USAGE AND ACCEPTANCE OF MANAGEMENT TOOLS IN PROJECT-BASED LEARNING ENVIRONMENTS

Rößler, Lisa;
Gericke, Kilian

University of Rostock

ABSTRACT

This paper aims to identify the reasons for neglecting and the motivations for using management tools among three groups of students participating in a project that was carried out and followed over a period of one semester. For this purpose, a survey in the form of questionnaires and interviews was created. Particular emphasis was placed on the use of project management methods, tools and techniques and respondents were asked to rate the effectiveness of their usage. Additionally, the participants were asked to report limitations or distractions they had encountered. The results revealed five aspects that mainly influenced the students' motivation in using management tools: the team atmosphere, determining responsibilities, performance transparency, expectations by the supervisors, feedback and performance evaluation. On that basis conclusions were drawn on what actions can be taken to motivate future students and designers.

Keywords: Project management, Design education, Organisation of product development, Design practice, Design process

Contact:
Rößler, Lisa
University of Rostock
Germany
lisa.roessler@uni-rostock.de

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1 INTRODUCTION

While the demand for multi-technical and individualised products is increasing, the development of products equipped with electronics and sensors is also increasing in complexity, because it requires the collaboration of different disciplines with specialised knowledge (Qureshi *et al.*, 2013). This, in turn, affects the remit of design engineers and the management of development projects. Design engineers must master administrative and communicative skills in addition to their usual tasks in designing products, since their actions influence the course of the development process. (Eckert *et al.*, 2017; Eigner and Stelzer, 2009). However, according to Eckert et al. (2003), managers complain about development engineers that tend to focus on design activities while neglecting the development process and their role in it. Instead, there is a widespread tendency to continue designing a product until the design engineer is satisfied, at the expense of exceeding cost and time limits (Eckert and Clarkson, 2003). On the other hand, design engineers complain about process guidelines that are too abstract and contain procedures that are difficult to implement while other central aspects are omitted (Eckert and Stacey, 2010). One reason for the divergent perceptions of process descriptions among design engineers and managers is insufficient knowledge about the associated process flows and their influence on a successful, time-efficient design in the development process (Stacey *et al.*, 2020). One way to overcome the resistance is to lay the foundations in a controlled environment in engineering education to change the mindset of future designers so that certain management tools and process steps are established as standard.

In recent years project-based learning has emerged as an outstanding strategy in engineering education. It is a student-centred, interdisciplinary method designed to enable students to expand their understanding of academic content and acquire a broad range of skills (Vincent-Lancrin *et al.*, 2019). Students are actively involved in the learning process. They are enabled to achieve a common goal through social interaction and exchanging knowledge, which leads to context-specific learning (Cain and Cocco, 2013). They are confronted with real-world problems and must apply their knowledge to solve them. The authentic nature of a problem promotes motivation as well as commitment and arouses students' interest (Becattini *et al.*, 2020; Vincent-Lancrin *et al.*, 2019).

This paper aims to determine the benefits and acceptance of project management tools through observation of a project by engineering students at the University of Rostock. Research subject were particularly tools that promise to provide an overview of a development process and support the structuring, organising and monitoring of projects.

2 RESEARCH APPROACH

This paper presents an exploration of the acceptance of project management tools by engineering students in the context of a product development project. Based on the motivation and actual benefits that the students attest to the use of project management tools, we provide suggestions on how to facilitate their implementation in future projects. We also formulated three research questions with the aim of gaining new insights regarding the use of software tools for project management in student projects to further adapt the project conditions to the needs of students and their supervisors:

RQ1: To what extent does the knowledge of students affect the handling of project management tools?

RQ2: What motivates students in a successful implementation of software tools to manage their project?

RQ3: What functions are needed for a software tool to become relevant for managing student projects?

2.1 Study design

The number of participants in this study was low, which is why both quantitative and qualitative data was collected to increase data collection. The quantitative research approach, subdivided into a *pilot survey*, a *diary survey* and a *follow-up survey*, was used for a self-assessment by the students and the evaluation of specific aspects of the projects, whereas the qualitative part was used to allow for unexpected findings. Response bias was avoided through providing a natural environment with low control. However, other confounding factors, such as the workload of other courses of the master's program, could not be excluded. The participation in the survey was voluntary and anonymous.

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The *pilot survey* took place before starting the project. Its intention was to classify the participants according to their previous knowledge and to answer RQ1.
A *diary survey* was sent to the students by e-mail weekly. It included a questionnaire containing five closed questions on the time spent, satisfaction and media usage during the project implementation. The questionnaire was intentionally kept short to increase the students' willingness to participate. The goal of conducting this survey was to observe changes in student behaviour across the different phases of the project.
The *follow-up survey* was intended to systematically capture the students' subjective experiences. For this purpose, they were asked to evaluate various aspects of the project and the teamwork in the form of verbal and numerical self-reports. A numerical assessment was followed by open-ended questions allowing students to justify their answers.
The *interviews* took place halfway through the project and were carried out in a semi-structured manner. At this point, the students had already been intensively involved in the implementation and planning of the project, but the most time-consuming phase, the prototyping phase, had not yet begun. The questions of the group interviews were related to the overall course so far and the benefits of the software program in use.
Note that during the semester in which the project took place, the COVID-19 pandemic forced the university to close for most of the time, and the students had to complete their project with the help of online media.

2.2 Course description

The Product Development Project is a learning module at the University of Rostock aimed at engineering students at master's level.
Through project-based, problem-oriented learning, the students combined theory and practice while participating in the project. They were confronted with a problem in the field of aerospace engineering, a field in which they were unlikely to have any previous knowledge. To address the initial problem, find a solution and develop a corresponding product, the students completed the first three phases of the product development process in accordance with Pahl and Beitz's 'task clarification', 'conceptual design', 'embodiment design' and 'detail design' (Pahl *et al.*, 2007). The students were also required to structure the project, subdivide the problem into manageable subtasks and assign them to specific persons, an important aspect of the implementation of projects (Filippi *et al.*, 2018). The students were expected to break down the tasks of each phase into subtasks, to describe the activities required to execute each task and to specify concrete results of the tasks. The subtasks were then assigned to specific persons to enable parallel work.
To ease the planning of the project, supervisors provided a rough schedule for the project containing the main topics on a weekly basis as well as milestones. The milestones were used for design reviews where the students were expected to present their progress. Students were encouraged to use Asana to help plan their project, which shall be considered as representative for project management tools in the context of the present study and represents the object of investigation.
The aim of the module was for the students to deal with complexity and manage a development project in addition to producing a prototype.

2.3 Participants

The survey was made available to all the student participants of the project (N = 15). Differences were observed in the response rates of the individual questionnaires. The pilot survey was answered by 14 students, whereas only 11 students answered the follow-up survey. One possible explanation is that when the final questionnaire was sent out, the examination period had begun, meaning that some students did not find the time to answer the questions. On average, 14 students participated in the diary survey.
All students were enrolled in a master's program at the time of the survey, with n = 5 (36%) students in their first semester, n = 1 (7%) in their second semester, n = 4 (29%) in their third semester, n = 2 (14%) in their fourth semester and n = 1 (7%) in their fifth semester. One of the statements was not included, because one of the questions was answered incorrectly. Eleven students (79%) were studying mechanical engineering and three students (21%) were studying industrial engineering.
For the duration of the project, the students were divided into three groups of five, which are referred to as 'GA', 'GB' and 'GC'.

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3 FINDINGS

3.1 Previous experience

Work experience

The initial questionnaire was used to ascertain how many students had already gained work experience before the start of the project, since it was assumed that some of the participants had already used software tools to manage projects. As can be seen in Fig. 1, ten of the participants had already gained work experience, with two employed as student assistants at a university and six having worked in a company. Four students did not have any professional experience at the time of data collection.

Project experience

The students had participated in an average of 6.3 projects or tasks involving group work. In detail, the number of projects ranged from two to 30, and the average team size was four students. Nine of the 14 participants of the pilot survey had already used software tools to manage projects, including Asana, Trello, Gantt-Charts and MS Project. All the participants had primarily used WhatsApp for communication and organisation in past projects. Other ways of communication named were Facebook, Mail, Discord, Skype and MS Teams.

Further, the students were asked to assess communication, time management and task distribution in past projects. The results can be seen in Fig. 2. When asked about the most relevant aspects that had a positive effect on communication during previous projects, six students stated that direct and simple communication was essential. Other factors with positive effects were the active participation of all team members and a structured distribution of tasks. The most frequent answers to the question of what constitutes well-functioning communication in projects were the existence of firmly agreed, regular team meetings (n = 5) and a clear distribution and description of the tasks required to achieve the project goals (n = 5). The full list of given answers can be seen in Fig. 3 and Fig. 4. Concerning time management, seven out of 13 participants claimed that they were unable to keep to the schedule in previous projects. The main reason was the inaccurate estimation of the workload. Other reasons are given in Fig. 5. The participants stated that the main factor influencing the distribution of tasks (i.e. assignment of tasks to team members) in past projects was the personal initiative of individual team members (Fig. 6).

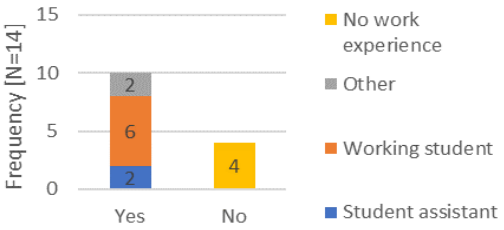

Figure 1. Professional experience of students

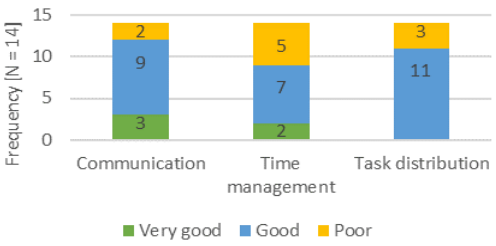

Figure 2. Evaluation of past projects based on communication, time management and task allocation

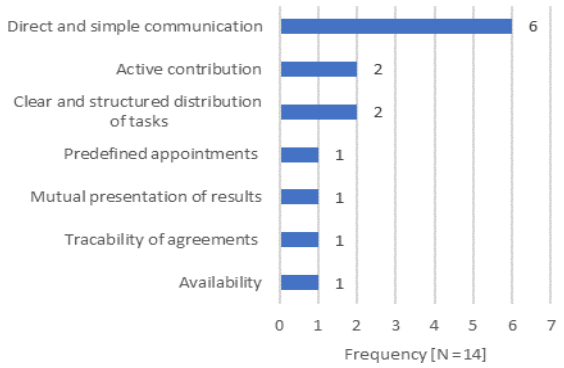

Figure 3. Factors of good communication that positively influenced previous projects

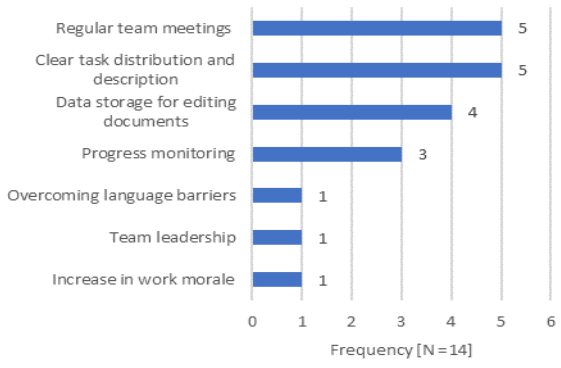

Figure 4. Wishes (measures) to improve communication in future projects

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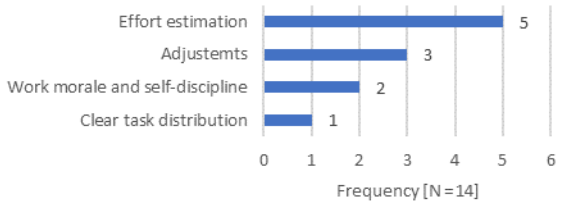

Figure 5. Factors that influenced the time management in past projects

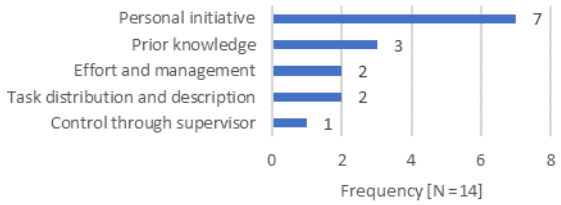

Figure 6. Factors that influenced task allocation in past projects

3.2 Motivation

Choosing an interesting topic for the project is one of the most essential factors concerning student motivation during project implementation. The project goal is also very important, as stated in one of the group interviews: 'it has a positive effect if you achieve a good result and a prototype is created in the process' [GC]. When asked what incentives would increase the project's attractiveness, it emerged that 'an embedding of the project in a framework, e.g. overarching projects at the university or an active contribution to a research project, where one can see if and how it really works' [GA] would provide additional motivation – a statement that met with agreement among the other team members.

The follow-up survey was intended to provide an overview of the general project activities. In this regard, the students were again asked to evaluate the overall course of the project, communication, distribution of tasks and time management. The results depicted in Fig. 7 represent the absolute frequencies. As can be seen in Fig. 7, the participants responded positively in all the mentioned categories. The most relevant factor that positively contributed to the project was good teamwork, as illustrated in Fig. 8.

Regarding the communication during the project, the participants responded that the most crucial aspects were short communication channels and the accessibility of team members and supervisors. The full list of influencing factors is given in Fig. 9. Further, it was stated that 'the creativity workshop', which was conducted during the project, 'had a positive effect on teamwork' [GB] and it was requested that 'there should be more workshops, e.g. in prototyping' [GB].

A clear assignment of responsibilities was considered an important aspect regarding the distribution of tasks. Some students were satisfied with how the tasks had been assigned while others found it problematic: 'I think the most important thing is that you have someone who leads the group and distributes the tasks. Otherwise, people talk past each other and in the end no one does it.' [GC]. In addition, there were differences in motivation and commitment between the team members, which influenced the execution of tasks (Fig. 10).

Another important aspect is the traceability of performance and expectation. This criterion was mentioned during the interviews and emerged as a crucial factor influencing the students' motivation. For example, a criticism made was that 'the tasks were vaguely formulated at the beginning' [GC], a point similarly voiced by the other groups. This led to not all groups delivering the expected results in the first design review. It was also stated that 'we felt at the beginning that our supervisor was missing results we didn't even realise that we were supposed to deliver. We have a semester schedule, but this doesn't contain everything. The chair seems to have concrete ideas, but these are not communicated properly.' [GB]. This indicates that misunderstandings arose among the students. By this time they had not yet understood that it was their duty to plan and structure their time and organise their tasks themselves.

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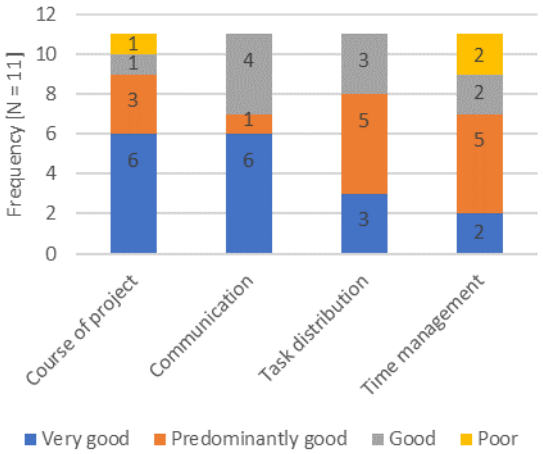

Figure 7. Assessment of projects progress according to predefined criteria

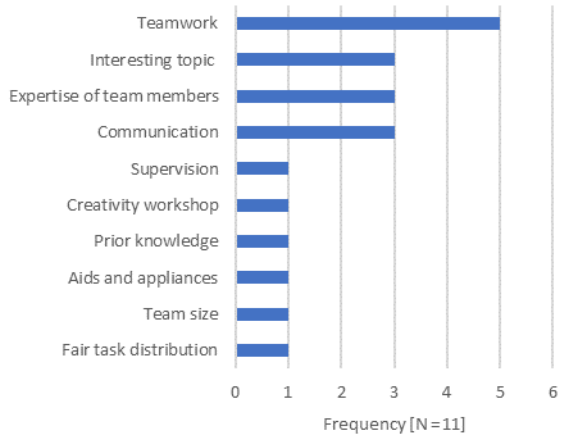

Figure 8. Positive influences on the course of the project product development

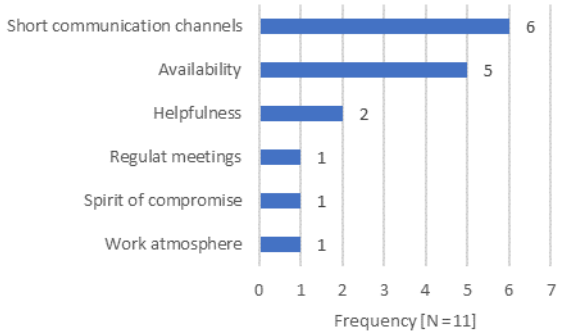

Figure 9. Positive influences on the communication during the project product development

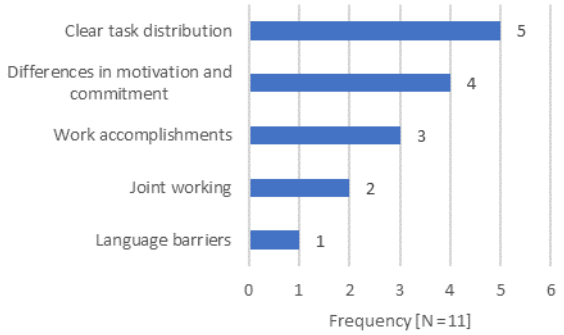

Figure 10. Positive influences on the task distribution during the project

3.3 Software tool Asana

Before starting the project, the students were asked to evaluate a (previously unknown) software tool designed to support communication, planning and organisation in projects. Fig. 11 shows that most students expected such a tool to be helpful in all the mentioned categories.

After using this management tool during the observed project, the students were asked to rate its effect on the implementation of their project. Again, most students positively assessed the tool's impact on the project (Fig. 12), but there was also considerable criticism, which reduced their willingness to use such a tool in future projects. Over 70% of the students were receptive to using a software tool at the beginning of the project, but at the end only 36% stated that they would reuse such a tool in future projects. In contrast, some students were initially sceptical about the program but found it helpful: 'At the beginning I thought we didn't need this, but now it's quite good, because we have all the information needed in one place and you can see some progress.' [GB]. Furthermore, the interviews provided some indications why the students' opinions changed:

'We tended to force ourselves to enter something in Asana, but then we did not stick to it.' [GB]

'At the beginning I thought we definitely need to use this, because I have already worked a lot with such programs. I struggled with it, though, breaking down the tasks.' [GB]

'We used Asana to present our current status, that is, the results that we could show. We did everything else using [Microsoft] Teams because that's where we could live-edit files. In Asana, you can only upload files and someone always has to put everything together.' [GA]

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‘You have to deal with Asana more in the beginning, then it would definitely have more impact.’ [GC]
As indicated by the preceding statements, the management tool was used for the initial structuring of the project and for presenting results, whereas it was not actively involved in organising and managing the project. One explanation for this may be the lack of knowledge of the students about the functions it offers and the lack of experience in how the program can be actively integrated into a project workflow. It was expected that the students would engage with the program and acquire the knowledge needed themselves after receiving a short briefing at the beginning of the project.
The aspects that the students highlighted as positive are listed in Fig. 13. The functions that were emphasised most were the ability to structure tasks and subtasks and the opportunity to gain an overview over the progress of the project. Most problems occurred due to the complexity of the software program and missing functions, such as the ability to simultaneously work on documents. Other problems mentioned can be found in Fig. 14.

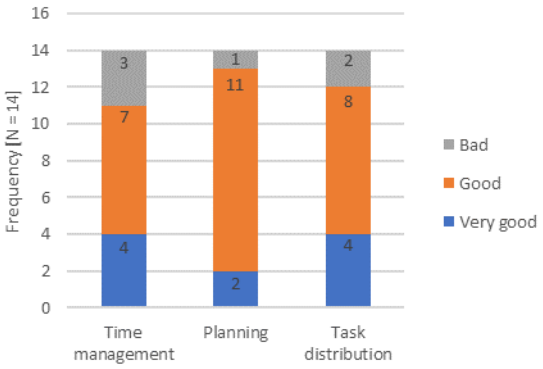

Figure 11. Assessment of projects progress on predefined factors after integration of a management tool

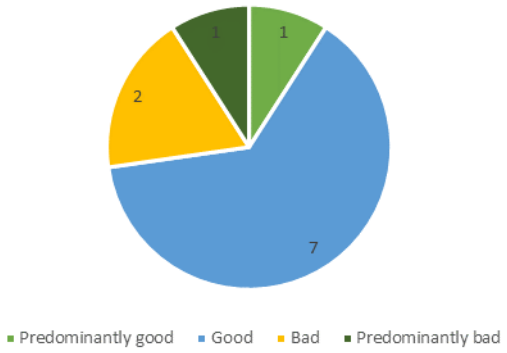

Figure 12. Assessment of influence of the management tool

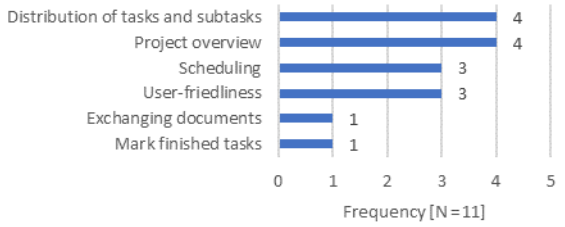

Figure 13. Positive aspects of a management tool

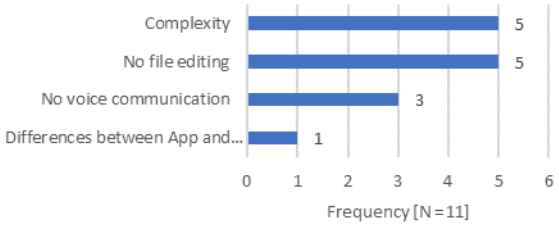

Figure 14. Negative aspects of a management tool

4 DISCUSSION

4.1 Students’ experience (To what extent does the knowledge of students affect the handling of project management tools?)

The initial survey provided a good overview of the prior knowledge and experience of the students. All participants had participated in at least two group projects before the observed project. Some students had already used Asana, although infrequent use was indicated. Nevertheless, it can be assumed that these students had an advantage in implementing Asana in their project, since others had to first familiarise themselves with the program. Three kinds of behaviour could be observed. Some of the students were already familiar with Asana and had less or no problem implementing the program into their group work. Some students had gained experience in using other software tools, which lead to them falling back to those already known during the project. Other students did not take the time to acquire the necessary knowledge handling the program through self-study and complained about missing functions or did not actively implement the program into their work schedule.

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Regarding the communication, time management and distribution of tasks in past projects, the students indicated that they had been satisfied, although more than half of the students were unable to keep to the time schedule. The main reason given was an underestimation of the workload.
Furthermore, the study revealed that most students were receptive to using a software tool before starting the project. The general expectation was that the program would facilitate project planning, time management and task distribution. By the end of the project, however, the initially predominantly positive opinion changed, with most students indicating that they would not use Asana for similar projects in the future. A potential way to avoid the mentioned problems in the future would be to improve the professional support of the project by the supervisors. This could be realised by providing a more intensive introduction and stricter inspection of the activity in the program. If the students are expected to acquire the required knowledge themselves, a precise task and predefined time slot should be provided to deal with project planning using a program.

4.2 Student motivation (What motivates students in a successful implementation of software tools to manage their project?)

When considering the students' motivation, five aspects emerged that significantly influence the handling of the software program: the working atmosphere in the team, the definition of responsibilities, the clarity of performance expectations by the supervisors, feedback and performance evaluation.
The implementation of a project, especially the achievement of all the goals, requires the close cooperation of all participants in the team (Qureshi *et al.*, 2013). In this context, a good working atmosphere increases the effectiveness of processing tasks and leads to better results (Schlabach, 1994). Usually, the team members are unfamiliar with each other when starting the project and cannot influence the formation of the group. As a result, some teams did not show a good group dynamic at the beginning, which hindered cooperation. This observation is supported by the students' statement that the creativity workshop, which took place in the sixth week of the project, significantly improved the working atmosphere, which resulted in a profitable working phase. A factor influencing the working atmosphere and motivation is the degree to which the students identify with the chosen project topic. The creation of a prototype also lent the project an authentic character and enhanced the commitment of the students. This confirms the findings of Vincent-Lancrin et al. that students' interest is stimulated when they must apply their knowledge to solve real-world problems (Vincent-Lancrin *et al.*, 2019).
In addition to creating a positive working atmosphere in the team, the processing of tasks can also be promoted through a concrete definition of responsibilities. This includes both the determination of persons responsible for processing subtasks as well as defining corresponding roles (Pahl *et al.*, 2007). For example, students pointed out that a designated team leader, who is entrusted with distributing tasks, would advance the project work. Without additional incentives, no one in each group was willing to take on this role. This suggests that the learning objective was unclear or insufficiently explained. Instead, the project confirmed the prior experience of the students that the execution of tasks depends on the initiative of the individuals. In response to the questions as to whether roles and responsibilities were defined within the groups at the beginning, there were contradictory answers. This indicates that a distribution of roles was implied but not agreed upon, which resulted in not all participants being aware that a distribution of cross-project activities had taken place. For this reason, it would be beneficial to involve the students in defining concrete roles at the beginning of the project. These roles could involve project management or administering a management software. Again, this process should not be left to the students' own initiative but should be actively initiated by the supervisors. An additional advantage of such an approach is that the planning can be viewed and controlled by the supervisors in the program and, if necessary, be supported. However, after the initial structuring of the project tasks, the students did not use the program for further planning and control, and it was only used to subsequently display the work status to visualise the process for the supervisors. For this reason, there is a need for stronger intervention in the project activities to promote the implementation of Asana. To achieve this, Asana could be made an integral part of the project, so that the software is also integrated into the reviews and the performance evaluation.
A central aspect in the implementation of student projects, especially if they are accompanied by a performance evaluation, is a transparent presentation of expectations beforehand (Schlabach, 1994). If the students are unable to meet the expectations, it is not necessarily due to a faulty problem definition

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or poor performance on their part; it may be due to insufficient clarity regarding the requirements and goals of the project (Bender and Marion, 2016). During the data evaluation it became increasingly clear that there was considerable uncertainty about the required performance, particularly at the beginning of the project, which resulted in not all groups presenting the required results during the first review meeting. Even though the students had access to a schedule with weekly tasks and expected results, there seems to have been misunderstandings in the process. Integrating a management software into the project has the potential to counteract developing misunderstandings – both for the students and for the supervisors. Controlling the creation and description of the subtasks in a management software by the supervisors would create possibilities for intervention, i.e. enabling them to react before reviews if important aspects are missing. However, in the reviews the results were mostly presented, while project planning was disregarded.

Feedback is also a significant motivating factor. The students stated that they received a large amount of constructive criticism from their supervisors, which they gladly accepted and found helpful. However, they noted that positive feedback was lacking, which reinforced the uncertainty already mentioned regarding performance expectations. Because of the aim of the Product Development Project of not only achieving a certain result in the form of a prototype but also dealing with complexity and managing a project, students should receive more feedback regarding the planning and structuring of their work.

The final decisive factor affecting student motivation is the performance evaluation, which is always a critical aspect when considering group work. The evaluated items are a report and a final presentation with a focus on the prototype, which are both a group effort. The content of the report was not explicitly specified. Instead, the students were expected to decide themselves which steps and results were most relevant to finding a solution and to be included in the report. This suggests that the planning and organisation of the project were not a focus of the performance evaluation, which led the students to focus primarily on producing the results rather than investing time and effort in planning and structuring the work path. This confirms the observations of Eckert et al. that development engineers prefer dealing with design while neglecting the development process (Eckert and Clarkson, 2003).

4.3 Software tool Asana (What functions are needed for a software tool to become relevant for managing student projects?)

During the data collection, many of the functions offered by Asana were named as helpful by the students. These include the possibility of structuring the project by creating tasks and subtasks, scheduling by setting dates and deadlines and the option of marking tasks completed. The latter has a particularly positive effect as it makes progress recognisable and fosters a sense of achievement. Nevertheless, the software was not used consistently, and most students stated that they would not use it for similar projects. One explanation for this is the functionality of the program. As addressed earlier, most students were unfamiliar with the program and initially found it complex. Other problems arose from the fact that files can be uploaded but not edited in Asana. Thus, the software only serves as a filing system for documents and does not directly contribute to the accomplishment of tasks. Asana has the option of assigning files to a concrete task, which has the advantage of tasks serving as a folder structure with the results linked below the respective tasks. However, students indicated that some files were lost due to this feature. One of the causes of this problem is that Asana lacks a central file repository, and when different people use the software, different opinions arise as to how file management should be implemented. Due to the above-mentioned limitations, the students switched to other programs that were more suited to their needs.

5 CONCLUSION

Product development is a complex process that requires a holistic understanding of a system. To achieve such an understanding, numerous tools and methods are available to accompany development processes and to support engineers in monitoring and controlling these processes. However, there are still various obstacles to their use. Although the adoption and implementation of management tools are sometimes associated with difficulties, the selection and adoption of a suitable management tool to meet the needs of a company represent a challenge (Browning, 2009; Eckert and Clarkson, 2003). The aim of this study was to determine the benefits and acceptance of management tools to develop

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measures to improve their implementation in the product development process. The data needed for this study were collected during a student project at the University of Rostock, in which the students undertook certain phases of the development process and developed a solution to a certain problem. The usefulness and acceptance of management tools were investigated for the web-based tool Asana, which the students were advised to use to plan and structure the project. The research field was chosen because it was assumed that the conclusions drawn from the students' approach and motivation could be applied to development engineers in industry.

Limitations of the study emerged due to the small number of participants. We therefore suggest that the study is replicated with an increased sampling size to acquire further knowledge. The questions of the survey could be adapted in a follow-up survey. Furthermore, the study was limited to the use of a specific software program; thus, some of the problems mentioned refer only to this program, and only limited general statements can be made regarding the selection of tools for project management. There is potential for a comparative study in which the use and acceptance of different management tools are compared. Another limitation can be traced back to contradictory answers that were given within a team, which might have led to the misinterpretation of certain results.

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