applying the practice? |
| Daily scrum meeting | | | |
| Sprint Planning | | | |
| Sprint review | | | |
| Sprint retrospective | | | |
| Scrum Board (Trello/Jira/ online whiteboard) | | | |
| Roles | How did you adapt the role in your context? | What is the positive aspect of it? | What were the challenges related to applying the role? |
| Product owner | | | |
| Scrum master | | | |
| development Team (Developer + UX designer) | | | |
| Tools | Specify the corresponding tool name you adapted in your team. How did you adapt the tool in your context? | What is the positive aspect of it? | What were the challenges related to application of the tool? |
| Project Management tools (Jira/Trello etc.) | | | |
| Communication tools (Teams, Slack, Discord etc.) | | | |

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