"Now they just start working, and organize themselves" First Results of Introducing Agile Practices in Lessons

Petra Kastl
Friedrich-Alexander-Universität Erlangen-Nürnberg
Martensstr. 3, 91058 Erlangen, Germany
petra.kastl@fau.de

Ralf Romeike
Friedrich-Alexander-Universität Erlangen-Nürnberg
Martensstr. 3, 91058 Erlangen, Germany
ralf.romeike@fau.de

ABSTRACT
This paper demonstrates a design-based-research (DBR) framework that provides the basis for refining agile practices and artefacts for school projects. It takes into account the pedagogical content knowledge of teachers by combining theory with practice. Based on qualitative analysis of material of the initial iteration of the DBR process, the findings provide an empirical basis demonstrating difficulties of teachers and students with sequential models. In addition, the preliminary findings substantiate the assumption that agile practices reduce teachers' effort in design and use of project-based-learning modules.

Categories and Subject Descriptors
• **Social and professional topics~K-12 education** • *Software and its engineering~Agile software development*

Keywords
Agile practices, agile methods, design-based research, project-based-learning, secondary CS education

1. INTRODUCTION
Project-based-learning (PBL) in computer science (CS) is typically conducted as software projects and constitutes a unique scenario: Professional software development has a long tradition of conducting software projects and hence provides several scientifically derived methodologies for organizing these projects. In order to provide students with a real life understanding of software engineering, it is general practice to refer to the same methodologies in CS lessons. For historical reasons, curricula follow sequential models, such as the waterfall model. Teachers are encouraged to combine objectives from pedagogical (PBL-) methodologies, such as cooperative and self-organized learning, with the methodologies derived from software engineering [11]. According to both, teachers' experiences as well as existing literature, school software projects suffer from numerous problems related to the sequential project setup [6]. This is in accordance with the experiences in professional software development, where the disadvantages of a sequential approach, such as long planning phases at the beginning and little flexibility in the later phases, leads to quality issues, breaking of deadlines and low customer satisfaction. Since 2001, agile methods are therefore getting increasingly popular among software companies in order to address these issues.

The interesting question is, if the proclaimed benefits of agile development methodologies (e.g. an emphasis on team motivation, flexibility, and communication processes) and the known positive experiences [7] can be transferred into computing education. In particular, will students and teachers be able to solve present problems by using an agile approach and how much improvement can be demonstrated with respect to the objectives of PBL? Indeed, characteristics of PBL [e.g. 5] show similarities to descriptions of agile projects. For example, the emphasis on self-organized and outcome oriented effort, a complex and typically unclear defined task, as well as in cooperative work and learning combined with a collective responsibility for the project are important in PBL as well as in agile development. Furthermore in PBL, students aim to acquire, apply and enhance a variety of subject-related, methodological and social competencies [1].

The positive effects of applying agile approaches in CS school projects are e.g. discussed by Göttel [3], who used communication-supporting agile practices to facilitate an interest in and attractive notion of CS, as well as by Meerbaum-Salant and Hazzan [6], who developed a mentoring methodology for software projects based on agile values that aimed to support teachers. With respect to problems that students experience with software projects, Romeike and Göttel [10] proposed an Agile Model for Projects in Computing Education (AMoPCE) for use in school software projects. The practices presented in AMoPCE were used as a first guide for teachers who conducted the lessons that are discussed in this report and are referred to as *agile framework* or *agile practices (and artefacts)*.

2. THE RESEARCH APPROACH
Educational research and practice have shown that sustainable teaching innovations can hardly be implemented on the basis of theoretical considerations only. There is the need of input from pilot teaching which can reveal problems that have not been foreseen. Untested theory-derived teaching models may lead to significant issues in practice. However, CS education (CSE) is dependent on continuous technical and pedagogical discussion of scientific innovations, due to the dynamic character of CS. Design-based research (DBR) [2] is a research format that may address this challange. It supports the design and implementation of innovative teaching models and is characterized by the motivation to improve teaching and learning. This will be achieved in an iterative process of theoretical design and practical implementation phases where researchers and teachers work closely together on an equal footing. With DBR, aspects of teaching interventions can be researched within different contexts in order to develop empirically derived design principles. Reed and Guzdial [9] also suggest a DBR approach for CSE in order to avoid polarities such as discussions about "the only path to success". Instead, DBR provides the ability to explore ways

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that describe interventions in relation to conditions that "lead to significant improvement in learning outcomes."

In our research [4], we apply a DBR process in order to use the pedagogical content knowledge (PCK) of experienced CS teachers with the goal of developing a field-tested and flexible-to-use set of agile practices and artefacts for school software projects. With this approach, we can take ideas, interpretations, individual adaptations and observations into account in order to successively enhance the agile framework with each iteration of the research process. The DBR process consists of phases for input and networking as well as of phases of transition into application. In the latter, teachers are encouraged to individually adapt or extend the agile practices.

3. RESEARCH QUESTIONS

So far there is only anecdotal evidence reporting problems with the waterfall model – which motivated the development of AMoPCE. Therefore, in the first iteration, we aim to solve the questions, whether there is empirical evidence for those problems and if we can comprehensively define the details on the problems with the adapted waterfall model that is used in many schools:

(1) Which problems and difficulties do students and teachers encounter when they apply a sequential process?

Based on own unpublished experiences and teachers' reports, we assume that the interviews will add data about a variety of problems that may impede the objectives of PBL. The data may also answer the question of how well characteristics and objectives of PBL are achieved with sequential process models.

(2) (Students): How do adapted agile methods support the objectives of PBL (better)?

An agile framework, when adapted to the learning setting by the teacher, may provide students with a meaningful structure and a practicable set of activities and tools to support students. We expect that this support will in practice have a positive effect on students' activities and will accentuate the objectives of PBL.

(3) (Teachers): Does an agile approach facilitate the planning, mentoring and assessment of SD projects for teachers?

The provision of students with well-defined practices carries several advantages for teachers. They will have to choose, adapt and introduce appropriate practices but may experience a change in the teaching-role since students work mainly independently. We expect that with an agile framework teachers will overcome previous obstacles related to the application of the sequential process model and that they are able to adapt the agile framework depending on the class-specific context.

4. METHODOLOGY

We started the DBR process with interested teachers, participating in an initial workshop where they got introduced to agile methods and AMoPCE as a corresponding model for CSE. The workshop encouraged teachers to adapt an agile framework to their individual in-class situation and to include own ideas. In the initial DBR iteration, six teachers applied the agile process in one 8^{th}, three 9^{th} two 10^{th} and three 11^{th} grade classes with approximately 170 students participating. In semi-structured interviews information about previous experiences with SD projects in CSE and about their motivations to apply an agile process this time was collected. Furthermore, qualitative data in relation to individual projects such as individual adaptations to fit the methodology to their context and individual observations and experiences were collected. For the analysis of the resulting data, a structured content analysis approach according to Mayring [8] was applied, in order to filter aspects of the material, which are relevant to answer the research questions. In order to guarantee the inter-coder reliability, the material was cross-coded in a peer-coding process.

The category system was inductively developed with respect to the research questions and the theoretical considerations related to AMoPCE. In the following, we sketch the main categories (italic): *Self-organization* comprises characteristics related to the learners' organizing of the product development and the associated activities as well as the learning and problem solving processes. The enhancement of professional, social and management skills as well as active and passive transfer of knowledge are summarized in the category *learning and social learning*. *Social interactions* encompasses the various aspects of communication and cooperation. Statements regarding the teachers' role and tasks are bundled in the category *teachers' activities*. The categories *transparency* and *assessment* are limited to aspects regarding the teachers in this report. The first one comprises aspects of keeping track of the project and its status as well as the insights into individual performances and the development of students' competencies. The latter encompasses the assessment of the achievements and the teachers' feedback to the students' individual developments and performances. Finally, *problems with sequential design models* refer to miscellaneous statements related to the first research question.

5. RESULTS OF THE FIRST ITERATION

5.1 Which Problems and Difficulties do Students and Teachers Encounter in a Sequential Design Process?

Problems with sequential design models were a topic in all interviews. After analysis of the material the following core problems were identified:

(1) Methodical competences: Since in sequential processes students only work once in each phase (analysis, design, coding and test), most of them are not able to familiarize with the used methods and activities. In addition they have too little opportunity to reflect on mistakes and to gain confidence. The point of an initial planning and design of a complex system which comprises a lot of considerations and decisions, remains purely theoretical for most of them as they do not experience and reflect on the consequences of missing or wrong decisions. Most students have not gained the ability to recognize and identify structural deficits in the planning. One teacher reflects: *"In principle I had to moderate each phase of the waterfall model[...] it was every time new for the students".*

(2) Self-organization: There is mutual agreement among teachers that students did gain almost no expertise in self-directed learning. This is highly likely related to the students' insufficient time for reflection and consequently the inability to develop confidence to master complex topics.

(3) Responsibility: Project-responsibility was mostly delegated to the teachers. Mistakes in the planning and design phases of a project are likely to lead to incompletion of the entire project. Thus teachers in general tightly guided the early phases. This role of the teacher typically did not change for the remaining project phases as well: *"They always saw the teacher as the leader of the process. The teacher is the one who knows and who can do everything [...]. When we started coding, after two minutes hands were up."*

(4) Motivation: Teachers describe the influence of the sequential project layout as highly problematic for the students' motivation, which was high in the beginning but decreased rapidly: *"Before a small program finally is running, half a year is over and students' enthusiasm by then has been gone."*

(5) Social skills: The development of the students' social capabilities and competencies is mentioned by some teachers in reference

to observations with agile projects. As one teacher describes it, he was now able to observe, foster and assess the development of social competencies that he did not see in the years before: *"[In a sequential project], the student wouldn't have developed such social skills. At the end of the day he would have been the same nerd as he was right in the beginning."*

(6) Ending: Another problem that was substantiated in interviews was the ending of projects. In sequential projects, delays, which were common, had a direct and severe impact on the final project phases of coding and testing. *"Well, I also felt that the waterfall model gives me the problem of 'sink or swim'. Because what are you supposed to do with half-finished projects?"*

The analysis of the interviews supports the assumption that the teachers have difficulties in achieving the objectives of PBL, especially with respect to students' self-organization and motivation, methodical and social competencies as well as in taking responsibility for the project. Consequently, the question needs to be pursued, whether an agile framework is more suitable for reaching the objectives of PBL and to avoid the outlined problems of teachers.

5.2 How do Adapted Agile Methods Support Objectives of PBL (Better)?

Three of the main categories (outlined under 4) provide answers with a focus on the students' learning process using agile practices and artefacts. The findings of the evaluation of the material corroborate the hypothesis that in contrast to sequential models, an agile approach supports the objectives of PBL, in particular self-organization, social learning, communication and cooperation. Analysis of the data from interviews showed that students conduct their projects predominantly in a **self-organized** way. Due to the concrete guidelines of the practices, the students mainly had to closely follow the defined planning and communication processes. For example, with respect to problem solving and the acquisition of new skills a teacher explains how students handle programming problems: *"If they [the pair] don't succeed, they… pull the ripcord, saying 'hey, folks, we need a stand-up meeting [...]' And then they systematically approach the problem by making a list of all issues."*

Analysis of the product development process showed that students were able to self-organize e.g. in terms of students defining their sub-goals, splitting them into tasks, distributing and implementing the tasks, and communicating the results in the next stand-up meeting. Further observations were related to the self-organization of the phases (design, coding and test) which were part of each iteration: *"If students showed uncertainty about their upfront planning, they went to the project board, got the missing information and continued the coding work."* - *"They documented and categorized errors and tested them again in each iteration. So they even used a kind of regression testing."*

Learning and social learning became a clearly visible process due to the iterative development, as can be seen in the analyzed material. The increasing methodological competences were expressed e.g. in the above described self-organization of the phases of an iteration. The gradual increase of social and professional competences was evident throughout the interviews. As intended in PBL, the students acquired professional knowledge predominantly via self-directed learning and used it to achieve certain goals or to solve problems. All teachers valued pair-programming as a valuable method to support the passive transfer of knowledge. However, they also in unison pointed out that the regularly changing of the roles (driver/navigator) and the following of the roles requires the supervision of the teacher. Data from interviews suggest that over time arrangements and discussions are happening on a more regular basis and become more efficient. Spontaneously students took over roles as moderators or customers; sometimes the students chose fixed roles within the team. *"By now – and it has been quite different in the beginning – they have a project leader and this job is alternating. […] The timing of the stand-up meetings they now master quite well. Here they plan goal-oriented and split up after five to ten minutes […] to continue working on the computer."*

As one teacher explains it, special moments occurred when students cheered loudly after reaching a targeted goal: *"[…] especially positive is, when they get sense of achievement if they figure out something by themselves. I have never experienced before that students yell 'YES! YEEES!' and everyone gets together to have a look and say 'Wow, good job!'"*

Social interaction. The teachers considered communication important in all projects and hence extended the function of stand-up meetings (see below). This provided students with a convenient structure for successful collaboration and facilitated collective responsibility and intermediate success. At the beginning of the lessons, stand-up meetings were used by teams for information and coordination purposes. In consequence, transparency was increasing, an effect, on which a teacher reflects as follows: *"Everybody knew what the others were working on, which problems they encountered and which approaches they used, and which ideas the team came up with."*

Some teachers adapted stand-up meetings so that they could use them to spontaneously gather the students to discuss problems, for iteration planning or for the discussion of goals. In some cases, stand-up meetings have been used in order to conduct "talks with the customer", a possibility for the teacher to intervene in a steering or encouraging way or to reflect on process and outcome of an iteration. These adaptations of the professional methods demonstrate how teaching can benefit from practices intended to organize professional work flow.

Teachers also reported on loud and intense discussions. However, in all reported cases the conflicts were resolved by the students themselves. Without being able to explicitly explain how conflicts were resolved, a teacher summarized: *"It never happened that a student went off alone and started frustrated working by himself. Instead, students usually finished their meeting and at the end everyone went to the computer with well-defined tasks."* Similarly, another teacher emphasized the value of students' sharing common goals and responsibility: *"Ambition was awakened among most of the students. Only very few were holding back. They were willing to do it as a team and hence were taking care of their outcome."*

Most of the projects have been conducted early in the school year with novice programming students. Despite marginal previous knowledge, students were consistently able to manage their projects by themselves. Those teachers, who had the opportunity to compare the achievements with the outcomes of the previous year, considered them of higher-value.

5.3 Does an Agile Approach Facilitate the Planning, Mentoring and Assessment for Teachers?

A change in the effort of students should have a direct impact on the activities and role of teachers. In the following, we will discuss the outcomes of analyzing those main categories (outlined under 4), which refer to teachers.

The changes in **teachers' activities** were valued by all participating teachers and were comparable with the statements referring to the students. The data clearly show that the agile approach is sufficient to motivate the conduction of the project by students. Instead of a continuous moderation, only sporadic mentoring and advice was used by teachers. The provision of support was described as much more relaxed, more intensive and more efficient. *"So I explained the principle once and then they worked […] Now I even had the opportunity to discuss issues in depth with the individual teams."- „Now there was time to help students even with simple errors like transposed letters, even if it took five minutes. I had the time, because I knew that the other students were working."*

Especially in the beginning, the teachers motivated and facilitated the communication and cooperation efforts of the students: *"In the beginning I pushed the students a bit: 'Wouldn't this be an opportunity to meet at the project-board to discuss?' And then over time I was surprised, they met regularly whenever they encountered a problem."* The flexibility of the requirements and the running prototypes after each iteration made planning and assessment easier. *"The students knew from the start that it's not about creating a perfect game but more about developing basic functionalities. This did not only change my own perception, but I had the feeling that also the students were positive about saying 'We have developed a prototype of game and we know how we could develop it further.'"*

The agile projects provided more **transparency** for the teachers in comparison to previous projects. On one hand, teachers gained insights into the progress of the projects and into students' activities by looking at the project board. This was beneficial for the provision of efficient support. *"You can actually choose which problem you want to address and at what time. I can't see anything from someone putting his hand up, but the project board tells me a lot."* On the other hand, due to the high significance of communication processes, teachers gained comprehensive insight into the individual progress of students: *"I found it totally interesting. You are not involved, you don't have to moderate – nothing. You can just listen. Of course, you notice much more; how they work, think, and how the process develops."-"You can better observe social behavior, and the group dynamics […] due to their constant interaction with each other."* - *"Indeed, by listening to them arguing about how they resolve the problems after mutual testing, you can determine that they are able to figure out if the problem lies in the coding or if they discuss 'we have to change something in the design of the class.'"*

Consequently, **assessment** is easier for teachers since they got a better understanding of the development process and can refer to individual prototypes. However, all teachers state that it was more important to them that, because of the increased transparency, they were able to give well-informed and comprehensive feedback with respect to individual performance, as it is expected in the PBL process. *"If I look at the individual progress of students, I have to say I observed significant improvements."* The interview statements support the hypothesis that an agile framework enables teachers to overcome significant difficulties that were present in sequential-model driven projects. Teachers adapted this framework to their individual situation and added own ideas. Such ideas included "student stories" to encourage subject-specific learning or "customer conversations" in order to guide projects. In the interviews there was no indication that teachers encountered difficulties to adapt agile practices to their context or to accomplish intended goals.

6. DISCUSSION

As one of the teachers stated, the effects of using agile practices in school software projects can be summarized as "Now they just start working, and organize themselves." The design is the core element of our DBR process. The iterative development of an agile framework for projects in CSE shall provide a framework that maintains a professional orientation and supports PBL at the same time. The results presented in this paper confirm the assumption that teachers can successfully create such a framework. Thus in a 2nd workshop teachers exchanged and reflected on their experiences. Together with the results presented above this provides the basis for further elaboration on agile practices being another step towards a set of agile practices as well as towards further contributions to theory.

Analysis of practical examples in the initial iteration showed that four out of six teachers applied the agile approach in classes early in the courses with programming novices. As they all valued the approach as profitable, we consider to reinvestigate the material with emphasis on students' self-efficacy and collective efficacy. Furthermore, the flexibility of the DBR process might be used to investigate how an agile approach enables teachers to structure projects in a way that they function as (collective) efficacy builders.

We were surprised about the passion and personal involvement of teachers. They adapted the approach courageously and creatively to their context, spending a lot of time for preparation. Therefore, a format which enables researchers and practitioners, both as experts in their field, to work together on equal footing has the potential to increase the sustainability of advanced teacher training. We are also surprised about the little trouble related to the application of the agile framework, which even was new to all of the teachers. We assume that the following aspects contributed to this success: Firstly we see the teachers' motivation and personal engagement, having their roots in the promising outlook to overcome real problems. As another success factor we see the combination of theoretical considerations as well as practical experience and PCK.

7. REFERENCES

[1] P. Blumfeld, E. Solowy, R. Marx, J. Krajcik, M. Guzdial, and A. Palincsar. Motivating Project-Based Learning: Sustaining the Doing Supporting the Learning. *Educational Psychologist* 26, 3 & 4, 369–398, 1991.

[2] Design-based Research Collective. Design-Based Research: An Emerging Paradigm for Educational Inquiry. *Educational Researcher* 32, 1, 5–8, 2003.

[3] T. Göttel. *Agiler Informatikunterricht: Soziale Aspekte der professionellen Softwareentwicklung im Schulunterricht erfolgreich erfahrbar machen*. Hamburg, 2012.

[4] P. Kastl and R. Romeike. Entwicklung eines agilen Frameworks mit Design Based Research. In *INFOS 2015 - 16. GI Fachtagung Informatik und Schule*. 2015.

[5] T. Markham, J. Larmer, and J. L.Ravitz. *Project based learning handbook. A guide to standards-focused project based learning for middle and high school teachers*. Buck Institute for Education, Novato, Calif., 2003.

[6] O. Meerbaum-Salant and O. Hazzan. An Agile Constructionist Mentoring Methodology for Software Projects in the High School. *ACM TOCE* 9, 4, 1–29, 2010.

[7] B. Meyer. *Agile! The good, the hype and the ugly*. Springer, 2014.

[8] P. Mayring. Qualitative Content Analysis. *Forum: Qualitative Social Research* 1, 2, 2000.

[9] D. Reed and M. Guzdial. The power of computing; design guidelines in CS education. *Commun. ACM* 55, 4, 8, 2012.

[10] R. Romeike and T. Göttel. Agile Projects in High School Computing Education: Emphasizing a Learners' Perspective. WiPSCE '12. ACM, NY, USA, 48–57, 2012.

[11] S. Schubert and A. Schwill. *Didaktik der Informatik*. Springer, 2011.