Challenges (and Opportunities!) of a Remote Agile Software Engineering Project Course During COVID-19

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Abstract

COVID-19 and its immediate impacts on teaching activities have required changes from computer science educators worldwide. We switched our on-site courses to remote setups without detailed knowledge of what tools, techniques, and methods would work in different teaching contexts. A growing amount of experience reports on general best practices for remote teaching in higher education are available. However, university courses featuring practical software development projects present unique challenges regarding remote learning, as effective student collaboration is vital. In these courses, students tackle situations in the project and their team meetings that would also occur in real software projects experienced in industry settings. In this paper, we share our experiences on how we successfully adapted our software engineering project course to a remote setup, which challenges we observed in student teams and how they can be mitigated, and what (surprisingly) worked better than expected. Finally, we propose improvements that we expect will be beneficial not only for future remote-only but also for hybrid or on-site courses.

1. Introduction

The outbreak of the COVID-19 pandemic has led to a global physical shutdown of educational institutions. Both faculty and students transitioned from in-person campus-based activities to distance learning and working from home (WFH) in a short time span [1, 2, 3, 4]. Considerable experimentation with remote teaching and learning approaches in Higher Education followed. Educators migrated the teaching concepts and learning goals of course curricula initially designed for in-person instruction to the digital domain. Radical changes were required of teaching staff and the student body, who potentially had little prior (technical) knowledge and experience with remote teaching and learning. These circumstances, however, also represent an experimental condition worth investigating, with the same courses being taught physically in one year and remotely in the next. Consequently, a growing number of papers document COVID-19's impacts on Higher Education and university courses [5, 6, 7, 8, 9].

This study positions itself within this body of literature, albeit focusing on the teaching of Software Engineering (SE) topics and, even more specifically, the application of Agile software development processes in a project course during the COVID-19 pandemic. The context of this study is an undergraduate capstone course featuring a large-scale student project employing the Agile software development methods *Scrum* and *Kanban* in practice. Practical project work in SE courses provides valuable learning experiences, teaching industry-required skills such as efficient teamwork, robust communication, scheduling, and work organization [10]. The pandemic made it impossible for students in the winter semester 2020/21 to meet face-to-face, work in their teams, and attend physical lectures. Teaching teamwork and collaborative Agile methods in the virtual domain presents particular challenges, as Agile processes highlight the importance of co-location and low-friction face-to-face interaction in teams. In addition to transitioning the lectures to an online format, all student project work was fully virtualized. The challenges of monitoring, evaluating, and supporting project progress and students' performance in a digital environment had to be addressed [3]. However, the inherent focus of the employed Agile methods on adaptation to context, continuous learning, and process improvements contributed to positive outcomes.

While completely online SE courses in higher education are not a novelty of the COVID-19 pandemic [11], these remote courses were designed from the ground up with digital attendance in mind. This is not the case with courses adapted to remote learning on short notice, such as the one presented in this paper. While the challenges we encountered in our emergency remote teaching experience mirror

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those previously reported to some degree—especially regarding lectures [5]—we also noticed positives and opportunities of transitioning to remote Agile SE education and student teamwork that we had not anticipated. In this paper, we report on the challenges we encountered and the positives in our first virtual SE project course.

The following research question (RQ) guides our work:

> **RQ:** What challenges and opportunities occurred in a multi-team Agile university project course taught remotely for the first time?

2. Case Study Context

The context of this case study is a capstone undergraduate software engineering course targeted at students in the fifth semester of Bachelor studies at the HPI, University of Potsdam, Germany. The course provides close to real-world software development experiences to student teams, featuring large-scale collaboration, software architecture, work organization, and customer management challenges. The participants possess programming experience by attending previous lectures on software design and programming languages in the curriculum. The course is credited with 6 ECTS points, with one credit corresponding to 25 to 30 hours of work [12]. The course is taught in two consecutive ninety minutes slots on Fridays, with time allotted to team project work as needed.

2.1. Course Project

The main focus of the course is a hands-on project with multiple collaborating student teams, simulating a professional software engineering context. The individual course teams build a single application and employ the Scrum and (in a second stage) the Kanban development methods. In the course examined in this case study, the teams worked on a web application (using the *Ruby on Rails* framework) for creating and organizing human connections and relationships during lockdowns and social distancing measures. Participants were free to choose their teams, while the option of being assigned a group was also available. Most teams formed around existing workgroups, which aided communication in the new remote setting.

2.2. Teaching Team Support

Teams organize all the events required by Scrum (Planning, Daily, Review, Retrospective) and manage as well as self-assign the tasks of the Scrum Master and Product Owner (PO). A teaching team member takes on the role of the project customer who supplies project requirements and feature wishes. The team POs interview the customer and extract and structure the requirements, turning them into user stories for their teams. Regular virtual, interactive live lectures and a practical exercise introducing the employed technologies [13] support the practical project work. Lecture frequency is slanted towards the beginning of the course, with the necessary process and technical knowledge being communicated at the start and more lecture slots being used for team project work towards the end of the term. We also rely on guest lectures from industry professionals.

As part of the course, members of the teaching staff participate in all of the regular student team meetings and additional meetings and video calls when requested. Student tutors are responsible for supporting the teams and act as knowledgeable confidants for participants. They observe student meetings, are available for questions, and give feedback. Other teaching staff joins meetings when required or requested. The 2020/21 setup of the course featured three student tutors and 16 students working in three teams.

2.3. COVID-19 Adaptations

In previous courses, all lectures took place in a physical lecture hall featuring extensive student involvement through active discussions, questions, and experience sharing sessions. During the pandemic, these lectures were held online using video calls with the *Zoom* platform and a dedicated streaming setup at the university. While we added additional material on remote work concepts and empirical guidance on work-from-home best practices, the main course contents and learning goals remained the same from 2019 to 2020. Table 1 summarizes the course's learning goals.

We attempted to keep the same style of interactive lecture that had worked well in the past. All the employed learning materials, the lecture schedule, and links to all project repositories are publicly available on the course website [14]. Previous course iterations had used *Slack* as the primary communication tool (next to email) between teams. In the remote 2020/21 course, we switched to *Discord*[1], which supported voice and video group communications in the application's free version. Where student teams had previously met in rooms on campus, their regular Scrum meetings were held in *Discord* rooms or using the university's *Zoom* video call infrastructure, with tutors joining virtually.

[1] `https://discord.com`

#	Course Learning Goal
1	Practical experience with the Scrum method and knowledge of its artifacts, roles and meetings
2	Knowledge regarding scaling Scrum in multiple collaborating teams
3	Ability to confidently use Agile practices, such as Behavior-Driven-Development and Test-Driven-Development, where appropriate
4	Confidence in using the full feature set of a source code management (SCM) and related developer assistance systems
5	Experiencing the value of rapid release cycles and continuous integration (CI) systems
6	Critical self-assessment skills regarding one's team role and knowledge of collaborative improvement strategies

Table 1. Overview of the course learning goals.

GitHub and git remained the project management and version control systems employed in the course, as one of the de-facto industry standards. These tools served as the primary synchronization and collaboration hubs between teams, with source code and user stories (in the form of GitHub issues [15]) available to all course participants in a shared location. However, for the various other tasks and responsibilities required by Agile methods, e.g., tracking the improvement decisions from retrospective meetings, the teams were free to choose their own tools.

3. Data Collection

We collected the perceptions of educators and students regarding remote Agile SE collaboration and education in two ways: (i) analysis of the semi-structured meeting notes taken in the regular teaching team meetings, (ii) analysis of the structured, anonymous feedback by course participants using the university's evaluation platform at the end of the course.

3.1. Teaching Team Meeting Notes

In regular meetings (at least biweekly), the entire teaching team discussed the teams' state, both in terms of product progress and process adoption. These meetings focused on identifying issues in teams having to do with motivation, teamwork, and psychological safety, as well as technical issues that teams should receive support for immediately. Furthermore, the teaching team conducted knowledge-sharing sessions on what remote collaboration approaches, adopted and trialed by industrial teams, had shown success (or not). During these meetings, we took notes on the reported challenges and opportunities of remote collaboration, teamwork, and learning in teams, as well as the experiences of students that were employing Agile methods while learning and adapting them along the way. Regular attendees of the teaching team meeting were the lecturers (two persons), the customer role (one person), and the student tutors (three persons). The teaching staff had taken part in at least one previous in-person course edition and were familiar with the course contents and the employed Agile practices. We filtered the resulting meeting notes to topics that found at least two teaching team members in agreement and categorized them into *challenges* or *opportunities*. We discussed each item within the teaching team and gathered the required course context necessary to understand and explain the issues. The results are summarized in Sections 4 and 5.

3.2. Anonymous Student Evaluations

At the end of each semester—before receiving their grades—students can evaluate their courses and provide feedback using a digital tool that collects answers anonymously. The survey includes general aspects, such as the provided level of support or the course structure, and specifics, such as how project work was perceived and what topics should receive additional focus.

68% of the participants (11 out of 16 total) provided their feedback. We collected both their ratings and the free text answers for survey items related to the practical project work, the lecture, or the remote teaching approach. We also collected the results for the previous two years of courses taught in person when answers for the same survey item were available. We then filtered these remarks using the same approach used for the teaching team meeting notes.

Table 2 summarizes the student evaluations for 2018 through 2020, with the 2020 course being remote. Survey items were rated using the German school grade system, with 1.0 being best/strong agree and 6.0 being worst/strong disagree). In particular, we compare the results of 2019 to 2020, as the courses' contents varied little.

The evaluation participants awarded, on average, slightly improved grades in the vast majority of survey items regarding the remote course setup, despite the limitations during the pandemic. These results surprised us, especially since previous course editions had already received very high grades overall. However, it has to be remarked that this sentiment comes from fewer overall students, both absolute and in terms of enrolled students, and the relative share of students supplying

Question	2020	2019	2018	Change 2019-2020
Answers/Enrolled Students	11/16	20/26	21/30	
Overall Course Grade	1.2	1.5	1.6	+0.3
The course was fun/sparked joy.	1.3	1.5	1.7	+0.2
The atmosphere was pleasant.	1.0	1.3	1.5	+0.3
The tutoring in the course was appropriate.	1.4	1.5	1.7	+0.1
The course motivated me to delve deeper into the topic.	1.5	2.2	2.1	+0.7
I learned much in this course.	1.2	1.8	1.6	+0.6
I spent the specified time for the course.	1.6	1.4	1.9	−0.2
I feel well prepared for the final exam.	1.6	2.3	2.4	+0.7

Table 2. Student ratings (in German school grades, smaller is better) of course iterations in 2018, 2019 and 2020 in selected items of the course evaluation survey. A positive change implies better grades in the 2020 course.

us with feedback. Furthermore, ratings always have to be interpreted with the initial expectation of raters in mind. In interviews with students, which we conducted to explore reasons for low course sign-ups, students expressed doubts regarding the feasibility of a remote project course. High ratings might, therefore, also be influenced by initially low expectations.

The increased satisfaction with the remote course's atmosphere reported by students can be explained partly by the gained flexibility of attending the remote lecture in a preferred surrounding: standing at a desk, lying on a bed, or in the garden. The "seminar-quality" of the remote lectures, i.e., a more intimate atmosphere, than would be possible in a large lecture hall, was highlighted by a survey participant: They stated they would like to see the perceived positive "spirit" be upheld in the (non-remote) future, by relocating the lecture to a smaller room. This perception was likely also related to the usually informal style of lecturing adopted in the course, which focuses on a practical understanding of Agile methods and examples for teamwork over more formal definitions and a fixed curriculum.

The decrease in ratings regarding whether the allotted time for the course was sufficient indicates that students felt the added communication overhead and loss of a clear time structure by switching to a remote setup. Other course evaluations from the same semester also reflected this finding. A likely explanation for the overall better evaluations, in general, can furthermore be found in the quality of the course compared to the other remote courses that students were attending simultaneously.

4. Challenges of Remote Collaboration

The reported challenges of remote collaboration in Agile student teams were not homogeneous and spanned various topic areas. The collected items focused primarily on the effects of remote work on collaboration strategies but also included technical, team organization, and project management aspects. Most notable were the two topic clusters of working together as a remote team and the impacts of entirely relying on technical tools and work-from-home settings. In the following subsections, we name the identified challenge and report on the context of the project course, which needs to be considered when interpreting these results. Furthermore, we include possible *countermeasures* that can be implemented in teams to address the identified challenge.

4.1. Teamwork & Process

• **Decreased implicit feedback:** Physical Scrum meetings facilitate communication structures and adherence to time-boxes through implicit feedback, e.g., the overall atmosphere in the room [16]. In virtual voice-only or chat-based communication channels, nonverbal cues are unavailable. This can promote more extended discussions due to weaker implicit participant feedback and the "switching off" by participants, e.g., turning the camera/microphone off and getting coffee. Thus, virtual communication fails when participants fall silent [17]. This issue is especially relevant for novice Scrum users with little experience running structured meetings and who rely strongly on implicit participant feedback to guide discussions.

Countermeasure: Dedicated question and answer rounds and actively inviting feedback may encourage the necessary "regular and consistent communication" within teams and meetings [17]. Tutors should be made aware of paying close attention to meeting participants that are falling silent.

• **Biased perceptions:** In only one course team, individual participants did not have cameras or refrained from switching them on in meetings. However, without

video, tutors reported that these team members often went unnoticed, their presence was less recognized, and their meetings contributions were potentially discounted. Tutors commented that even though they were aware of this inherent bias, it was still present and that they felt it necessary to actively combat it, which would not have been an issue in physical meetings. In recognizing the possibility of biased perceptions by others, team members may turn to over-commitment and self-exploitation in fear of being overlooked [18].

Countermeasure: Making all tutors aware of the biases enabled by virtual communication can increase their attention to communication structures and result in fairer team assessments.

• **Work outside of core working hours:** Remote meetings are more likely to be placed outside of core team working hours, i.e., 09:00 to 17:00, as team members are more likely to agree to a "short video call" at 7 PM than a physical meeting at that same time slot. Furthermore, with remote work offering fewer shared events for student teams, e.g., consistent lunch break between lectures at noon, scheduling in groups can become more challenging [1].

Countermeasure: We found that defining precise shared working times and adhering to them was beneficial. While students are very flexible in structuring their workdays, restraining this flexibility can lead to better collaboration in the entire team.

• **Less social interaction:** The digitization of team meetings inadvertently shifted their focus to project-related topics at the expense of social interaction with peers. The team calls and meetings have a clear, dedicated goal. However, student team members are peers and likely friends; but they are unlikely to set up another call to "hang out" and socialize with the same people in the same modality they just worked in. This is different in in-person meetings, where lunch together after a completed meeting was common. Furthermore, digital communication affords fewer opportunities for banter before a meeting starts. It is easier to join a virtual meeting precisely at the starting time while still using the previous minutes productively.

Countermeasure: We suggest implementing open virtual meeting rooms that can be used to ask questions "across virtual desks". These should be open during all working hours and can have assigned moderators [8]. Additionally, instant messaging applications and open chat rooms can promote informal communication [19].

• **Fewer opportunities to offer help:** Virtual meetings reduced the awareness for team members who were struggling or had issues, as the body language and exclamations as important pointers in co-located work are missing. It is easier to ask for help in person by asking over a desk when someone is taking a break than in a virtual group setting. In remote settings, often the earliest scheduled remote sync was the daily (in our case weekly) Scrum meetings. Thus, the sole use of technology can lead to feelings of isolation [20].

Countermeasure: Ideally, the current status of team members, i.e., "taking a break" or "focusing", should be available during core working times, so it is clear who might be able to help immediately (or is available for a chat). Team building exercises can increase trust and the willingness to reach out to others.

• **Reduced psychological safety:** Psychological safety is one of the most influential factors for effective teams [21]. In groups with high psychological safety, it is possible to ask for help or discuss team issues without fear of negative consequences [22]. Team psychological safety is especially relevant in Agile Retrospective meetings that focus on identifying problems and shortcomings. The meeting may suffer in remote settings due to the lack of body language as a tool to assess psychological safety (e.g., by the Scrum Master).

Countermeasure: Promoting "water cooler" conversations in breaks and setting up video conferences with team members even before the project's start can help remote student teams build trust [17].

4.2. Technical & Tool Use Aspects

• **Technical issues impact meeting quality:** Video conferencing tools and audio/network issues impact the adherence to time-boxes and discussion quality. Newman et al. found that improved audio quality led to the speaker being judged as more intelligent, competent, and likable and the content as more important [23]. In line with this research, our students stated that the streaming quality was important to them: "Zoom is way more stable than Discord". Related research also points to possible issues with Internet connectivity in student homes and technical solutions not working on all platforms employed by students [8].

Countermeasure: We suggest investing in dedicated streaming setups where feasible, especially for the teaching team. If space allows, dedicated university rooms can be used for students who otherwise struggle.

• **Video call fatigue:** Scrum meetings, especially for inexperienced teams, can last multiple hours, even for comparably short iteration durations. This is especially relevant for the complex Sprint Planning meetings and teams new to Agile meeting structures. While concentration in long meetings is already an issue in an in-person meeting, the isolation in front of a screen can further decrease the capacity to focus. Additionally, as

the lecture is delivered in the same modality, it further adds to the amount of time spent looking at faces on a screen. A tutor noted that "there is a point of time in virtual meetings, where participants "switch off", more so than in in-person meetings".

Countermeasure: Including regular breaks in calls, e.g., at least 5 minutes away from the screen every hour, and using active reminders of this policy can help renew concentration [8]. Furthermore, physical activity, which someone ideally models and moderates, can help decrease fatigue.

• **Decreased focus through distractions:** The focused work of participants in Agile meetings is crucial, as decisions are made that impact the entire work iteration. Scrum discourages changes of work items during a Sprint, highlighting the relevance of best-effort planning. In WFH environments, Agile team members are exposed to numerous virtual and real-life distractions, such as instant messages, web surfing, children, flatmates, or pets. This is also true for the local computer, instead of a computer lab machine in university, which is used for work and private communication. Students voiced having some trouble with this issue, noting that "there was too much noise in some of the used channels, due to many different topics being discussed in the general channel".

Countermeasure: We suggest encouraging team members to mute notifications and shutting down non-essential tools during meetings. Separate communication channels with assigned priorities, e.g., an "emergency" chat channel, can help ignore other distractions.

• **Compromised work environment:** In WFH settings, personal and professional spaces collide. This overlap is especially relevant for students living in student housing, shared spaces, or single-room apartments not designed for (possibly multiple) people to work from for long periods. However, home office ergonomics should not be overlooked, as they have been found to affect well-being and productivity [24].

Countermeasure: If space allows, open university rooms in a rotation fashion for students that struggle. Actively discuss the importance of home office ergonomics and investigate how university resources possibly freed by remote or hybrid courses can benefit students.

5. Observed Positives of Remote Collaboration

While the analysis of the collected teaching team meeting notes and the anonymous student comments revealed several challenges mirrored in related literature, we were also positively surprised by some aspects of the remote teamwork collaboration approach that were deemed explicitly beneficial. However, we are not alone in our surprise. Hjelsvold et al. state: "some educators seemed to be expecting that transforming to online teaching would be much harder than what they experienced" [8].

This section describes the observed positives of remote collaboration in the student teams of our remote course setup that we had not anticipated. We include *Action Items* that will positively impact a given positive aspect in future courses:

• **High levels of trust in teams:** Contrary to our expectations, the vast majority of student team members trusted each other enough to share images of their personal work from home settings by switching on their cameras and embracing the possibilities of remote tools. In two of the three course teams, all participants switched on their cameras during regular meetings with tutors from the beginning of the course. The possibility to see the faces and expressions of others is vital for meeting effectiveness and engagement. Communication is essential to building relationships and trust between remote team members [25].

Action Item: Encourage the teaching staff to lead by example in switching on their cameras and building trust that other people's surroundings might also not be ideal. Conversely, the things visible in the background might be used in initial "ice breaker" activities [26].

• **Stable communication structures:** Contrary to our expectations, teams' communication and organizational structures did not drastically change from in-person to remote collaboration setups. Most of the required communication during Agile development happens within a team. The contacts to other teams were handled repeatedly by the same few team members, who acted as relays. This inter-team communication was overwhelmingly digital in previous in-person projects, so communication structures, especially between teams, did not change. This effect is helped by the fact that instant messaging is heavily present in modern life and that sending a chat message even in co-located teams is not unusual.

Action Item: Existing communication norms and structures (e.g., chat groups or other communication channels) can be leveraged by Agile development teams. This approach aligns with experiences from other SE courses in which chat tools were prevalent [6].

• **Tools augmenting communication:** We noted an increased willingness of students to use short video calls over writing asynchronous chat messages in the remote course setup. Calls were much less employed in in-person courses, and voice communication was almost

exclusively used as a last resort. In the remote course setup, video calls became the standard communication solutions, avoiding delayed feedback [27]. These tools offer higher information density and more social context, making meetings more effective [6].

Action Item: Establish video calls with cameras as a norm by having the teaching team model this behavior in the communication with students. Attempt to build trust in teams so that video calls can lose some of their potential initial awkwardness.

• **Effective Sprint Plannings:** We fully expected the quality of Scrum's Sprint Planning to suffer in the new remote setting with students inexperienced with the complexities of the meeting. However, tutors explicitly mentioned that these meetings did not suffer from virtualization. Sprint Planning requires high levels of understanding, discussing, and synthesizing information. These tasks may benefit from access to one's own, fully customized computer setup at home.

Action Item: Further pay close attention to the effectiveness of teams' Sprint Planning as the central meeting that influences the success of an entire development iteration. Encourage team members to prepare the meeting in advance to use meeting time effectively, and *video call fatigue* is avoided.

• **Deeper connection to teaching team:** In the newly remote course setup, tutors were spontaneously asked to join ongoing team video calls when questions or issues arose. This was not possible in in-person meetings, which might not even have taken place at the university. Course tutors reported improved connections to the teams through instant messaging in the remote setup. Other educators also noted this effect: "I get closer to the students through chat" [8].

Action Item: Normalize frequent exchange with the teaching team as mentors and coaches by having them be available on digital communication tools with low barriers for reach out.

• **Similar learning opportunities:** The meeting inefficiencies most often reported by tutors were not exacerbated by the remote setting and were similar to those in in-person courses. This is positive, as the course concept of practical Agile method application relies on learning from mistakes. Having issues, noticing and addressing them is a necessary part of the learning experience.

Action Item: The main issue with learning from teamwork mistakes in remote teams is the danger of working alongside one another instead of with each other and, therefore, not realizing that teamwork issues are even present. The Retrospective meeting should explicitly address this issue, e.g., by employing a checklist of best collaboration practices.

• **Improved note-taking**: Virtual Scrum meetings were reported to offer an improved possibility to take notes. Instead of those in a standard, mostly bare university meeting room, these provided full access to all digital and physical tools available in the home office.

Action Item: Ensure that Scrum meetings with a high information density, such as the Planning and Retrospective meetings, offer effective ways of taking notes. Encourage teams to define what "effective note-taking" means for their contexts.

• **Focused virtual meetings:** Student team members highlighted the increased focus of virtual meetings as a benefit: "when we meet, we meet with a specific goal".

Action Item: Encourage creating agendas for meetings to promote meeting focus. However, time for socializing in remote teams should not be neglected and can also be built into the meeting agenda.

• **Easier organization of team building activities:** The tasks of finding a common time and place and organizing team-building activities were reported as more straightforward in remote teams. As all required setup for efficient virtual communication was already present, virtual collaborative team activities were quick to setup. Mentioned examples in our course included *Scribble.io*, *Among Us*, or virtual *Settlers of Catan*.

Action Item: Take advantage of the easy setup of online team building activities by including them in the regular workweek of teams and encourage sharing what is the most fun between teams.

• **Creative energy to customize process:** An increase in motivation to find 'individual solutions by the teams" to the challenges of remote teamwork was reported by tutors. While employing familiar in-person meetings for Scrum events worked acceptably well for student teams in previous course editions, the familiarity of this meeting modality also led to fewer innovation opportunities. The obvious challenges of the remote setup that had to be addressed to run an effective meeting led to more individual, customized solutions in student teams.

Action Item: Ensure that teams are aware that a core idea of Agile methods is customizing processes and that experimentation and deviating from the norm can offer significant value. Especially Retrospective meetings provide ample opportunities for customization, e.g., through different activities [28] or games [29].

• **Documentation by default:** The use of digital collaboration tools in student teams leads to interactions and team decisions being documented by default. This was especially reported for Retrospective meetings: Team issues and proposed solutions were immediately persisted in the employed shared digital whiteboards and

were available in the next meeting. This was an issue in previous in-person course iterations, where progress on previously decided improvement actions could not be tracked because they were forgotten.

Action Item: Encourage the use of digital note-taking tools for meetings that ensure that results are persisted, especially for Retrospectives (action items) and Plannings (task distribution).

• **Increased team Check-ins:** The remote course teams frequently used team "Check-Ins"and warm-ups, i.e., activities unrelated to the project, to bring the team together and start a meeting. An example that worked well (in the winter of 2020) was answering the question, "what is your favorite Christmas beverage?".

Action Item: Prepare meeting agendas for virtual events that feature a dedicated warm-up slot at the beginning. The teaching team can make use of these activities in their own meetings and communications.

• **Increased Pair Programming**: The remote course included significantly more use of Pair Programming (PP) and code collaboration tools such as VisualStudio Code LiveShare[2]. The virtual setup does not require physical co-location in front of a shared computer. Both "driver" and "navigator" can use their customized computing setups, which is more comfortable.

Action Item: Motivating students to try out PP is an ongoing challenge. Explore using virtual code collaboration as an initial step with low(er) barriers.

6. Related Work

The related literature on the impacts of COVID-19 on teaching in general and the switch from face-to-face instruction to completely virtual courses is continuously growing, as more and more research groups publish their experiences [5, 6, 8]. Especially related to the European university context of this research is work by Ebner et al. at the TU Graz in Austria [7]. The authors use the *McKinsey 7S model* [30] to gauge and describe the "e-learning readiness" of their university before the pandemic and detail their internal procedures, processes, and decisions during their COVID-19 teaching. They identify many of the same "enablers, barriers and bottlenecks" in their remote course setups that we described in this paper, such as inadequate hardware equipment and poor Internet connectivity, and already existing digital communication infrastructure that could be leveraged.

However, a core component of the course described in this paper is the practical project work by student teams employing and learning Agile methods, which previously happened almost exclusively in a physical face-to-face format. Therefore, we explored related work regarding the impacts of COVID-19 on Agile teams and their collaboration practices and Agile software development education.

6.1. Influence of COVID-19 Pandemic on Agile Teams and Collaboration

Summarizing a panel at the XP 2020 conference, Mancl and Fraser describe the impacts COVID-19 had on the daily work of Agile teams and Agile practices. The authors point to the challenge of performing Agile practices using virtual collaboration tools, especially for "high-bandwidth or informal interactions". Furthermore, they point out that forming new teams and onboarding, a critical part of student projects, is more challenging in virtual work environments [31].

In a survey of 120 participants, Marek et al. studied Agile software development teams which transitioned to fully remote work due to the COVID-19 pandemic [32]. The survey revealed that the majority of responding Agile teams were already, at least partially, distributed. The authors describe that these teams were already using tools that supported virtual work, easing the transition to a fully remote approach. In fact, the survey results included previously distributed teams, who reported improved team communication by moving all communication entirely online.

6.2. Remote Agile Software Development Education during COVID-19

Lindsjørn et al. compare survey results collected from students of their capstone Agile software engineering course in the years 2019 (42 teams) and 2020 (39 teams), with the 2020 edition being completely virtualized due to lockdowns [6]. The authors highlight the speed with which students adapted to virtual teamwork. The authors' survey results from the virtual course regarding teamwork, satisfaction of work, and the product showed ratings similarly to the previous course featuring physical meetings. We provide additional evidence for these findings.

Hjelsvold et al. describe the results of a survey of 56 educators, including 22 affiliated with a Computer Science department, shortly after the end of the spring 2020 lockdown [8]. Nearly all the CS educators reported having a positive change experience from face-to-face to online learning. While the authors report on challenges, they also include some aspects of online teaching reported as improvements, including more positive student attitudes.

[2] https://visualstudio.microsoft.com/de/services/live-share/

A similar survey was conducted by Watermeyer et al. of 1148 educators in UK universities regarding their emergency online migration due to the COVID-19 [5]. While the authors point to their results showing a primarily "downbeat diagnosis of the impacts of online migration", they also highlight a few "affordances" including precise control of the teaching environment and a challenge to long-held assumptions on teaching.

In a setting similar to ours, Ahmed et al. report on their experiences of running a project-based SE course with 30 student teams in 2020, when COVID-19 measures were applied in the middle of the semester [1]. Instead of relying on student self-assessments and tutor observations, the authors examined written student project reports summarizing their experiences regarding communication, teamwork, and their learnings. The authors point out challenges to student projects during COVID-19 in teams, process, and product but explicitly do not aim to offer solutions.

7. Conclusion

The drawbacks and the advantages of remote working and learning regarding student experiences were already established before the COVID-19 pandemic [11, 33, 34]. However, the emergency migration of project-based courses that heavily relied on student teamwork created additional challenges for educators unprepared for them. A course designed with virtual attendance in mind can offer specific features that take advantage of the chosen modality. However, in the wake of COVID-19, rapid adaptations had to be made by educators. In this paper, we report on our experiences with such an emergency course migration.

RQ: What challenges and opportunities occurred in a multi-team Agile university project course taught remotely for the first time?

RQ Conclusion: We point out ten challenges of remote collaboration in Agile student teams that we observed as a teaching team or that were self-reported by students. For these, we offer countermeasures based on our teaching experience. We also provide 13 positives of remote collaboration and action items detailing how we expect to maintain these identified positives in future courses, whether they will feature fully remote or hybrid setups.

Similar to other educators, we expected that the transition to online teaching would include more barriers than we eventually encountered, both for the teaching team and the students [8]. We hope this report will help other educators transition to online teaching, especially in setting up project courses featuring practical applications of collaborative Agile software development practices. Surely, proven COVID-19 course adaptations will remain in the future and can hopefully lead to an improved "new normal" [35] for teaching institutions and course curricula.

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