# A Teamwork Tool to Support Group Work in Online-based Higher Education: Exploring User Experience and the Use of Support Mechanisms by Students

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Abstract: Teamwork is often used in online and blended courses. However, numerous problems can arise within computer-supported groups. In this paper we present a tool for supporting teamwork in computer-based collaborative learning (CSCL) in higher education. The tool was implemented as a Moodle plugin and combines automatic analyses of student behavior as well as students' self-reports on their teamwork. The tool was evaluated in two field tests by students of an online and a blended learning course. Surveys, group discussions, and log file analysis were used as evaluation methods. The teamwork tool was rated positively in terms of usability and visual aesthetics. Functions that reflect participation of group members and task deadlines turned out to be very useful for students. In general, students consented to the automatic analysis of their learning behavior. Based on the results of our studies, we derive design implications as well as suggestions for improving functionalities to support students' teamwork online.

## 1 INTRODUCTION

Due to the growing number of students studying online, teachers are faced with the challenge of designing didactically meaningful learning settings for online courses. This is especially challenging in very large courses, making it harder for teachers to monitor individual learning processes. Collaborative learning (Dillenbourg, 1999) by students can be particularly conducive to learning and is often part of innovative teaching formats (Krämer et al., 2017). So far, standard learning management systems (LMS) have mostly offered few advanced possibilities to support students' teamwork online, mainly regarding group formation, collaborative editing, or teacher dashboards for monitoring student's activities. However, awareness for the coordination of group activities is required (Dourish and Bellotti, 1992). The framework the 'Big Five' in teamwork describes core variables that influence the effectiveness of teamwork (Salas et al., 2005). Shared mental models, mutual performance monitoring and mutual trust are key factors for effective learning teams (Fransen et al., 2011). Furthermore, team effectiveness also depends on team constellations and roles within a team (Fransen et al., 2011) as well as provided materials and task complexity. Collaboration scripts can have positive effects of the effectiveness of team collaboration as well as negative effects through the risk of over scripting and avoiding natural team work (Dillenbourg, 2002). A substantial review of research literature on designing and supporting effective collaborative learning is provided by Strauß and Rummel (Strauß and Rummel, 2020).

We focus on solutions within teamwork regarding coordination, communication and engagement (reciprocal interaction) to avoid free-riding effects (Janssen et al., 2011) and making activities transparent for group members. For example, unequal participation of group members or lack of feedback from team members can cause problems (Strauß et al., 2018). The aim of our research is to develop intelligent, automated diagnostic methods and interventions that support teamwork in online teaching environments. Visualizations that mirror, for example, learning behavior and activities of students

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and prompts with concrete calls to action to improve learning behavior (Soller et al., 2005), can possibly increase group awareness and enable successful teamwork. We developed a teamwork tool to support group work in online teaching environments, delivering fast feedback to students and give groups the opportunity to regulate themselves and to avoid group conflicts during teamwork. Our tool contains functions that are quickly visible to students within their standard online teaching environment to reduce cognitive effort.

In this paper, we present the teamwork tool and its use and evaluation in two field tests. To collect evaluation data, online surveys, group discussions and log file analysis were used to address the main research questions: 1) Do students benefit from using the teamwork tool? 2) Which functions are most useful to actually make teamwork better? Based on the results of our mixed method design, we derive design implications as well as suggestions for improving functionalities to support students' teamwork online.

## 2 RELATED WORK & PROBLEMS WITHIN GROUP WORK

Learning analytics – i.e. measuring, recording, analyzing and reporting learners' data – has great potential for reflecting learner behavior and guiding learners in LMS (Siemens et al., 2011). The reflection of learner behavior by means of learning analytics tools can raise awareness of teachers and students (Verbert et al., 2014). Iterative workflows, such as the LATUX workflow (Learning Awareness Tools – User eXperience) (Martinez-Maldonado et al., 2015) and guidelines for designing for social awareness of cooperative activities (Janneck, 2009) can support the design, development and validation of learning analytics tools.

Fundamentally, feedback from teachers to students should be timely, relevant and constructive, understandable, positive and contain suggestions for improvement (Silverman et al., 1992, Hardman, 2008, Brown et al., 2013). This should also be taken into account when designing automatic tutoring systems.

Many standard support mechanisms and tools for synchronous (video, chat) and asynchronous (e-mail, forums) communication within CSCL/CSCW platforms are already available (Appelt, 2004). Open learner models (Bull and Kay, 2010) and group models (Upton and Kay, 2009) that support and enable awareness and self-regulation of individual learners and groups by reflecting learning data are used by intelligent tutoring systems which collect and analyze student data. Some standalone learning analytics- and educational tools developed within research contexts, such as LOCO-Analyst (Ali et al., 2012), GLASS (Leony et al., 2012), Course Signals (Arnold and Pistilli, 2012), StepUp! (Santos et al., 2012), SAM (Govaerts et al., 2012) and Student Inspector (Scheu and Zinn, 2007) enable teachers and learners to analyze learners' traces, interactions, activities, time spent on activities, and performance evaluation. Likewise, early warning systems seek to identify and support students at risk of failing a course by analyzing behavioral data; e.g. Course Signals (Arnold and Pistilli, 2012), StepUp! (Santos et al., 2012), SAM (Govaerts et al., 2012), Student Inspector (Scheu and Zinn, 2007) Automated Wellness Engine (AWE) and Personalized Adaptive Study Success (PASS) (Leitner and Ebner, 2017). However, the impact of such systems on learner behavior is not clear. In Verbert's (Verbert et al., 2014) investigation of several learning analytics tools, only one – Course Signals – had a clearly positive effect on students' learning. Moreover, many tools focus on individual learner data and behavior. Regarding teamwork, Narcissus was developed especially for the overview of activities of group members for students (Upton and Kay, 2009).

In the following we refer to small teamwork and their support in online teaching higher education. Groups that exist for a specific purpose, such as learning groups that pursue a common goal, are viewed as *formal groups* (Janneck and Janneck, 2004) or as *pop-up communities* (Garreta-Domingo et al., 2018). Small groups usually consist of 3 to 5/6 people. To support small teamwork, it is essential to focus on typical problems that may occur during online teamwork. As a basis we used a library of typical problems developed by Strauß et al. (Strauß et al., 2018). Furthermore, we evaluated numerous ideas for support mechanisms in online teaching environments as part of usability tests in which we presented paper prototypes to students, and within a workshop with students. Based on this, we focus on main problems in the area of communication, engagement and coordination such as 1) missing or late feedback to posts, 2) unbalanced participation between team members and 3) lack of awareness of task progress (described by Strauß et al., 2018).

As a basis for our development of support mechanisms for team collaboration we use the learning management system Moodle, which is

widely used in academia. Many extensions and plugins are made available by a large developer community. This is also true regarding learning analytics tools, which we analyzed prior to our developments. Regarding *no/late feedback to forum posts,* e.g. plugins like Moodleoverflow[1], forum graph[2] and unanswered discussions[3] allow to structure and represent discussions. Regarding *unbalanced participation,* plugins for analyzing students' activity like Analytics and Recommendations[4], GISMO[5], IntelliBoard™[6], SmartKlass™[7], Completion Progress[8] exist, which provide analysis of student data to teachers. Plugins with predictive models like students at risk of missing assignment due dates[9] support teachers as well. Regarding *missing awareness of task progress,* ToDo List[10], Checklist[11] and note[12] plugins and modules as well as Level up![13] – a gamification tool where students can gain experience points and reach levels in the course based on their activities – are available. However, most plugins provide functions for individual learning or representations of student behavior for teachers. Therefore, we aimed at developing a *teamwork tool* that supports online teamwork and enables group members to reflect on their learning behavior. We focus on design, acceptance and usage of the teamwork tool by students.

# 3 DESIGN OF A TEAMWORK TOOL

To support problems that can arise during online team collaboration, we developed a modular tool that includes six functions intended to support typical problems within teamwork: Managing *deadlines*, monitoring *participation* and *contributions*, keep track on a shared *ToDo List*, allow awareness of group dynamics and group members' *mood*, and manage the group members' *availability*. A modular tool provides the possibility for teachers to adapt the functions to the respective didactic setting or course. In addition, more functionalities can be added easily in the development process.

## 3.1 Appearance

Data can be visualized in many different ways (Zelazny, 2001, Lengler and Eppler, 2007, Abela, 2008, Behrisch et al., 2018). Studies show that classical data and information visualizations, such as bar, column, donut charts are often preferred, because people are familiar with these visualization methods (Grammel et al., 2010). As they were also rated best besides bubble charts by students in terms of their attractiveness, usability and comprehensibility (Brandenburger and Janneck, 2018), these classical visualization techniques were used for the visualizations we address. We mainly use donut and bar (column) charts to reflect learning results and information to students. Regarding the color appearance, studies show that tetradic color schemes are attractive to students, but do not attract more attention than analog color constellations within the first impression (Brandenburger et al., 2019). Therefore, we decided to use a scheme with color contrast for the teamwork tool, which matches the color design of our LMS Moodle. In addition, we chose a sans-serif typography to ensure good legibility on all possible end devices (Vaughan, 2006).

The teamwork tool has three areas: At the top the "My Team" area lists team member names (fictive for presentation), online status and contact opportunities like chat and email. Below in the "My Teamwork" area navigation (function) buttons can be found. For the tile navigation we designed icons ourselves and also used some from the font awesome pool[14]. Icons are supplemented with a label to enable users to communicate quickly and easily with the teamwork tool. In the bottom area the content of the selected function is shown (Figure 1). Detailed descriptions for all functions are available so that students can see what exactly is being visualized.

In terms of positioning, studies show that visualizations are generally perceived better in the header of the LMS than in the sidebar during the first

[1] https://github.com/learnweb/moodle-mod_moodleoverflow
[2] https://github.com/ctchanandy/moodle-report_forumgraph/tree/Moodle-3.1
[3] https://github.com/deraadt/moodle-block_unanswered_discussions
[4] https://moodle.org/plugins/block_analytics_recommendations
[5] https://bitbucket.org/steveorulez/block_gismo/src/master/
[6] https://intelliboard.net
[7] https://github.com/klassdata/moodle-local_smart_klass
[8] https://moodle.org/plugins/block_completion_progress
[9] https://github.com/dmonllao/moodle-local_latesubmissions
[10] https://github.com/mudrd8mz/moodle-block_todo
[11] https://moodle.org/plugins/mod_checklist
[12] https://github.com/gautamdas130780/moodle_block_mynotes
[13] https://github.com/FMCorz/moodle-block_xp
[14] https://fontawesome.com

impression (Brandenburger et al., 2019). However, different Moodle installations and course templates might require different layouts, therefore the teamwork block plugin can be placed in the sidebar as well as in the header.

For the investigation of the teamwork tool in the field tests (section 4), we decided to place the tool in the sidebar (Figure 1, tool translated to English for presentation). Positioning in the sidebar enables students to familiarize themselves with the tool without changing the main content area. The header of the main content area in this Moodle set-up usually contains course-relevant information that should be accessible as usual and easy to find for students.

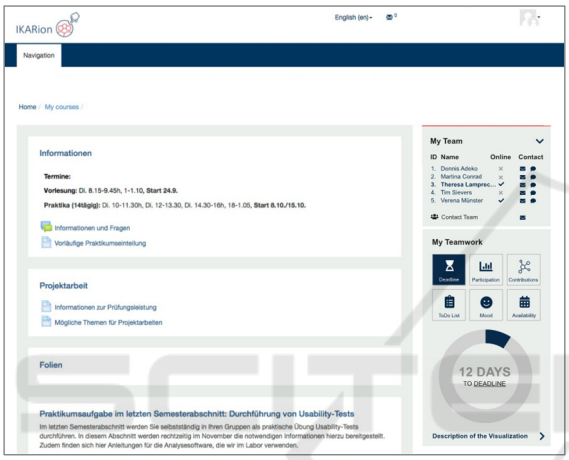


Figure 1: Teamwork tool in the Moodle sidebar.

## 3.2 Functions

In the following we describe the six functions of the teamwork tool more in detail.

The ***Deadline*** function illustrates course-related deadlines (e.g. submission due dates) by means of a donut chart illustrating days to pass until the next upcoming deadline (Figure 2a, a). A donut chart was chosen because donut charts were rated well in other studies in terms of aesthetics and usability to show task progress (Brandenburger et al., 2019).

***Participation*** illustrates the participation of team members in comparison to each other based on their contributions in the group forum and their contributions when editing a common document in the wiki determined by word count to measure productivity. The relative participation of the individual team members is reflected by means of a bar chart (Figure 2a, b) for showing frequency distributions and making the comparison visible to team members (Zelazny, 2001, Lee et al., 2017). This function exists in two variants; variant 1) mirroring of the participation tracked by the system and variant 2) mirroring of the self-assessed participation (students got to see this variant in the blended learning course – variant 1 was less meaningful in a blended learning scenario. The function participation (self-assessment) contains a button “self-assessment”. If students click this button, a pop-up opens with three questions, whether they have a) followed contributions, b) wrote contributions or c) worked offline. Stacked bar charts indicate their ratings (points (from 0-4) of the 3 answered questions on the 5-point Likert scale). If there is no self-assessment by students 10 days after the start of the course or 10 days after the last self-assessment, the pop-up for assessing the own participation appears automatically.

In addition, the ***Contributions*** function visualizes the contributions of team members in the forum and wiki by means of a network diagram/graph. The function supports individuals as well as the entire group. By clicking on the graph a pop-up opens. Each circle represents a forum / wiki post, with its size proportional to the size of the post. There are two zoom levels. On the first level the entire network is visible, on the second level the number of words per contribution is shown. When users hover over a post (node) in the second zoom level, a tooltip is expanded including a direct link to the original post. Contributions which are missing a response are marked, so that other students may respond directly (Figure 2a, c).

The ***ToDo List*** allows students to post and assign tasks. Each team member may add personal tasks that are only visible to themselves as well as tasks that are relevant and visible to the entire group. A task can be marked as “done” and afterwards appears at the bottom in the dropdown “completed ToDos" list. Tasks can also be completely removed from the list. Group tasks can be created by any group member and are visible for all group members. A group task can only be deleted by the person who created it and must be checked as “done” by all members to be displayed in the "completed ToDos" (Figure 2a, d).

The ***Mood*** function illustrates how satisfied team members are with their teamwork. Each team member can indicate the current level of satisfaction with the teamwork by means of a three-level Kunin scale (‘smileys’). The aggregated ratings (from sad = 0% (grey smiley), neutral = 50% (middle blue smiley), happy = 100% (dark blue smiley)) are displayed in a donut chart to all team members, complemented by an emoticon corresponding to the

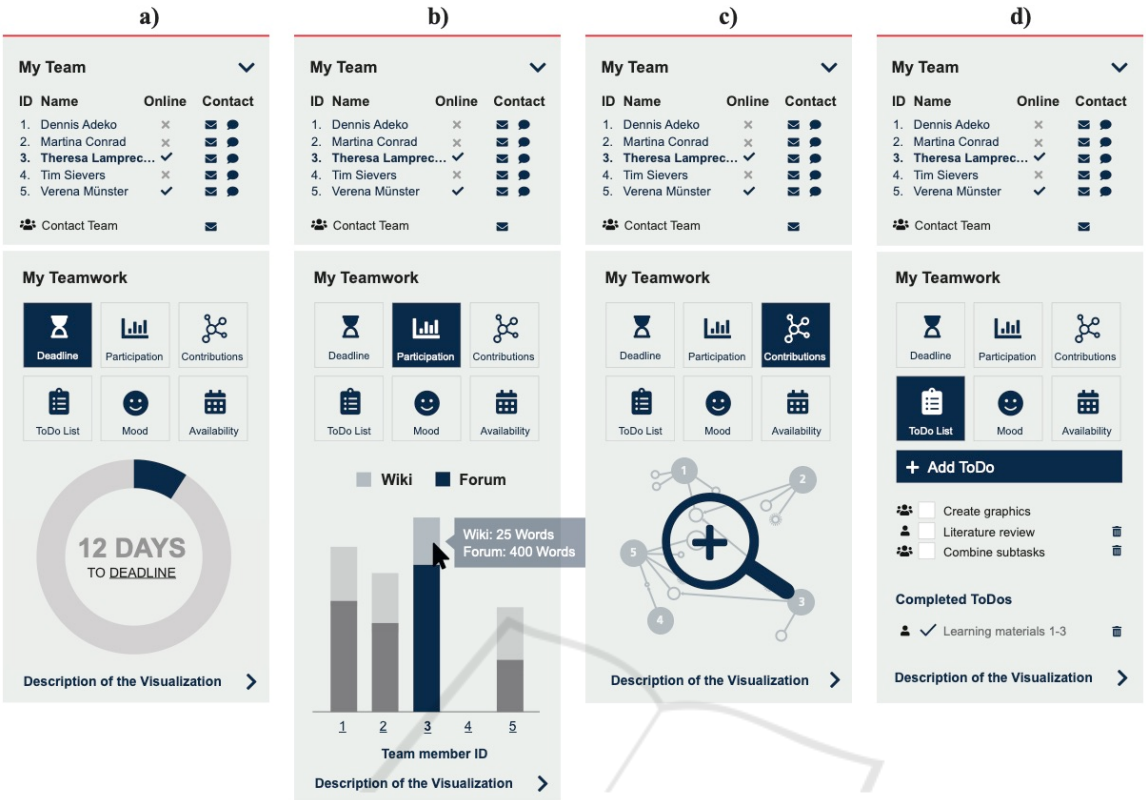


Figure 2a: Functions of the teamwork tool; Deadline a), Participation b), Contributions c), ToDo List d).


Figure 2b: Functions of the teamwork tool; Mood e), Availability f).

average ratings (0-33% = sad smiley, 34-66% = neutral smiley, 67-100% = laughing smiley, Figure 2b, e).

***Availability*** shows the current availability of team members to make scheduling appointments easier.

Each team member may indicate preferred days and time periods. Matching results are shown. (Figure 2b, f).

***Participation, Contributions*** and also ***Mood*** address the problem of unbalanced participation within groups. ***ToDo List, Deadline*** and ***Contributions*** address the problem of missing awareness of task progress. ***Availablity*** and ***Contributions*** address the problem of missing/late feedback to forum posts.

## 3.3 Implementation

As stated above, the teamwork tool was implemented as Moodle plugin. The plugin uses the d3.js library for data visualizations (Bostock et al., 2011). The backend system, which diagnoses upcoming problems within the group based on interaction patterns of the students, consists of a distributed feedback system, a learning analytics backend and a

rule-based intervention system. It is described in-depth in Constapel et al., 2019.

# 4 EVALUATION

The teamwork tool was evaluated in winter semester 2019/20 in an online Psychology course (named 'OC' further on) and a blended learning Computer Science course (named 'BLC' further on) at three different German universities. A total of 58 students participated in the online course (OC, first field test). In this course, students completed assignments in small groups which changed every two weeks. The students were able to see and use five functions of the teamwork tool: ***Deadline, Participation*** (detected and tracked by the system), ***ToDo List, Mood*** and ***Availability*** and used the wiki for collaborative writing. The ***Contributions*** function had not been fully developed at the beginning of the semester. For the sake of completeness, however, we wanted to introduce the concept of that function as part of the teamwork tool in this paper. We also consider this function in our online studies (section 4.1).

In the blended learning course (BLC, second field test) a total of 33 students took part. In this course students worked in small groups (3-4 students) on a large project throughout the semester. Teamwork was done online as well as offline. The students were able to see and use four functions of the teamwork tool: ***ToDo List, Participation*** (self-assessment), ***Availability*** and ***Mood***. Like in the OC, the ***Contributions*** function was not ready yet at the beginning of the semester and the ***Deadline*** function was not used because there was only one fixed deadline for handing in the semester project.

For evaluation, online surveys (section 4.1), group discussions with the BLC students (section 4.2) and log file analyses (section 4.3) were used to examine how the functions of the teamwork tool were used and perceived by students. Only data from students who had agreed to participate in the accompanying research was included in the evaluation.

## 4.1 Online Studies

### 4.1.1 Method

An online survey was set up to evaluate the functions of the teamwork tool. In the online course (OC) 34 students (female = 27, male = 6, average age 24 years) participated. In the blended learning course (BLC) a total of 17 (female = 7, male = 8, average age of 23 years) students took part in the survey. The survey contained questions related to the usefulness of the various functions of the teamwork tool. (This was only included in the OC questionnaire, as additional group discussions took place with the BLC students to address these aspects). To evaluate the overall experience with the tool, the meCUE 2.0 questionnaire for interactive products (Minge and Riedel, 2013, Minge and Thüring, 2018, Minge, 2018) was used. Furthermore, we included a semantic differential to make detailed assessments of attractiveness and group perception. Students were also asked whether they preferred automatic assessments of their activities by the system or rather assess their level of participation themselves and whether they were critical of the way their data was recorded in the LMS for analysis.

### 4.1.2 Results

Overall, the students indicated that they were somewhat interested in reflecting on learning outcomes and their learning behavior (OC: M = 3.76, BLC: M = 3.5, see Table 1).

Table 1: Results of the items of the online surveys.

| Item | | Online Course | | |
|---|---|---|---|---|
| | | N | M | SD |
| Question[1] | | 34 | 3.76 | 1.046 |
| Question[2] | Participation | 31 | 4.32 | 0.871 |
| | Mood | 31 | 2.23 | 1.146 |
| | Availability | 31 | 2.9 | 1.375 |
| | ToDo List | 30 | 2.23 | 1.165 |
| | Deadline | 31 | 4.1 | 0.978 |
| | Contributions | 29 | 2.93 | 1.252 |
| Item | | Blended Learning Course | | |
| | | N | M | SD |
| Question[1] | | 16 | 3.5 | 1.211 |
| Question[2] | Queried in group discussion | | | |

[1]How interested are you in visualizations of your learning outcomes / learning behavior? (1 = no interest at all to 5 = very great interest)

[2]How useful do you find the following functions? (1 = not useful to 5 = very useful)

According to a parameter-free Mann Whitney U-Test, there are no significant differences regarding interest in visualizations of learning outcomes / learning behavior between the OC and BLC students.

All six functions had been presented and described again in the survey (including those that students had not been able to test themselves).

The concrete functions of the teamwork tool were rated medium to very useful, resulting in the following: 1.) ***Participation***, 2.) ***Deadline***, 3.) ***Availability***, 4.) ***Contributions***, 5.) ***ToDo List*** and 6.) ***Mood*** (see Table 1. and Figure 3.).

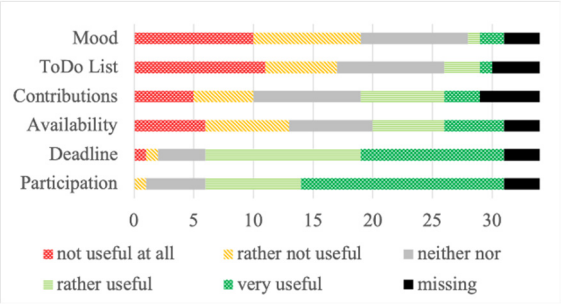


Figure 3: Usefulness of functions of the teamwork tool (OC, N = 34).

Two OC students indicated that they had comprehensibility problems with the function ***Participation***, three with ***Mood***, two with ***Availability*** and four with the ***ToDo List***. Two of them stated that they did not understand exactly how the ***ToDo List*** worked, and three of them said that the participation display did not work properly. The BLC students were asked within the group discussion for comprehensibility problems – nobody indicated any, but they indicated suggestions for improving functions. Results are presented in section 4.2.

Overall, the online students did not object to the analysis of their learning behavior and data collection for this purpose – 24% of OC students viewed this critically. BLC students were asked for that in the group discussions in section 4.2.

The semantic differential shows the results of the assessment of the OC and BLC students in detail. In general, the teamwork tool was rated rather positively (see Figure 4 and Figure 5). BLC students tended to rate the tool more negatively in terms of incentives, attention to group work, group perception. Moreover, they find the tool less informative and motivating than OC students; however, the sample size was very small.

Regarding the measurement and reflection of students' participation, 73.5% of the OC students prefer that the system detects and tracks their participation whereas 70.6% of the BLC students prefer to assess their participation by themselves (see Table 2).

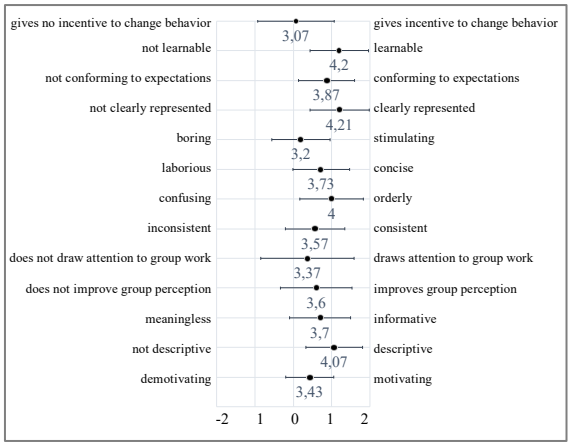


Figure 4: Results (M, SD) of the semantic differential evaluated by online course students N = 29-30.

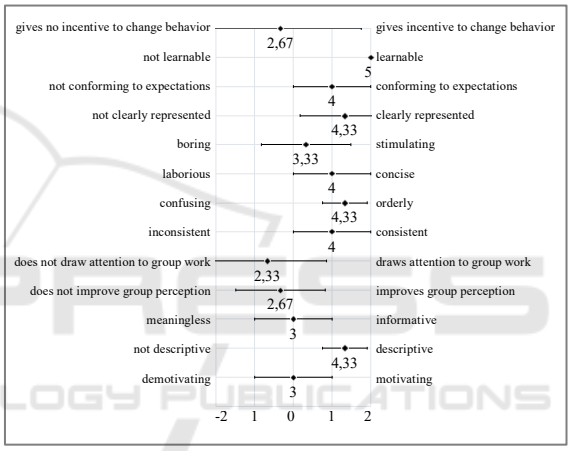


Figure 5: Results (M, SD) of the semantic differential evaluated by blended learning students N = 3.

A chi-square test – $\chi^2$ (1, n = 49) = 11,492, p = .001, φ = .484 (Yates' correction for continuity p = .002) shows a highly significant relationship between form of study and preferences for forms of measurement and reflection of participation during an online course (no cells had an expected frequency below 5).

The OC students used the tool much more often than the BLC students (see Table 2).

Table 3 shows the results of the meCUE ratings for the online and blended learning course. The meCUE items are measured by means of a 7-point Likert scale (from 1 = completely disagree to 7 = completely agree).

The overall impression was determined by a semantic differential from -5 = bad to 5 = good.

Table 2: Form of measurement of participation students prefer and usage of the teamwork tool.

| Item | | Online Course | | Blended Learning Course | |
|---|---|---|---|---|---|
| | | N | % | N | % |
| Which form of measurement and reflection of your participation during an online course do you prefer? | I prefer to assess my participation myself | 8 | 23.5 | 12 | 70.6 |
| | I prefer that the system detects and tracks my participation | 25 | 73.5 | 4 | 23.5 |
| | Missing | 1 | 2.9 | 1 | 5.9 |
| How many times did you use the "teamwork tool"? | Not at all | 2 | 5.9 | 13 | 76.5 |
| | Rare | 19 | 55.9 | 3 | 17.6 |
| | Regularly | 10 | 29.4 | 0 | 0 |
| | Frequently | 2 | 5.9 | 0 | 0 |
| | Missing | 1 | 2.9 | 1 | 5.9 |

Table 3: Results of the standardized meCUE questionnaire.

| meCUE Scale | | Online Course N = 31 | | | | |
|---|---|---|---|---|---|---|
| | | Median | Mean | SD | Min | Max |
| M* I | Usefulness | 4.67 | 4.51 | 1.09 | 1.67 | 7 |
| | Usability | 6 | 6.10 | 0.72 | 4.67 | 7 |
| M* II | Visual Aesthetics | 5 | 5.23 | 0.96 | 3 | 7 |
| M* V | Overall rating | 2.5 | 2.40 | 1.60 | -1.5 | 5 |
| meCUE Scale | | Blended Learning Course N = 3 | | | | |
| | | Median | Mean | SD | Min | Max |
| M* I | Usefulness | 4.67 | 4.67 | 1.33 | 3.33 | 6 |
| | Usability | 6 | 5.78 | 1.02 | 4.67 | 6.67 |
| M* II | Visual Aesthetics | 5 | 5 | 0.33 | 4.67 | 5.33 |
| M* V | Overall rating | 4 | 3.30 | 1.20 | 2 | 4 |

*Module

Overall the teamwork tool was rated as rather useful (OC: M = 4.51, SD = 1.09, BLC: M=4.67, SD = 1.33). The usability was rated very good with (OC: M = 6.10, SD = 0.72, BLC: M = 5.78, SD = 1.02). The same is true for visual aesthetics (OC: M = 5.23, SD = 0.96, BLC: M = 5, SD = 0.33). The overall rating is good (OC: M = 2.4, BLC: M = 3.3). A benchmark comparison is not possible because there are no benchmarks for the meCUE yet (Minge, 2018).

The OC and BLC students also had the opportunity to note ideas or suggestions for improving the tool. Feedback was mostly related to the Participation function, e.g. questioning the objectivity of the self-ratings. Furthermore, some students wanted to see who was last online and when in order to assess how active their group members are. Other comments suggested different visualizations or positioning of the tool.

## 4.2 Group Discussion

### 4.2.1 Method

In addition to the online questionnaire, we conducted group discussions with students from the blended learning course from our University to gain qualitative insights, learn more about their perception of the tool and discuss possible improvements. Due to organizational reasons (travel / distributed participants) this was not possible with participants from the online course.

A total of 16 participants of the blended learning course, divided into three smaller groups (4-7 members) to ensure lively discussions, took part in the group discussions. Each group discussion lasted about one hour.

The students were asked about the usefulness of the functions of the teamwork tool, difficulties in understanding and suggestions for improving the teamwork tool. In addition, students were asked whether specific prompts (with concrete recommendations for actions to improve teamwork) would generally be helpful for students in LMS and whether they view the recording of their learning behavior critically. Only statements that were confirmed by at least one other person were taken into account in the presentation of the results.

### 4.2.2 Results

The overall impression of the teamwork tool was mostly positive. Students indicated that *"you do not have to leave the learning platform and may have to use fewer external services because the tool offers many useful functions"*. However, the positioning in the sidebar was criticized by the students because in their experience *"less relevant information is placed there"*. They suggest positioning the tool in the header with a minimization function. Furthermore, configurability of the tool would be interesting in general, so that the students can decide for themselves which functions (support mechanisms) they want to use. However, students generally stated that other external services are used for communication purposes, such as WhatsApp, Discord etc. They emphasized particularly the speed of communication with WhatsApp and the advantage that they can see who has read a message, while chat and email functions in the LMS come with a certain delay.

Students were also asked if they prefer to be able to assess their participation themselves or if they prefer that the system detects and tracks their participation. Both self-assessment and automatic tracking have disadvantages: *"participation tracked by the system poses a great risk, because it is difficult to define the threshold values correctly to categorize participation as 'good'. People generally find it difficult to self-assess because they do not know whether they classify themselves correctly and the perception of people is different. You don't want to over- or underestimate yourself. You don't want to wrong anyone".* Also, students fear that conflicts may arise: *"Self-assessment can lead to conflicts within the group, and there is also a risk that performance will be misjudged because students are at different levels in the learning process, have prior knowledge and have to make different efforts to solve a task".* A mutual anonymous evaluation is proposed as a suggestion, which is very popular. For example, *"there could be a presentation of the value of your own rating compared with the value of the average rating by other team members"*, but according to the students, this possibility *"carries the risk that it depends too much on sympathy".*

The ***Mood*** function showing satisfaction with the team was generally interesting for the students because this information is not available elsewhere, but they indicated that the display of team satisfaction can also be *"...demotivating and cause bad mood if no real conflict resolution is offered".*

The ***Availability*** function is generally considered to be practical, but not necessary in a blended learning course. Furthermore, linking this function with the calendar would be desirable. Also, more intelligent functions were suggested: *"When entering personal availability, the system could give feedback if other team members have already checked the selected date".* In this case, the system / automatic tutor could remember and assist.

The ***ToDo List*** function was seen as very useful. Nevertheless, many students have been using other tools for years, such as Trello or GitLab (which, however, is probably less common in other fields of study, as all participants were Computer Science students). According to the students, *"it would be desirable to be able to assign tasks to team members if this is documented in a transparent way. Tasks should also be assignable to more than one person. Milestones could possibly also be added".*

Students were also asked if and how they generally want to receive feedback from the system – e.g. as prompts with specific calls for action, information that draws attention to group events, or suggestions for improving learning behavior in general. According to the students, factual feedback is particularly helpful to remind them of deadlines for example. In general, however, textual hints that something is going wrong within the teamwork is not essential, because the team usually notices when things are not going well. *"Text feedback on the issue may lead to an even worse mood. On the other hand, if there is a positive message, you might just lean back. If there is any text feedback from the system, it should provide conflict resolution solutions that offer real help."*

The students were also asked about using virtual agents or tutors, as discussed in other studies (Brandenburger and Janneck, 2018). In general, they state that *"...an automated tutor (e.g. chatbot, mascot) indicates that someone is supporting us. A mascot could be funny and give a nicer, maybe more beautiful appearance, but actually you don't need it."* An automated tutor, if available, *"...should not look like a teacher".* In general, a human appearance is rather rejected.

The recording of student data for learning analytics is mostly viewed uncritically "...compared to data that is otherwise provided". Beyond their personal benefit *"...the university could benefit from this for further development of the learning platform".* However, a clear advantage for students should be present. About half of the students indicated that they would object if data were used exclusively for the evaluation of students by teachers. About one third of the participants generally took a more critical stance. However, *"more students might agree to data collection if there is accurate information about who has access to the data and what data is recorded. A configurable data collection with opt-ins would be a good solution".*

The students indicated that they might use the teamwork tool more often in an online-only course. However, there is a habit of using other external services such as WhatsApp, Trello, GoogleDocs, Dropbox, GitLab, etc.

## 4.3 Log Data

### 4.3.1 Method

For an insight into the actual use of the tool, we took a closer look at the log files of the online course (OC) during a period of 42 days, in which the students were able to test the functions freely. Only data from students who agreed to participate in the accompanying research was taken into account, resulting in N=50.

In the following we analyze the *views* of the teamwork tool. A view is created after visiting a page or changing a function of the teamwork tool. Every time students logged in, the ***Deadline*** function was open per default, while during navigation through the LMS the last chosen function was visible.

### 4.3.2 Results

Over a period of 42 days, there were a total of 4269 views of the ***Deadline*** function and 2136 views of the ***Participation*** function, followed by fewer views of the ***Availability, Mood and ToDo List*** functions (Figure 6).

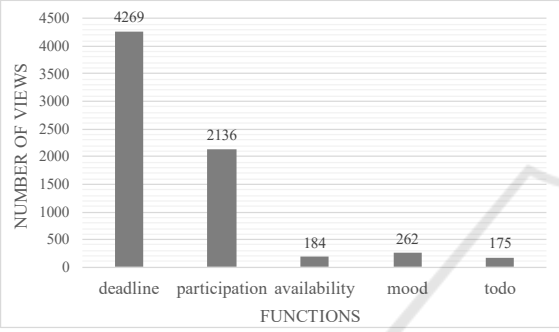


Figure 6: Views of functions of the teamwork tool by students.

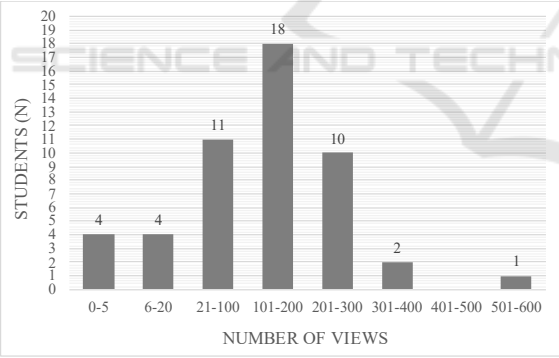


Figure 7: Number of views by students (N).

Looking at views per person, most students (18 students) have viewed the teamwork tool between 101 and 200 times (see Figure 7). Counting only workdays, there were 5.6 views per person per day.

In total, 22% of the students did not view the function ***Availability***, 18% did not view the function ***Mood*** and 34% did not view the function ***ToDo List***. After all 64% viewed all functions of the teamwork tool.

# 5 DISCUSSION

Regarding the appearance of the teamwork tool, the visual aesthetics was rated as good and the teamwork tool seems to be very clear, orderly and descriptive. Nevertheless, the teamwork tool does not seem to attract high attention, incentive and stimulation according to the evaluation (section 4.1). It is unclear whether this is due to the positioning in the sidebar, the color design or the functions themselves. We need to take a closer look at what attracts users' attention and whether students prefer to configure the teamwork tool individually to show and hide certain functionalities (which is more space-saving) or display all functions side by side, as is usually the case in a dashboard. Research has shown that individual factors such as personality, experience and cognitive abilities (Ziemkiewicz et al., 2012, Carenini et al., 2014, Ottley et al., 2015) as well as external factors, e.g. devices and level of adaptability (Toker et al., 2012), influence the use of visualizations. In addition, personality may influence preferences for color appearance of visualizations (Saati et al., 2005). Therefore, we suspect that understanding, use and acceptance of the tools' visualizations is highly individual (Ziemkiewicz et al., 2012) and needs to be investigated in more detail.

A small number of students stated in the survey that they had problems understanding the visualizations. We could not identify the exact origin of these problems, but will closely monitor issues of comprehension in the future, e.g. by usability tests.

By issuing prompts and advice for the students, the teamwork tool acts as a kind of 'automatic tutor'. In its current form the tool does not provide any (humanoid or non-humanoid) representation of this 'tutor'. In the group discussions and also in other studies (Brandenburger and Janneck, 2018), we have seen that students prefer, if any, a non-human appearance / symbolic representation. They also stated that such a representation is not necessary, but might enhance the user experience of the learning environment. In future studies we would like to investigate the impact of humanoid or non-humanoid representations of 'automatic tutors' on motivation and user experiences. Also, gamification approaches could also be interesting.

Some of the functions of the teamwork tool, namely ***Mood*** and ***ToDo List***, were considered to be not as useful, according to the results of the online questionnaire. Likewise, analyzing the log data showed that 34% of the online students did not view the ***ToDo List***. However, this might also reflect that the function was simply not needed, as students in this

course worked on smaller tasks over shorter periods of time, whereas the students in the blended learning course – working on a semester task – stated that the ***ToDo List*** was particularly helpful. Thus, features of support tools need to be adapted to the didactical setting in a particular course. This is possible due to the modular structure of the teamwork tool, but was not done in this case to make the evaluation in the two courses more comparable. Moreover, tests should follow to determine how long ToDo lists will actually be during the semester and whether regular automatic "cleaning" of the lists could be helpful.

The ***Mood*** function was seen more critical by students in both courses. Although students in principle liked the idea of reflecting team mood, they suggested that mechanisms for conflict resolution should be available in case that team mood turns out to be bad. This is an interesting prospect for future development, albeit challenging, as reasons for bad team mood will probably be very diverse.

The OC students particularly preferred the functions ***Participation*** and ***Deadline*** followed by ***Availability***. This reflects that in online courses coordination is particularly challenging, as students possibly don't get to know each other face to face.

In general, the biggest challenge is to analyze student participation correctly. Participation is likely to be very different in different courses, didactical settings and also between groups in the same course, as they organize their teamwork differently. This is also reflected in our data: The online students used the tool much more often than students in the blended learning course; they also generally used the LMS much more often. Naturally, teamwork in blended learning courses often takes place in personal face-to-face contact, while online students often do not know each other personally and do not necessarily live close to each other. As many activities of BLC students do not take place online, this might explain why they took a more critical view of automatic assessments of their participation in the system. In contrast, online students lack opportunities to observe their team members' activities and thus benefit from the system recognizing and tracking their participation. With regard to appearance, a bar chart was selected to reflect the relative participation in order to ensure comparability with other studies in studies running at the same time. In our experience, a donut chart should be a better choice to reflect the distribution of participation and could provide a better understanding. Since the teamwork tool has a modular structure more individualized visualizations and analyses could possibly be implemented for both OC and BLC learning scenarios.

Furthermore, students noted that they are at different levels of expertise and have different speeds in solving a task, for example. This also makes it difficult to track the time spent on learning materials and tasks as an indicator of activity, as it is done in other tools and dashboards (Verbert et al., 2014, Leitner and Ebner, 2017). In our tool we used word counts in wiki and forum posts and also self-assessments of offline / online activities, but defining suitable metrics is still a challenge and will be subject to further work, especially regarding the quality of contributions.

Students indicated that more possibilities to configure the tool individually would be desirable and might improve user experience. Currently, only teachers have the possibility to configure the tool for their respective course. However, individualization of groupware tools is difficult and may impair group awareness (Janneck, 2009): e.g. if certain team members decide to turn off the ***ToDo List***, it is practically useless for the rest of the team. Nevertheless, we will explore possibilities for careful or maybe group-based individualization to give students more autonomy.

Generally, our results show that students are very interested in seeing visualizations of their learning behavior or learning outcomes. Logfile analysis showed that the functions of the teamwork tools were viewed in average 5.6 times per person on working days. However, this data does not reflect how students actually interacted with these functions. Furthermore, the Moodle log file data was sometimes hard to interpret: e.g., the function that was clicked last during a login session, even when changing pages within the same session, was reloaded and evaluated as a view. This constitutes a limitation of our study. Furthermore, since the teamwork tool only constitutes a small part of the LMS, we cannot rule out that experience with the whole learning environment was also included in the assessment. So far, we have only measured the experience with the tool, not the impact on student learning outcomes.

Interaction with the tool has to be learned and forming habits of use certainly plays a role in evaluation and future use of the tool. This should ideally be investigated in longitudinal studies spanning different courses and semesters to observe whether usage patterns change over time and whether e.g. the use of external tools decreases.

# 6 CONCLUSION

This paper described the development and evaluation

of a teamwork tool to support student's teamwork in online teaching environments. The teamwork tool was designed based on psychological findings of typical problems within teamwork, investigations regarding visualization methods, appearance and positioning in LMS and tested in two online and blended learning courses by means of online surveys (N = 34, N = 17), group discussions (N = 16) and log file analysis (N = 50). Overall, the teamwork tool was rated well in terms of usability, visual aesthetics and overall impression. Nevertheless, certain areas for improvement were identified. These might also serve as general guidelines for designing learning analytics tools for groups (see section 6.1). In general, the use of the teamwork tool is suitable for small groups up to 6 members. The use of the ***participation*** function is recommended for courses in which wikis (for editing a common document) and forums are heavily used. Ideally, group forums and a group wiki should be set up for the students to work on common tasks. A solution for tracking participation in programming tasks (e.g. in computer science courses) does not yet exist. Further investigations regarding the effectiveness of the tool use and its possible effect on positive collaboration must follow. The development of real-time performance reflection tools in an online learning environment is becoming more and more important, especially in pandemic times like nowadays when online study programs are being more and more attractive.

### 6.1 Design Recommendations

- Use classic data and information visualizations like bar and donut charts for visualising learning analytic results.
- Enable students to stay on the online learning platform while viewing learning analytic results. They appreciate if they do not have to leave the online teaching environment.
- Place learning analytic results that are important for students prominent in the header of the online teaching environment.
- Students generally welcome visualizations of learning behavior and activity and low-threshold functions for task management (availability functions could be connected to the calendar, so that personal information can be compared with entries in the calendar and the system can warn if there is an overlapping appointment. ToDo lists could be extended to a task planning tool through the possibility of assigning ToDo's to team members and defining milestones).
- Participation could be mirrored as a combined rating of self-assessment, the average rating of team members and system tracking.
- Integrate possible extensions / connections to external tools, which students like to use (especially for the organisation of their team work).
- A non-human appearance / symbolic representation of an automated tutor is preferred by students. A human appearance of an automated tutor is rather rejected.
- Use prompts for reminders of appointments, deadlines etc.
- Integrate customizable approval opt-in process for students' data collection - Students generally accept data analysis of their personal learning behavior, if it is transparent.

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