

EFFECTS OF MIGRATING LARGE-SCALED PROJECT GROUPS TO ONLINE DEVELOPMENT TEAMS

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ABSTRACT

This contribution presents challenges in a project-based course with large project groups, that have arisen through the Covid-19 pandemic. Traditionally, the course has been dependent on a larger number of physical meetings to coordinate the work, and to solve the task technically. However, the pandemic requires that work must be redirected to forms where students work online, physically distributed as much as possible. It is furthermore interesting to see the course in the core context of its main theme, that is, software engineering. Here, the pandemic actually has consequences on software engineering subjects, such as, choice of development methods. The course teachers (authors of this contribution) have especially observed this adjustment, and documentation is kept on how the students meet these new challenges through online discussions, and questionnaires.

KEYWORDS

Project-based education, Teaching on distance, Software development styles, the Covid-19, Standards: 5, 6, 7, 8

INTRODUCTION

Software Engineering 2 (SE2), is a 15-credits course, which runs part-time during the first semester of the third year for students in the international Software Development Program, Kristianstad University, Sweden. The course has a focus on one main project, where students shall develop Smart Home-techniques in project groups of approx. 15 participants. A project group is then divided up into subgroups of about 3 to 4 students to solve subtasks of the main project. At the autumn 2020 semester, the course involves about 45 students, which means that there are three major groups, each with the same main project purpose.

Due to the Covid-19 pandemic, that strongly has affected the teachings during the autumn 2020, the ways to provide SE2 have been drastically changed. SE2 is normally a campus-based course, that is heavily dependent on physical meetings for reasons, such as those of effective communication, and integration of technical solutions. Instead, physical meetings have been more or less fully replaced by online-activities. Due to this upcoming situation, the teachers have seen that several conditions that previously were considered given, have been needed to be considered with new approaches. Example in this include:

- Within a project group, the development process must be coordinated in a uniform manner, where requirements are put on project-documentation, and integration of the subgroups' technical solutions. This means that the course has great demands on teamwork, and communication at several levels, such as within the subgroups, within the project group, and towards the teachers, all preferably done localized, typically campus-based.

- Besides from the project, SE2 also covers principles, and theoretical foundations for large-scale software development. Distributing the development geographically puts such principles

in focus. For example, agile development processes correspond to development groups with physical meetings for quick decisions. The students have been trained from previous courses in agile development processes, and questions arise according how these can be applied to cases of distributed development.

At the online-meetings between the teachers and students, during the autumn 2020-course, several aspects have been discussed, such as the state of health, how the work is progressing, what plans there are for integrating the subgroups' technical solutions, etc. Several reflections have been expressed such as: “*Difficulties in communicating in larger teams, online meetings are often controlled and do not allow for spontaneous comments*”; “*More like presentations, than discussions*”; “*Coding previously done together, is done by sharing screen*”; “*You get more and more used working like this*”. Moreover, several discussions have led to interesting open questions, unfortunately lying outside the scope of this contribution to be answered.

In conclusion, it can further be mentioned that the new situation that has arisen can contribute to several pedagogical benefits that also correspond well with several CDIO-based learning objectives (CDIO, 2021). While hard and difficult, this new situation can therefore also be valuable, both for the teachers' internal reflections on teaching, and for the students' awareness of a possible future professional practice in change.

BACKGROUND

A brief course overview

The core structure of the course has been the same during several years, even though changes have been done to improve the course (Einarson & Saplacan, 2017). A main purpose in developing Smart Home-techniques have been to support disabled people for the sake of their independence (Einarson & Teljega, 2020). The technical challenges require several technical perspectives, concerning user-controlled units, home devices, and a mediating server, all that need to be developed and integrated to work as a whole (Figure 1).



Figure 1. A Smart Home-System overview (Einarson & Teljega, 2020).

This in turn requires a project group being divided into (at least) four subgroups (Figure 2), where they take care of one of the following main subjects: 1) Technical devices such as lamps, fans, and temperature to be controlled and monitored, from 2) Smart Phones and 3) Web-based interfaces, and 4) the Server that mediates between the different system parts. Besides from this, among the students there is a dedicated Project Manager, and Requirements Manager.

The students are trained in an agile process style (Alliance, 2020) from previous courses. Still, the SE2 project process, mainly corresponds to a more controlled way of working, through the Unified Process for Education (UPEDU, 2014), which is based on an iterative and incremental process model with four main phases, i.e., *Inception*, *Elaboration*, *Construction*, and *Transition*. In (Einarson, 2011), it was shown how well those phases correspond to the CDIO's *Conceive*, *Design*, *Implement*, *Operate*, and that using the Unified Process as a model for the project process clearly puts the course in a context of CDIO-based education.

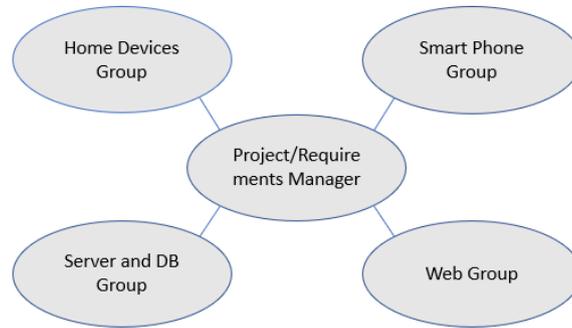


Figure 2. Project organization.

In SE2, the iterative and incremental way of working, is corresponding to project meetings (PM) between teachers and students, and where increments relate to progress with respect to phases of the project. At the PMs, artefacts, delivered by students are communicated, where those artefacts correspond to documents representing project *Requirements*, *Design*, *Risks*, and more. Figure 3, outlines the process, with project meetings, student presentations, and relation to phases.

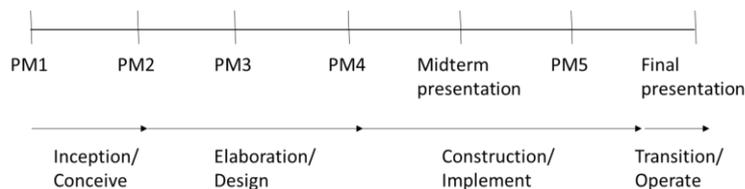


Figure 3. Process organization, where time-line corresponds to autumn semester, 2020.

Communication, especially pointed out through CDIO Syllabus, Section 3, on *Interpersonal Skills*, is here strongly significant for the progress of the process, and for efficiency reasons, preferably done through physical meetings. Communication can be seen at different levels, such as between:

- teachers, to coordinate course
- teachers and student groups, especially at the PMs
- students in subgroups, and project group as a whole
- students in subgroups

Besides from this, students shall develop, test, and integrate their technical solutions. Within this context, the migration to online-based education is especially critical.

On process models

Process models may be put on a scale based on grade of agile methods for development. At one point of that scale there are the authoritative, planned, and controlled methods, and at the other end of the scale there are the agile styles, with more liberal perspectives on decisions, planning games, and brainstorming at common physical places. Figure 4, proposes which is the most appropriate choice, based on known circumstances.

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| <ul style="list-style-type: none"> • Non-agile methods to be chosen when: <ul style="list-style-type: none"> – Goal is clear – Many requirements, which are clear – Project has many external dependencies – Fixed contract – Fixed deadline – Geographical distribution within the project group – Changing costs are too high | <ul style="list-style-type: none"> • Agile methods to be chosen when: <ul style="list-style-type: none"> – Fast useful result is desired – Requirements are vague – Changing situations – Project is implemented in the same place |
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Figure 4. Choice of project method (Sommerville, 2015).

For the project in SE2, that project is normally run through a rather agile style, which corresponds well to the parameters of Figure 4's right side, even though the process, at an umbrella level, is run in a controlled way according the UPEDU-process model. Still, especially, within subgroups, the working method is highly agile. However, the current situation with online-development, certainly has effect on localization of development, which is forced to be distributed. This in turn, has effect on communication, and how an agile process is driven forward.

REFLECTIONS DURING COURSE

Communication between teachers and students has mainly been conducted through PMs and occasions for student presentations, which also is the usual way to provide the course. However, it can be seen that communication between these meetings, primarily via email, has been more frequent this time. At PMs, the teachers have initiated discussions that also have concerned the special situation of the pandemic, and documented this, with the students' consent. An observation was that both students and teachers adapted to the situation over time. At early PMs students could argue that "*Working in a team is always a challenge and it is especially tricky in our case since we are working as a remote - distributed team*", while at later PMs express that: "*More used to the online-thing*", or "*It gets better for each week*".

Below is a subset of points of discussions and observations, with the addition of the teachers' own reflections. While discussions during the PMs have been free, subjects of those have afterwards been categorized as follows:

- Process model – Controlled vs. Agile
- Health and Social Concerns
- Communication and Conflicts
- Changing Work Situation

Process model – Controlled vs. Agile

We here again refer to the discrepancy between planned (or control)-based process-styles and agile process-styles (Figure 4). As previously mentioned, the students are trained in agile software development since before. It is usually also this method that has been used at the course SE2, although the process is guided by clear phases with milestones and formal meetings. The agile method includes several sub-methods, such as, common brainstorming, and pair-programming (one is programming, the other guides and checks for correctness) (Alliance, 2020). Such sub-methods are normally dependent on physical meetings, and will suffer from the forced distributed, online-based development.

As claimed by students: *“Meeting physically works better, more efficient”, or “War-rooms (physical places for brainstorming ideas) are beneficial, with white-board for ideas”.*

Here it can be seen that communication needs to be handled in new ways, as stated by a student: *“Preparing ideas before meetings. That is, ideas are carefully prepared and presented, rather than elaborated on at the online-meeting”.* When it comes to joint-development, this was solved by sharing the screen, and thus pair-programming as a method could actually be used.

How to implement the chosen process style was actually left to the project groups. This means that the dedicated project group leaders (Project- and Requirements Managers) had a responsibility where a leadership style of choice could be significant. Leadership style was also a point of discussions at the PMs, and questions were raised, such as: *Does a too liberal-democratic management style actually work in this situation? Where on a scale from too authoritative, to too liberal democratic management, would leadership be preferable?*

The teachers could see a difference in leadership style between the groups, where the first of the groups' leaders were clearly authoritative (even though collaborative), the third was at the other end-point, and the second somewhere in between. The outcome was in clear favor of the first group, that worked consciously authoritative from the beginning. As expressed in one of the documents: *“Effective communication and collaboration within a development team is fundamental for the success of the project, more importantly so during the COVID-19. Since the beginning of the project, we strive to create and refined a collaborative project management method to coordinate the team's operation”.* It is certainly hard to tell if the higher grade of success is due to an authoritative leadership, or if there are other reasons. Still, in addition to this, the third group had the most problems, with quite serious conflicts (more on that below).

An interesting question arises from teachers: *Can Software Development be agile even though development is distributed, and communication is clearly controlled? In that case, or if not: to what degree can this still be realized?*

Health and Social concerns

According to the pandemic, the teachers (and students) are subject to the rules and policies that are expressed in the context of the pandemic, and where you beforehand do not know how they will be like. From the point of view of the student project, they have to prepare for a *Plan B*, where equipment of the lab needs to be replaced by alternatives. From the point of view of the process, students are encouraged to treat the situation from a Risk Management perspective. Some, but not all, students followed that recommendation, as exemplified by:

Risk 4. *Illness and inability to meet at the lab can result in some issues – Impacts: Illnesses not allowing members to meet, Indications: A group member could fall ill at any given time, and during times of the pandemic can harm other members in our group. Mitigation Strategy: Follow pandemic procedure and attempt to prevent exposure to high risk locations of people.*

Risk 9. *Falling ill has always been a concern no matter the circumstances, but in the midst of a pandemic, it has become an even bigger and prioritized concern. We see the impacts of the pandemic, influencing the course structure and communication. Everything is digitalized, meetings are now taking place online instead of having physical meetings, face to face. The subgroups that were supposed to work together in person are now only communicating via Discord or Zoom. It is important to include sickness or falling ill because the possibility of it*

occurring is very likely. If one or more group member(s) were to fall ill, the project would be affected in certain ways such as not being able to deliver the work on time and delaying internal deadlines, etc.

Each PM started with a discussion regarding the health status of the students. It turned out that no-one actually got sick from Covid-19. Still, also social concerns were discussed. Some students claimed that *“Working from home is a dream come true”*, while others expressed that *“You lose focus when you are working from home”*, or *“Mixed, blended, is best”*. A conclusion from teachers is that working distributed did not seem to be very socially dramatic. Some claimed that they never felt free though, like they always were available and online. Still, teachers addressed the importance in working in sustainable pace, and accepting asynchronous communication, which means that it may take time before a request got a response, depending on habits.

Communication and Conflicts

At the PMs each student shall answer to his/her contribution to the work. Online-meetings are most often characterized by controlled manners. Communication is restricted to one specific theme, with one speaker at a time, and no room for spontaneous comments. This also means that teachers find themselves in a situation where it is hard to give feedback on detailed levels. With about 80 documents to read before each PM, the demand on controlled communication implies that mainly the bigger concerns are treated. There were also complaints from some students according lack of appropriate feedback at the PMs. Moreover:

- *On the positive side*, it can be mentioned that the online-tools opened up for valuable ways of showing the code, and have that as a basis for discussions. Moreover, a student commented that the controlled communication manners required the speakers to be more well-prepared than before. Student comment: *“Preparing ideas before meetings. That is, ideas are carefully prepared and presented, rather than elaborated on at the online-meeting.”*

- *On the negative side*, Miscommunication is riskier in online. It seemed to be extremely hard to solve hard difficulties, which could lead to pointless conflicts. Lack of clarity in communication, among other things due to bad sound-quality, in combination with non-native English for all students, with nuances in expressions that could be hard to grasp, probably contributed to this. Again, online meetings do not presume spontaneous comments, and do not give valuable support for non-verbal communication, and sketches and drawings, as alternative ways to clarify yourself (see relation to CDIO Syllabus 3.2.6, and 3.2.5). Such examples do especially point out the critical importance of *communication* in itself.

Changing Work Situation

Further discussions concerned a possible change in ways of working. Student comments: *“We may see a future way of working, Cross-country, a kind of game-changer, internationally. Companies may have other possibilities to find talents internationally, they don’t have to move, they work from home”*. These are of course extremely interesting reflections, that open up for even more reflections from teachers, such as: *What is expected from tomorrow’s employee, and from the employer point of view? What can an employee require from a hiring company? What personalities are expected, or even required, from employers if the game-changer takes place? Who, with respect to personality, will benefit from online-environments, who will suffer from it? Introverts vs. Extroverts?* Moreover: *There seem to be no sufficient online-tools today. Should we expect white-boards included in online tools of tomorrow? A Project Manager must*

be mentally stable, must be able to avoid pointless conflicts. If employment forms really will change, students of the current SE2 course are actually well-prepared. Furthermore, there is certainly a reason to study how the discipline of Software Engineering in itself will be affected, according possible new process models, new tools for communication, development, test, and integration.

Finally, yet one important finding is that students now use the programming environment IntelliJ (JetBrains, 2020), to do pair programming in real time and at the same time could ask questions and learn from each other: *“I used pair-programming to learn how the system works, it’s just like looking at a YouTube video, the difference is that you can ask questions whenever.”* Another student pointed out that pair programming doesn’t any longer mean that two persons are sitting in front of the computer screen. Because of the IntelliJ IDEA (JetBrains, 2020) possibilities to have several contributors at the same time (recommended maximum of 5) doing pair programming can consist of more than two persons: *“Pair programming have we used in our subgroup since **three** brains are better than one!”*

SURVEY

A survey was conducted at the end of the course to look at the students' attitude to how well they related to the course under the prevailing circumstances. The discussions during the course, as pointed out in the section above, showed an increasing adaptation to the situation. The survey, on the other hand, shows the condition at the end of the course.

From about 45 students, responses were received from 20 students. The survey was answered anonymously which is reasonable, but which makes it difficult to look at the relationship between the group of respondents and the answers received. For example, if it is mostly the more ambitious students who answer, this can also be reflected in a more positive attitude towards the questions, and the responses to those.

The survey was divided into a quantitative, and a qualitative part. The questions of the quantitative part, as well as the results of the survey can be seen in Figure 5. The conclusion that can be drawn from the results is that students think that it worked quite well to work in the way they did. This applies to the course as such, and communication, as well as technical development.

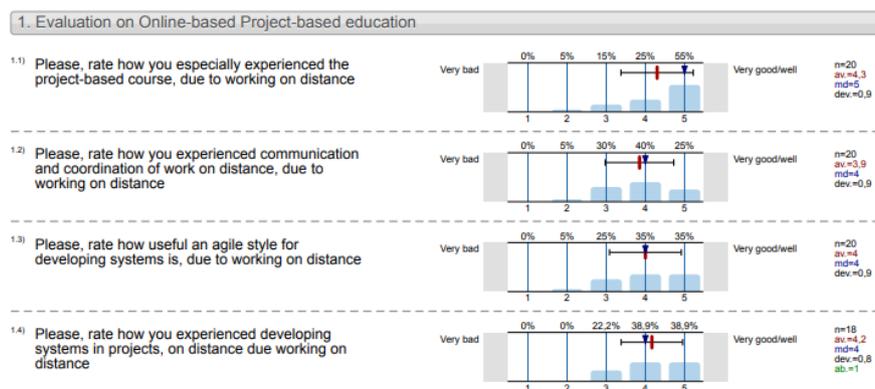


Figure 5. Result of the quantitative part of the survey

The qualitative part was divided up into the questions as stated below. All of those should be seen with respect to the current specific situation. While there are many interesting and

contributing answers, well worth further reflections, there is only room here for an excerpt from these. Still, the full material can be found at (Einarson & Teljega, 2021).

From the teachers' point of view, students' attitudes do not really differ much from previous years, which means that the migration to an online teaching context has not been that dramatic.

1. What was the most important insight to achieve successful project work?

- *To have good communication and to be able to ask questions/discuss with the subgroup. We have achieved success also with pair programming fully remotely.*
- *Working on distance give a clear view about peoples work ethics and how they value responsibility. Not easy to hide behind others.*
- *Teamwork That it worked better than expected. It is no different setting time schedules for meetings, finishing tasks, meet deadlines and so on than working on site*

2. Are project meetings and communication in real life-better, more efficient? Why/why not?

- *I don't see any difference to be honest. I think that online is my choice because I'm more productive in this way*
- *I think a combination of both is best. But meeting in real life isn't necessary unless the physical aspect concerning hardware demands it*
- *yes, easier to not misunderstand each other*

3. Have you used any agile methods like pair-programming, standup meetings? Why / why not?

- *Pair programming: because it can bring a subgroup together. If done right, it can make members understand the code properly.*
- *Yes, did pair-programming somewhat (screen sharing) as it was easier to get in the working mindset when someone is there forcing you to focus*
- *Yes, to practice together while making progress*

4. Have you done your project work physically, digitally or both?

- *Both, I have been working with the PM physically to review coming events and to code together. I have also worked physically with hardware centred groups to support and help them. The rest of the communication has mainly been digital.*
- *Both. We are the physical house group so the name kind of explains that we had to meet in person as well :)*
- *I have only done it digitally, being part of a group that didn't have to deal with hardware.*

5. Were there any conflicts in your project group? If Yes, did you solve it and how?

- *In the subgroup we didn't have any but in our whole group we did have. I rather not do anything about it if it's not about me*
- *No, really good team work all along.*
- *yes. Big issues. through teachers, project manager and finally we solved it internally*

6. Anything else that you think is of importance but is not covered in the questions above?

- *I think that it is important to keep in mind that no one in the group has worked in a larger group before. It is therefore hard to compare this experience to what it would be if we were working physically together.*
- *Personally, I loved this course and I enjoyed studying it a lot, except for the first two weeks since we didn't understand what kind of project and requirements the course cover. Thank you for everything and I appreciate your guidance during the past three months.*
- *Think it was a good survey in all. Thank you! Interesting to work remote and I can only see the benefits prior the negatives. I'm more productive when working remote.*

RELATED WORK

Einarson & Saplacan (2017) shows how the course SE2 and its projects especially correspond to CDIO Standards 7, and 8. In this specific case Standard 6 should also be highlighted, since that standard especially relates to lab workspaces, but here especially interesting since the concept of workspaces rather relates to an effective distributed context. Furthermore, Einarson & Saplacan (2017) addresses a number of points from CDIO Syllabus, within Section 2, 3, and 4, that are clearly regarded through SE2. However, in this particular contribution, we would especially like to highlight Section 3, regarding *Teamwork and Communication*, which has been particularly critical. We can here address several points that are challenging, such as, 3.1.2 *Team Operation*, 3.1.4 *Team Leadership*, and 3.1.5 *Technical (and Multidisciplinary) Teaming*. For the latter, we further exemplify with *Distance, distributed and electronic environments*, and *Technical collaboration with team members*, as especially challenged. Furthermore, non-native *Communications in English*, combined with bad communication links, have led to significant challenges in e.g., 3.2.7 *Inquiry, Listening and Dialog*, 3.2.8 *Negotiation, Compromise and Conflict Resolution*, and 3.2.9 *Advocacy*.

While the upcoming situation due to the pandemic certainly is unique, related work can still be seen regarding online teachings. For instance, (Norberg, Stöckel, & Antti, 2017) applied Agile time tools found in industry, as a design for a preparatory level course which they moved online and proved that with time tools, students could control their learning and could keep the pace. Their course consists of small number of students which don't know each other, and it is an ordinary length of the course. In this article, we make a further contribution by observing larger groups of students over longer period of time. In contrast, our students know each other at least two years, also they have met physically before the pandemic. Our observations confirm (Norberg, Stöckel, & Antti, 2017) findings, despite our course consists of a larger sample of students and a longer period between project meetings.

(Lucke, Brodie, Brodie, & Rouvrais, 2016)'s study is based on many references that have proved that if carefully planned course/program curriculum, and by being prepared to use a flexible way of working, it is possible to adopt CDIO for distance and online education. Our observations motivate that it is possible to keep the quality of CDIO standards when moving the CDIO campus course online, even though it was done rapidly because of pandemic situation. Many new digital tools are born every day which can be used to successfully cover activities that maintains CDIO standards.

CONCLUSIONS

It was, in the name of honesty, with some degree of concern that the teachers approached the course during the situation of the pandemic that arose. At the same time, we could see an interest in how to complete a course, so dependent on a physical location, completely online. The teachers, as well as the students, had to prepare to be patient and flexible before this new situation. All in all, it can be said that the actual outcome of the course was clearly good. That is, the migration from onsite-, to online teaching was not that dramatic. This can be seen as a consequence of that the students (and also the teachers) over time adapted more and more to the new situation, and saw how problems could be tackled in new ways. For instance, agile methods, which are normally related to physical sites, can be partly performed online, and development, integration and testing of technical solutions can be performed distributed.

All in all, the quality seems to have been maintained, with regard to course requirements, as well as to CDIO Standards and Syllabus. This can be concluded through the outcomes of

student projects, as well as through the results of the formal course evaluations, and through the teachers' informal reflections. In addition to this, observations have included the fact that we may face a game-changer, where we work more and more online in the future. From such perspectives, the course can be seen as particularly interesting, and contributing to the students and their future work careers, as well as to the teachers' view upon how provide future project-based courses.

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BIOGRAPHICAL INFORMATION

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