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Integration Of Agile Development In Standard Labs

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INTEGRATION OF AGILE DEVELOPMENT IN STANDARD LABS

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ABSTRACT

In addition to the technical content, modern courses at university should also teach professional skills to enhance the competencies of students towards their future work. The competency driven approach including technical as well as professional skills makes it necessary to find a suitable way for the integration into the corresponding module in a scalable and flexible manner. Agile development, for example, is essential for the development of modern systems and applications and makes use of dedicated professional skills of the team members, like structured group dynamics and communication, to enable the fast and reliable development. This paper presents an easy to integrate and flexible approach to integrate Scrum, an agile development method, into the lab of an existing module. Due to the different role models of Scrum the students have an individual learning success, gain valuable insight into modern system development and strengthen their communication and organization skills. The approach is implemented and evaluated in the module Vehicle Systems, but it can be transferred easily to other technical courses as well. The evaluation of the implementation considers feedback of all stakeholders, students, supervisor and lecturers, and monitors the observations during project lifetime.

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1 INTRODUCTION

Including practical training of professional skills into existing modules is rather challenging and many different teaching strategies were developed with different emphasis on problem or project based learning, online and offline activities or active learning (Fitzgerald and Lentmaier 2016, Aluvalu et al. 2017). Problem or project-based learning (both abbreviated with PBL) or cooperative learning are commonly used methods to combine technical and non-technical content (Fedorinova et al. 2018, Prasad and Reddy 2015, Fernandez 2017, Johnson and Hayes 2016). Problem based learning approaches define a specific problem to be solved by the students, whereas project-based learning relies more on self-defined projects of the students. These methods target to motivate the students to be engaged with the material, show interest in the course contents, participate in the class and collaborate with other students. With regard to electrical engineering, PBL is commonly used, both for complete curricula like in (Macías-Guarasa et al. 2016) or for dedicated courses (Kumar et al. 2016). Many projects at university have a dedicated deadline and the time between start of the project and the deadline is often managed spontaneously by the student team. As most students have no experience in project management, sometimes just a few team members do all the work without any overall structure. Therefore, a dedicated project development method should be implemented.

Agile development focuses on flexibility, collaboration and self-organisation to increase the efficiency of a team during an iterative development process (Dyba and Dingsoyr 2009). The success of this methods relies strongly on dedicated professional skills of all team members, including team work, expedient communication and feedback, engagement and reliability. Acceptance of this method including all the required skills and tools for collaboration is essential for all team members. Hence, incorporation of agile development as dedicated PBL into university courses directly enables the students to improve their professional, communication and social skills and to train modern development processes, which make the students feel more confident in working together and also discussing problems.

1.1 Module Vehicle Systems

The course Vehicle Systems is part of the curriculum of the bachelor program Electrical Engineering at UAS Aachen (FH Aachen 2023). It covers different kind of systems in modern vehicles, from powertrain systems to advanced driver assistance systems (ADAS) and autonomous driving. The course consists of lecture (2 lessons per week), exercise and lab with 1 lesson per week, respectively. Up to 50 students participate in this one-term-course of 14 weeks every year. The previous knowledge of the students is rather heterogeneous as some students already finished a vocational training in the area of vehicle mechatronics or similar.

The goals of the course are rather simple: every student should gain competencies in technical fields and applications of vehicle systems as well as professional skills needed for modern development methods like agile development.

A flipped classroom concept was introduced for the module in the last years. During the lab, the students used a vehicle dynamics simulation software, IPG carmaker, to develop an adaptive cruise control system for a car (ACC). So far, all steps were predefined in the lab manual, from the initial setup and start-up of the software to the different development steps to realize the final system. In addition, an agile development method, Scrum, was introduced to increase professional skills of the students. The following description focuses on this introduction of agile development into the lab.

1.2 Agile development

Agile development is an established process for the iterative software development (Zhong et al. 2011). Its key element is a feedback loop which offers a continuous improvement not only of the product, but as well of the collaboration of the development team and the clients. The Agile Manifest defines four guiding principles (Cohn 2010). Individual strength and weaknesses of team members should be concerned and used so that the whole team learns interdisciplinary. The final product can only be achieved by reacting on changes during the implementing process, like changes of features of the productor financial, timing or personnel changes. This is a contrast to the normal development approach which focusses on fixed processes and working instruments, comprehensive documentation, a contract and plan agreed with the customer.

Goals of agile development are a higher motivation, engagement and productivity, as well as continuous working, iterative learning, a project structure by defining responsibilities and at the end a faster way to the final product state.

A common agile project method framework is Scrum. Here, three main roles define the Scrum team, which are the Scrum Master, the Product Owner and the development team (Gloger 2016). A sprint is a processing time interval for implementing a version or part of the product, the product increment. The sprints are supposed to have mostly the same length to maintain a continuity in working and planning, so time scheduling becomes easier. The product backlog defines a red line of tasks and is dynamic, in contrast to a linear project. The new prioritisation for the next sprint is continuously adjusted during the current iteration. At the end of a sprint the highest prioritised tasks are set to the sprint backlog to get implemented. The Product Owner is responsible for this procedure. At this point the Scrum Master has to accomplish the Sprint Review, Retrospective and Sprint Planning to organise a new working iteration and especially turning the focus on reflecting the previous collaboration. During the iteration the Scrum Master also organises Daily Scrums. This helps the whole team to get an overview of the project state and the responsibilities. Furthermore, the Scrum Master should identify possible collaboration problems in the Scrum team and help the team solving them.

2 METHODOLOGY

2.1 Concept and implementation

In 2022, 33 students participated in the course lasting for 14 weeks. The lab using Scrum for the ADAS development is based on the previously used lab. The initial structure of the lab is not change from technical point of view, incl. the dedicated tasks that are covered by the lab manual to develop an ACC system. This structure is maintained to ensure that all students are able to complete the tasks and to gain the required technical skills. The development of an emergency brake assist system (EBA) is added to the lab without dedicated tasks to enable a free and flexible work for the students. For both parts of the lab, the predefined and the free part, Scrum was used.

Depending on the group size the time effort and effort per person can be estimated as seen in Fig. 1. The time effort is most efficient with 5-7 people. The productivity per person is also better in smaller groups, but it does not vary that much between 1-7 people (Cohn 2010). For this project, productivity was defined as degree of achievement of the required professional skills and technical knowledge and a positive development within the process. Effort is referred to the time spent on the project. Referring to this statistical observation, six to seven students formed a Scrum team.

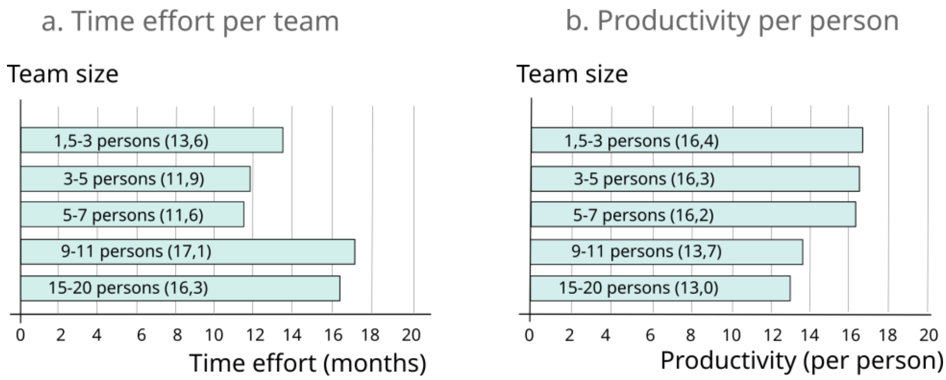

Fig. 1: Evaluation of team size acc. to (Cohn 2010)

The students self-selected their group at the beginning and hence, the groups differed in the composition of the team members. For some groups the team members already knew each other (group type 1), for other groups the team members did not know each other before (group type 2).

In general, the Scrum Master and the Product Owner should not be part of the development team to avoid personal conflicts (Cohn 2010). Nevertheless, all students should reach the technical goals of the course. Hence, for this project the Product Owner and the Scrum Master also act as team members to be able to follow the technical implementation completely.

Weekly Scrum meetings with supervision by a lecturer were held by each group. As it was impossible to implement a Daily Scrum event, every team accomplished at least one further meeting per week without supervision.

The supervision meetings started with the sprint review, where the product increment was presented, as well as the technical state of each team member. Afterwards the

Scrum Master moderated the retrospective. Positive feedback and observations of the last sprint, as well as problems were communicated, followed by discussions about improvements. The last step was the sprint planning to prioritize the next tasks of the product backlog, to estimate the effort and to assign the responsibilities.

The Product Owner communicated all technical requirements with the lecturers as needed. Another important task of the Product Owner was to update the Product Backlog and to ensure that the technical objective is achieved and that the quality requirements of the functions in IPG Carmaker were also observed.

To get an overview of the tasks and their current state as well as to update the tasks continuously, the online tool Trello was used (Trello 2023). The Trello boards were designed individually by the teams reflecting the four categories 'Stories/Product Backlog', 'Tasks/Sprint Backlog', 'Work in Progress' and 'Done'. To maintain the goal of technical learning success for all students, the 'Definition of Done' (Gloger 2016) in this project was that each team member implemented and understood the tasks.

At the beginning of the project a few moderation tips were given, but afterwards the students should first try to find their own way of moderating. During the supervised meetings recommendations were given when needed, e.g. how to handle a situation or how to structure a meeting. In the end, each group presented their organisational process and the technical results.

3 RESULTS

3.1 Evaluation

The evaluation of the implemented Scrum method is done in different steps, analysis of different aspects over project lifetime, observations of the lecturers, statements from the students and the official evaluation of the module.

Analysis of different aspects

Three different aspects – Scrum elements, group behaviour and results – with corresponding sub-items are analysed as depicted in Table 1. The analysis of the group behaviour was based on three sub-items reflecting the acceptance of the process by the Scrum Master and the group and the observation of active participation during the meetings. For the results, the communication within the group, the achievements during the project work and the retrospective were analysed. The numbers 'x/y' indicate the result of the analysis for each group at the beginning and the end of the project, respectively. As indicated by light green and green, the results improve significantly over project lifetime for most of the items and groups. In the end, all items but 3 achieve a very good result of 7 and more. Just for two groups the tool (Trello) is judged worse at the end of the project.

Observations by lecturers

As the two lecturers acted as supervisors during the weekly Scrum meetings, they are able to observe the group behaviour, the different roles and the communication very closely. Some observations show a clear difference between the two different group types, some observations were very much the same for both group types.

For all groups the direct communication improved during the project, in particular for groups of type 2. The initial meetings of these groups were rather silent, but after some time an active communication took place, strongly motivated by the corresponding Scrum Masters. Some groups established additional communication via a messenger for asynchronous communication between the meetings. This kind of communication did not work well, as questions were often answered too late from other team members, blocking the questioner with this task. The issue was solved in the Retrospective by forming sub-groups of two people. Other groups solved a similar problem with an additional online or presence meeting with the whole group.

Table 1. Analysis of different aspects of the implemented Scrum method on a scale from 0 (worst) to 10 (best). Numbers indicate the value at the beginning and at the end of the project. Yellow: slight deterioration, light green: slight improvement, green: strong improvement

	Scrum elements			Group behaviour			Results		
Group	Tool (Trello)	Roles	Procedure	Acceptance by group	Acceptance by Scrum Master	Active participation in meetings	Communication	Achievements	Retrospective
1	8/7	7/9	6/10	8/10	8/9	8/10	8/10	10/10	6/9
2	3/7	3/9	3/9	8/10	10/10	4/8	6/8	5/8	4/7
3	7/6	8/8	6/9	7/8	7/8	6/8	9/9	9/10	6/7
4	6/10	6/8	7/8	5/7	6/7	6/7	5/6	9/10	4/6
5	6/9	4/9	5/10	6/9	8/10	5/9	3/7	4/7	6/9

Initially, all Scrum Masters had to find their role as a moderator and they had to learn that their task is not to find the perfect solution by themselves. Over time, all Scrum Masters managed to moderate their group and the meetings properly, the moderation style and extent strongly depended on the group type. For group type 2 the moderation efforts were significantly higher. It was remarkable that the Scrum Masters learned to change their role from team member to Scrum Master and back easily.

For all groups there was a steep learning curve regarding the Scrum process. In the beginning, the technical status update, the retrospective and the sprint planning were not properly separated but were mixed up altogether. With some support of the supervisor all groups found a better meeting structure reflecting the Scrum process with separated sections for the update, retrospective and sprint planning. Groups of type 1 did not follow the process too close but sometimes started side discussions during the meetings. These discussions were stopped after some time by the Scrum Master. In general, groups of type 2 oriented themselves more exact on the Scrum rules compared to groups of type 1 reflecting the need for a clear structure to support the communication of the type 2 participants. Overall, the atmosphere in the groups was very harmonic and result-oriented.

The role of the Product Owner did not have a high significance in this specific project due to the missing customer and missing change requests. Anyway, the Product Owners supported the Scrum Masters and communicated technical questions with the lecturing professor. For the dynamic aspects of the project, in particular during the sprint planning with corresponding task prioritization, Trello as a taskboard was of great benefit for all groups. Open and new task cards were replanned according to their new prioritization and relevance. Due to missing experience with the tasks and the corresponding effort, sometimes not all tasks could be completed as planned, and sometimes the tasks were finalized long before the end of the sprint. In the latter case, the group reflected that they should have distributed the previous tasks better over time and iterations. All in all, the dynamic structure allowed the students to manage their time individually and to react on problematic tasks.

Direct feedback of students

After the course finished, the students were asked for direct feedback in form of a question-leaded discussion in plenum with all students and additionally of a group-internal reflection. All in all, the project work was considered to be very good and helpful for their future work, in particular the structure and the Scrum roles. The Scrum method was appreciated in general, but for some students the effort for implementing and living Scrum was too high. These students preferred to have more time to work on the technical topics. Trello gave a good overview of the status of the project and each team member. Also, the individual goals defined in each sprint were helpful to work continuously. All groups profited from the organizational skills and the efforts of the Scrum Master. Hence, as the Scrum Master acted also as developer, the effort for the Scrum Master was higher than for other team members. During the time the effort for the Scrum Master decreased as the meeting procedure was more clear. The role of the Product Owner was unclear in this context and the students proposed to include the role of a customer. Face-to-face meetings were preferred to online meetings and were usually more productive. Regarding the technical tasks, the students concluded that Scrum was more helpful for the free EBA task, including higher creativity, better teamwork and communication and increased use of Trello.

Module evaluation

The module was also evaluated with a standard questionnaire that is used for all modules, just about half of the participating students participated in the questionnaire. Some students judged the method to be ineffective and too time-consuming, especially for the first, conducted part of ACC development. However, it was considered more helpful for the EBA task. Others found it interesting and helpful for structure and teamwork.

3.2 Discussion

The purpose for implementing an agile development process was to increase the professional skills of the students and to introduce Scrum as a state-of-the-art tool. Professional skills like communication, role behaviour and process understanding were strengthened for all participants due to the interactive meetings and the agile project structure. Just little effort was spent by the supervisors in the beginning to introduce the process, to guide the initial meetings and to give some hints for improvement. The extra effort for the students was judged to be not too high, even though not all students liked this way of project work in the lab. In contrast, most students appreciated the learning outcome and agreed with the extra effort.

The effort for the Scrum Master, when also acting as developer, is higher compared to the other team members. On the other hand, Scrum Master benefits by increased management and organizational skills. Changing the Scrum Master during the project could spread this learning outcome also to other students, but at the expense of more unstructured project setup. This idea could be tested in following labs.

Due to missing customer or external change requests, the role of the Product Owner was not really useful in the current setup. In the next turn, either a customer request or change requests can be introduced by the lecturers to increase the work for the Product Owner.

The Scrum method fitted very well to the free part of the lab, the development of EBA. Here, all advantages and features of agile development were clearly visible for the students. Some groups worked in sub-groups with two students implementing different solutions for the tasks. During the following Sprint meeting advantages and disadvantages of the different solutions were discussed and the best fitting solution was selected, improving the project outcome.

For the conducted part of ACC development, Scrum did not fit that good due to missing dynamics of the project. But, based on this approach, Scrum was introduced rather softly, and the students could focus on the technical aspects first. Nevertheless, for future labs it could be tested to run the static part of the project (ACC) in a conventional way without Scrum, and to use Scrum just for the dynamic second part (EBA).

The final technical results of all groups were very good and very similar to former years. All groups managed to run the static part of the lab, and for the EBA development they found different, but always working solutions. Therefore, all technical learning goals were fully reached.

As Scrum is a general agile project management method, it can easily be transferred to other modules. According to the results of the implementation presented in this paper, the lab should contain at least some free parts. For these free parts Scrum could provide many benefits to increase the professional skills of the students, introduce and experience a modern development process maintaining the technical learning goals. The roles and the concrete implementation of the process can be adjusted to the modules easily as well.

4 SUMMARY AND ACKNOWLEDGMENTS

The introduction of Scrum as an agile development method into an existing lab of the module Vehicle Systems is presented. The purpose is to increase the learning outcome with regard to professional skills, maintaining the technical learning outcome. The lab consists of a conducted part and a free part, and Scrum is applied for both. The benefits of Scrum are higher for the free part of the lab reflecting the dynamic development of this part. In general, the effort to implement and lead the Scrum process is medium, whereas the extra efforts for the students is rather low. Nevertheless, the benefits for the students with regard to professional skills and process understanding is significant.

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