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Digital Classroom – A Communication Platform for Online Teaching

Full Paper

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Abstract: In an increasingly digitally influenced teaching and with the desire to work together despite spatial separation, it is becoming more and more important that communication can take place quickly and flexibly between all those involved in teaching and learning. Unfortunately, the opportunities of on-site tutorials, in particular quick changes between group communication and global communication as well as organization issues between lecturer and tutors are poorly represented by existing video conferencing solutions. In this paper we use the design science approach to develop the concept of a digital classroom (DC), a design artifact that aims to map the requirements of academic group work and group discussion into the online context while taking advantage of the online setting.

Keywords: Online Teaching, Communication Requirements, Digital Classroom, Ticket System, Design Science

1 Introduction

One of the main problems in distance learning and online teaching is that students miss the interaction and connection with other students and lecturers and therefore feel disconnected [Be15]. Online group discussions and group work are two learning approaches that seem suitable to cope with this problem and can help to reconnect students. They even foster students' communication and collaboration skills, which are highly valued by firms [Al11; Ro13]. The first step in group discussion involves students discussing a problem and possible solutions together. The second step, group work, entails solving the problem based on the approaches discussed. Moreover, these two teaching approaches have a very positive effect on understanding and knowledge acquisition [De19; El18; HA13; ML07; RAC15] due to higher learning motivation and engagement [Bö21; GOA22; Wu13] and self-efficacy [Mu21a]. However, group discussions and group work can only be successful when several

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requirements are met. First of all, timely feedback is crucial for the acceptance and success of online teaching and learning. Otherwise, students easily become frustrated because of response delays when posing questions or exchanging ideas [Ha00; Ke10; LC19; Ro13].

The support provided by lecturers strongly influences the students' learning experience and their perception of the learning effectiveness in a positive way [Bu22]. In addition, the feedback improves students' understanding and deepens their knowledge [Ki14; LHC17].

Although many students think that group discussions should take place in offline settings [Ch21], students favor online group work over the offline setting, as in the online setting it is easier to exchange ideas with other students than the ones of their direct peer group [GH22]. Despite students' readiness for online learning post-pandemic, existing technical tools such as Zoom and Adobe Connect fall short for group work and discussions due to their lack of specific functionalities, such as flexible tutor coordination, quick group switching, and effective document sharing. Therefore, there is a critical need for a concept that adequately supports these teaching methods online, which this paper aims to address.

RQ: How can academic peer group discussions and group work be transferred into the online context?

2 Method

To answer our research question, we used the design science research approach (DSR) introduced by Hevner et al. [He04]. For this, we orientated to the DSR processes of Conboy et al. [CGC15] and Peffers et al. [Pe12] as well as to the recommendations given by Gregor; Hevner [GH13]. Hence, the remainder of this paper is organized as follows: After the problem identification in this section, we review the related literature in the field of communication systems for group work and group discussion in Section 3. In Section 4, we identify the characteristics of the teaching and learning methods group work and group discussion. Based on these characteristics and the literature review, we then derive requirements for digital tools that aim at supporting group work and group discussion in online settings. Subsequently, the concept of an online platform for group work and group discussion is developed with the help of these requirements. To evaluate the concept, a prototype was developed and used in a specific setting for assessment purposes. The evaluation process included two main approaches: qualitative feedback from users, such as lecturers and students, which was integrated into the prototype in real-time and is not extensively reported in this document, and a quantitative survey conducted to gauge the perceptions of students, lecturers, and tutors regarding the prototype. The paper presents the initial findings from the quantitative survey. The document concludes with a discussion on these results, the implications they suggest for the future, and the necessary steps to further refine the prototype and concept.

3 Related Work

For the development of our artifact, we conducted a literature review to identify its key aspects. Our literature review is based on the PRISMA approach of Page et al. [Pa21]. Before we started the literature search, we analysed existing literature reviews in the research field ([AG15; Mu21b; NC19]). With the help of the two literature analyses, we developed our keywords and were able to identify suitable databases (IEEXplore, Sciencedirect, ACM) for the search. We used the following search strings between 1990 and 2023: "virtual teams" AND ("digital communication" OR "distance education" OR "learning communities" OR "group work" OR "group collaboration" OR "digital classroom") to identify relevant publications. Using the keywords, we were able to identify 608 papers. For this reason, we have added a criterion for the literature screening process: We excluded all studies that did not examine computer-supported media communication in group work within a conference system. By adding this criterion, we reduced the literature to 12 studies. In addition, we applied a backward approach and were thus able to identify three further relevant studies.

Step	Search and filtering criteria	IEEEXplore	Sciencedirect	ACM	**Total**
1	Search string	19	173	132	324
2	Filtering by computer-supported media communication in group work within a conference systems	0	9	3	12
3	Apply a backward approach				15

Tab. 1: Search results

The first five publications investigated group work communication with asynchronous text based communication. The first study by Hollingshead et al. [HMO93] explored the asychron computer-mediated communication via forum and group messenger and task type on group task performance with two theoretical models. The findings suggest face-to-face groups performed better on intellective tasks. The study of Potter; Balthazard [PB02] compared virtual teams and conventional teams with regard to their interaction style (e.g., constructive, passive), decision performance (e.g., solution acceptance, satisfaction) and process outcomes. The students were able to communicate with each other via a forum. The results show that the interaction styles of virtual teams are consistent with those of conventional face-to-face groups. The study by Geister et al. [GKH06] investigated the effects of process feedback on motivation, satisfaction and performance in virtual teams. To do this, students were divided into several teams to develop two solutions to the problem. These teams were then randomly assigned to receive online feedback or non-online feedback. The students of this study certified that they had communicated exclusively by electronic communication tools (e.g., e-mail) and had no face-to-face contact. Virtual teams that used the online feedback system showed an increase in performance compared to the control group. Oliveira et al. [OTP11] focused on online group work patterns. The lecturer divided the participants into eight groups (with 4–5 participants each), and the participants had to develop a project that would be presented to the whole class. The results show that the successful groups had a higher level of communication (e.g., participants actively

contributed with feedback and elaborations). The study of Smith et al. [Sm11] analyzed overcoming student resistance to group work in the context of online versus face-to-face group work. The communication in the online group work context was based on an text-based forum. The results revealed that students in the online group were less satisfied than on-site group because of fewer communication channels and the lack of immediacy of face-to-face meetings. The publications show that communication between students also takes place in a similar way in digital media and forms the basis for successful learning. However, electronic means of communication cannot prevail over face-to-face events.

Five further studies therefore addressed communication between group members (e.g. students) using a synchronous approach. The first study by Walther [Wa92] examined the effects of time and communication channels among computer-mediated (computer conferencing system with a microphone to communicate) versus face-to-face groups. The results showed that computer-mediated groups approach the level of face-to-face groups regarding several dimensions (e.g., formality). Jang et al. [JSP02] investigated a web-based collaborative system called TeamSCOPE to support the awareness needs of virtual teams. This was evaluated with a survey. All teams appreciated the shared file space, but no information was reported how students perceived the integrated live chat function. The study by Robinson [Ro13] analyzed the interrelationship of emotion and cognition when students undertake collaborative group work online. The study design requires students to collaborate online, in small groups of 4–8 students by using text-based forums and live chats. The study revealed that students who engage in online group work should adopt verbal immediacy behaviors so their peers can get to know and trust them [Ro13]. The second study utilized the Adobe Connect Meeting Platform system to investigate group work activities. In the digital group room, students could display documents, share their screens, broadcast webcam and voice, and exchange text chat and files. The results indicate that students were more engaged in group work than in pure online classes [Bo07]. The study of Jia et al. [Ji23] applied design-based research to develop and evaluate design principles for a fully online flipped classroom to support students' learning outcomes. In this study, students communicate asynchronously via Moodle and synchronously via Zoom. Moreover, the lecturer checks each group during online discussions to provide guidance or feedback as necessary. Results show that the fully online flipped model was as effective as the conventional flipped model in promoting student learning outcomes [Ji23]. The studies show that collaboration between students can be successful not only offline, but also through synchronous digital communication.

Four of the remaining five studies investigated communication among all participants (lectures and students) within a digital classroom system. Sabin; Higgs [SH07] investigated teaching and learning in a digital classroom with the so-called iLinc communications system. Students can participate in an online lecture without commuting to the university. But the communication among all participants in the investigated system does not enable synchronous discussions. Students and lecturers can only communicate via a text-based forum. Gonçalves et al. [Go14] investigated the impact of direct communication architecture and virtual communication architecture on the user perspective. In the case of the virtual communication architecture, the end-user can see and hear an interlocutor on the other side

via computer-mediated face-to-face communication. Whereas the virtual communication architecture uses an avatar or software agent representation of the interlocutor's image, and the end-user cannot see or hear the real image of the human interlocutor. 60 different students tested both architectures in an experimental setting. The result indicated that the virtual communication architecture does not affect end-user communication. Chang et al. [Ch21] investigated the difference of learning effectiveness between a physical and a digital classroom in an oral pathology and diagnosis course. From the students' perspective, the study revealed a better learning effectiveness, especially in terms of effective usage of time or convenient learning methods in the digital classroom. However, the investigated digital classroom only provides a chat communication function for students [Ch21]. Petchamé et al. [Pe23] designed a smart classroom system and investigated the students' and lecturers' perceptions of the artifact. The system supported hybrid learning, which allowed for flexibility in the location of both lecturers and students. However, it lacked features for fully integrating remote students, such as chat or a virtual hand for questions. Zolfaghari Mashhadi; Reza Kargozari [ZR11] discussed the advantages and disadvantages of digital classrooms but did not provide any information on developing requirements, an artifact, or empirical studies. Nevertheless, they highlighted the potential of digital classrooms to enhance traditional education methods.

The following key aspects for the development of the artifact can be derived from the existing literature.

1. Most studies focus on text-based communication, either via chats or via forums. Only Bower [Bo07], Jia et al. [Ji23], and Petchamé et al. [Pe23] used face-to-face communication. We also consider communication to be a central aspect, as it promotes the exchange of information and understanding [Ba77], which supports the transfer of knowledge and work in groups (e.g. [Ha00; Ki14; OTP11; Ro13; SH07]). Therefore, we consider communication one of the most important pillars for the artifact (see subchapter 4.2).

2. Former studies indicate that, besides communication, feedback is a crucial aspect for the learning success of students (e.g., [Bo07; GO08]). For instance, feedback provides students with specific information on what they are doing well and where they need improvement. Therefore, we consider various features to enable student feedback (see subchapter 4.2).

3. Except for Petchamé et al. [Pe23], most studies relied on existing videoconferencing systems such as Adobe Connect or Zoom, which have known weaknesses for online teaching, such as limited organizational features (slow change between rooms, keeping track of requests to speak, assigning tutors to work groups, etc.). The smart classroom artifact of Petchamé et al. [Pe23] is limited to live video with communication between participants and playback of recorded video. Regarding the artifact, we consider the organizational requirements a crucial part of the artifact's development, providing lecturers with the necessary support to manage their courses effectively (see subchapter 4.2). For instance, features allowing lecturers to track group-building processes or monitor students' learning

processes can significantly streamline course management. The administrative workload can be substantial in large courses, but targeted functionalities can simplify these tasks.

4 Artifact: The Concept of a Digital Classroom

4.1 Group Work and Group Discussion in the Scope of Application

When using group discussion and group work for teaching and learning, two different roles can be distinguished: The students who are the active learners in this scenario and the lecturers who set up this learning scenario for the students to teach them. The lecturers can be divided into two subgroups: The main lecturer(s) who is(are) responsible for the course and tutors who support the lecturers. Consistent with existing research we establish three categories of functionality alongside the views of the two roles: communication (C), feedback (F), and organization (O).

Students' view. Students come together in groups either self-organized (O) or predetermined by the lecturer, to work out a solution to a problem. For this purpose, the students communicate (C) with each other in order to coordinate, exchange information and thoughts, and jointly create documents, presentations, drawings, texts, etc., in this way successively creating the solution [OTP11]. If the students need support from the lecturers, e.g., because questions arise or they are unsure whether they are on the right track, the students call the attention of the lecturers through hand signals or voice. One of the lecturers will then usually come to the group in a timely manner to provide assistance. If several groups ask for support at the same time, the lecturer must decide on the sequence and remember it. Since group work often takes place in the same room and only at different tables, students can also listen to questions from other groups that they find interesting, as well as the lecturer's response. In this way, students receive feedback (F) from the lecturer on their questions as quickly and briefly as possible [GKH06].

Lecturers' view. The role of the lecturer includes organizing group work, supervising students, and managing their requests for assistance. This involves assigning students to groups, if not self-organized, and communicating with groups individually or collectively to address common questions. When working with tutors, lecturers coordinate their use for answering student questions and providing feedback, especially when multiple groups have simultaneous inquiries. Lecturers also oversee the work within each group, ensuring effective supervision and guidance.

4.2 Requirements

With regard to the categories established in subsection 4.1, we derive the following requirements for the artifact with a closer look at the categories:

Communication. The better students can communicate and the more communication

opportunities they can use, the better are their learning outcomes [OTP11]. Hence, a digital tool for group work and group discussion has to support both user groups, students as well as lecturers in their communication tasks. In particular, the following communication requirements (C1-C4) should be met by a digital tool:

C1. All kinds of communication forms. Learning needs bidirectional visual/aural communication [Da69; Ki14; LHC17]. Tutorials also need to consider the different forms of communication (gestures and facial expressions, verbally, (hand) sketches, etc.). There is substantive evidence showing that dialogue-rich teaching promotes student achievement and cognitive development [HA13; ML07; RAC15].

C2. Easy communication between students. First of all, students need to get to know and interact with their peers [SH07]. During collaborative work, conflicts are an important element that must be managed through communication [OTP11; Ro13].

C3. Easy communication between lecturer/tutor and students. Students need direct interaction with the lecturer [SH07] and the lecturer needs to choose exactly which students (plenary, groups, individuals) the interaction is directed at [Bo07].

C4. Quick follow-up with the lecturer/tutor. Students become frustrated if communication is not fast and easy [Ha00; Ke10; SKK91]. Furthermore, in tutorials, a quick question often helps to prevent students from working in the wrong direction. If communication is not fast and easy, students avoid asking their questions when they are almost sure.

Feedback. Also the feedback part concerns both user groups [HT07]. As group work and group discussion is a guided and supervised teaching method, asking for and receiving feedback is an inherent part [Bo07; GO08]. In detail, the following feedback requirements (F1 – F4) shall be met:

F1. Draw attention to a question. Often, students are reluctant to pose questions. Hence, the obstacle to asking a question should be as low as possible [Ch21].

F2. Asking questions without interrupting the lecturer. Students prefer to comment or ask questions to a lecturer without interrupting him/her [Bo07; Ch21; GH22].

F3. Fast Feedback from a Lecturer. The students prefer to raise questions in a physical class. The reason for this is that in the offline context they get immediate feedback [Ch21]. Hence, a digital tool should support feedback to be provided as fast as possible.

F4. See Questions of Other Students and Hear Answers. It happens that students have similar questions about the content of a lecture or exercise. In addition, students also find the questions raised by others are also very interesting as well as a summary by the professor and his answers. Students often listen to such a discussion very carefully or even participate as they like this kind of interactivity [GH22].

Organization. The organizational requirements (O1-O5) concern only the lecturer who is responsible for the organization and setup of the course [Co20].

O1. Student/Lecturer controlled group building/changing. Often the group building process is a crucial part of the teaching method. In general, students appreciate the opportunity to choose their groups [Bo07] or work alone [Sm11]. But working together with other students than already known peers, is also a valuable skill. Besides, lecturer controlled group building allows spontaneous and quick groupwork [Bo07].

O2. Fair coordination of the questions. In offline as well as online settings, keeping track of students questions is often difficult. Usually, questions should be handled in chronological order, which is mostly regarded as the fairest order possible. In particular, each student should receive equal support and no question should be overlooked [Co20].
O3. Coordination among several lecturers/tutors. To avoid duplicates and unnecessary allocations, lectures and tutors should know which questions are being answered by other lecturers/tutors [Al20; Ji23].
O4. Knowing who raised a question. To understand the learning progress of a student, a lecturer must know which student raised a question. Also, questions may be used in the assessment and grading process [Al20].
O5. Monitor students learning progress. Similarly, to O4, lecturers must monitor group performance during activities and in retrospect [Bo07] for assessment and grading.

4.3 Concept for Mapping the Requirements of an On-Site Turorial Online

Based on the evolving roles of teaching and the related functional requirements for a digital tool for conducting group work and group discussions online, we develop a concept for a digital classroom with four components that cover the specified requirements.
Video conferencing system. With the integration of a video conferencing system, the different types of communication (C1) can be mapped in a digital classroom. In this way, a digital classroom supports collaborative work on documents and sharing notes. Furthermore, a suitable video conferencing system offers the possibility to ask questions in a chat without having to interrupt a lecturer during his lecture (F2).
Group Work. A digital classroom should support work in groups. To ensure easy communication between several students as well as between students and lecturers/tutors in the groups (C2, C3), a video conference is created for each group. Such a group conference can be created in a classroom by a lecturer but also by a student (O1). In order to be able to work undisturbed as a group, such a conference should be locked or switched to invisible. If a conference is visible, every user should see which users are in this conference and can join this conference (O1). A lecturer should see all conferences and join them to provide quick feedback. To make this process easier, a lecturer should see for each student which conferences they have in common, so that they can join and give feedback more quickly (F3).
Plenum Conference. In addition to group work, a plenary conference allows the lecturer to address all students at once, providing explanations for tasks, clarifying errors, or answering common questions. While students work in groups, it is crucial to maintain clear communication during the plenary. Thus, a digital classroom should include a clearly marked plenum conference as a separate video conference to ensure that students stay connected to both their group and plenary discussions, receiving all pertinent information seamlessly.
Ticket System. With the help of a ticket system, several important requirements from all areas can be managed at once. To support all kinds of communication forms (C1) a student should be able to raise a hand to call attention to a question. This is also possible in

several web conferencing systems. A problem arises when groups are in breakout rooms. They can still raise their hands in the main conference, but a lecturer does not know in which breakout room s/he has to go. Some conferencing systems offer a solution for this by allowing you to call for help from a breakout room, but this also leads to problems, because after clicking away such a call for help the lecturer has no possibility to find the group again. You also quickly lose track when there are many calls for help (O4). To solve this kind of problem, a digital classroom should offer a ticket system to better coordinate support for students (O2). This ticket system allows students to create a ticket and link it directly to a conference (C4). Once a ticket is created, lecturers and tutors receive an auditory signal and a push notification to alert them that the ticket has been created (F1). This ensures that s/he notices the creation of a ticket even while s/he worked on another ticket (O4). Notifiying all teaching persons, lecturer and tutors, is a big advantage over classic web conferencing systems, where only the host receives notifications of help calls. Additionally, by linking group conferences directly to tickets, an lecturer can more easily track student learning (O5). Another advantage of the ticket system is that the questions become visible to others, which is not the case when raising the hand or calling for help (F4). This allows students to join an existing conference of an open ticket to get the answer from the lecturer or tutor. If, nevertheless, several tickets have been created for one particular question, a student, lecturer or tutor can easily see this from the ticket list. In this case, a lecturer or tutor could decide to answer this question in the plenum conference for everyone. To give students feedback that their ticket is being processed, a lecturer or tutor should assign a ticket to themselves or others (O3). This also allows a tutor to ask the lecturer for help if s/he cannot help the student.

A ticket system offers several advantages over an on-site tutorial. For example, the ticket system results in a fairer learning environment. It guarantees equal attention for all students, as tickets can be handled in the order in which they are created (O2). Also, lecturers or tutors cannot be intercepted by other students to answer their question first, rather than the question of the student who asked first. Another advantage is that the ticket system solves coordination problems. As tickets are assigned to a specific person, lecturer or tutor, (O3) situations where two tutors want to help in the same group because they did not know of each other, are avoided.

5 Design Evaluation of the Digital Classroom

5.1 Implementation

To evaluate the digital classroom concept, we created a browser-based prototype that includes all the intended features and provides easy access for students. We selected Big Blue Button due to its open-source nature and ability to effectively meet our web conferencing requirements. The interface is designed to provide a simple user experience for lecturers, tutors, and students, consolidating the digital classroom into a single page with

individual video conferences in separate tabs. It displays the participants (Figure 1, area 1) with the possibility to create or join a conference with a specific participant(Figure 1, area 4 and 5), the tickets for organizing the questions (Figure 1, area 3), and the existing conferences (Figure 1, area 2) for communicating with the participants and in groups.

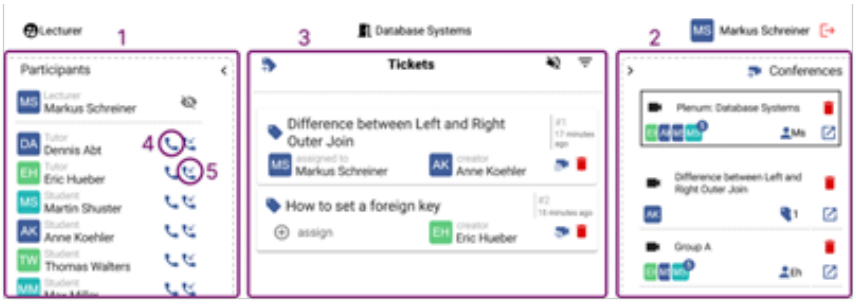

Fig. 1: Overview of the Digital Classroom interface
(Names changed by authors)

5.2 Scenario

Following the design science research approach [GH13], we evaluate the validity and utility of our proposed artifact in two ways. We evaluated the artifact using a real scenario and user feedback, complemented by a questionnaire derived from user comments and aligned with a theoretical construct. The scenario involved five database tutorials, each with a lecturer, four tutors, and about 30 students tackling SQL tasks. If needed, students could seek further clarification in online tutorials through the Digital Classroom accessed via Moodle. At the tutorial's start, a plenum conference is created for initial instructions and to address common questions, enabling simultaneous group and plenum participation. This setup facilitated efficient query resolution and allowed for direct support from lecturers and tutors during group activities, demonstrating the artifact's practical application and educational benefits. To find out whether users would use the artifact, we used the variable intention to use as a theoretical construct in the survey. The intention to use can be defined as follow: Behavioural intention to us is a measure of the strength of one's intention to perform a specified behaviour (e.g., [FA75, p. 288]). In studies with different contexts of technology acceptance (e.g. mobile banking, self-service, (online) learning systems), behavioural intention consistently precedes and predicts actual system use (e.g., [Al21; Zo23]. Furthermore, Turner et al. [Tu10] found strong evidence in a meta-analysis that behavioural intention reliably predicts system usage both subjectively and objectively.

5.3 User Evaluation

During the winter term of 2021/2022, 50 students from different semesters participated in an evaluation of a database tutorial. Of these, 78.9% attended online and 21.1% attended

in person. The results showed that 91.3% of online participants were satisfied with the Digital Classroom. The platform's ease of use and effective support were highlighted. The ticket system of the artifact was praised for its simplicity in raising questions and the prompt response when a tutor joined the group room after a ticket was issued, enhancing learning efficiency and productivity. It is important to note that this feedback is subjective and may not reflect the experience of all users. However, some students found the ticket system less practical and more time-consuming than traditional methods, and a few noted technical issues like video transmission and functionality. However, students expressed their appreciation for the Digital Classroom's organizational capabilities. They indicated a preference to continue using it due to its convenience, separate group rooms, and ticket system. Additionally, they enjoyed the comfort of participating from home.he Digital Classroom (create their group room). In general, students plan to use the Digital Classroom in the future because of the separate group rooms or the ticket system. Moreover, they considered joining the class comfortable even when staying home.

Tab. 2: Overview of the evaluation of the Digital Classroom functionalities

Functionalities	**Students/Lecturers**
Collaborate work on shared PDF documents.	3.4 / 4.4
Share notes with fellow students and lecturers/tutors.	4.4 / 4.5
Possibility to chat with fellow students and lecturers/tutors.	4.4 / 4.4
Create a group room.	4.2 / 4.9
Lock the group room.	3.0 / 3.9
Switch group room invisible.	2.6 / 3.8
Create a ticket for my questions.	4.4 / 4.9
I can place my ticket so that I don't disturb the lecturer/tutor.	4.8 / 4.5
Coordination of student questions through the ticket system.	4.4 / 5.0
Ticket system invites lecturers/tutors to the group room.	4.0 / 4.9
I can see the processing status of my question.	4.0 / 4.8
Obtain questions from other groups.	3.8 / 4.1
Notice the lecturer's/tutor's answers to the questions of other groups.	3.8 / 4.3
Your camera image is only seen by the lecturer/tutor.	2.7 / 3.8
Set myself invisible so that the lecturer/tutor only sees me.	2.4 / 3.3
Use plenary for general information and group work Conferences.	4.0 / 4.6
Assignment of lecturers/tutors to tickets.	n.a. / 4.9
Ticket assignment overview.	n.a. / 4.9

5.4 Evaluation of the Functionalities

We applied a build-and-evaluate loop iteration with the user evaluation and the evaluation of the functionalities to develop the artifact further [MMG02]. By doing so, we invited experienced users to evaluate the current functionalities of the digital classroom in a survey. The first part of the survey collected data on the functionality and participants' usage intention. The second part focused on demographic variables (gender, age) and additional

information (e.g., traveling time to the university or students' learning preferences). The demographics of the 16 respondents show that 13 are male, 2 are female and 1 are divers. All questions were measured on a five-point Likert scale. For the measurement of the intention to use, we followed the design of Venkatesh et al. [Ve03]. The results of the descriptive analysis can be found in Table 2.

For lecturers and tutors, the key is to efficiently coordinate student queries to streamline question organization during lectures. They find features such as group creation, tracking question progress, tutor assignment, and an overview of ticket assignments vital for managing classes. Conversely, students prioritize the ability to submit questions (tickets) without disrupting tutors. They also value document sharing, chatting with peers, and the ticket system of the artifact for posing questions. The ticket coordination function is appreciated by students. Upon evaluating the intention to use the artifact, we noted a generally positive inclination among students (average: 3.6) and a more pronounced positive response from lecturers and tutors (average: 4.0).

There are discrepancies between the perspectives of students and lecturers with regard to the assessment of the functional capabilities of the digital classroom. The mean rating for the "Collaborate work on shared PDF documents"function was 4.4 for lecturers and 3.4 for students. This discrepancy could be attributed to the fact that lecturers perceive the overview and collaboration aspects to be more straightforward, whereas students may experience challenges due to the limitation of only one individual sharing and editing the screen with the document, which constrains collaboration. The other features for which the ratings differ also exhibited the lowest ratings. For instance, the room locking function was rated 3.0 by students and 3.9 by lecturers, while the adjustment of room visibility scored 2.6 from students and 3.8 from lecturers. These low ratings might stem from a preference for an open learning environment that promotes continuous interaction. Similarly, features such as the exclusive use of cameras by lecturers (students: 2.8, lecturers: 3.8) and the ability to prevent one's visibility (students: 2.4, lecturers: 3.8) were also rated poorly. These scores further indicate the importance of maintaining an open and interactive learning atmosphere. Additionally, the low evaluations may be due to a lack of perceived necessity for these features. Students and lecturers might find these functions unnecessary. Consequently, these evaluations suggest that these features do not align with the primary objective. Therefore, it may be beneficial to consider removing these features in future versions of the digital classroom.

6 Conclusion

6.1 Discussion of the Research Question

To answer our research question, we developed the concept of a digital classroom that aims at mapping on-site academic peer discussion and group work into online teaching.

Following the design science approach, several iterations of design, development, and evaluation have been run through leading to gradually improved requirements according to the needs of lecturers and students. Concerning our research question: *"How can academic peer group discussions and group work be transferred into the online context?"*, we focused on communication between all participants, feedback of lecturers, and the ticket system. An important feature in online group discussion is to have rich communication types (C1) and several communication channels in parallel as well as to be able to switch between these channels very easily (C2-C4, O1). Consequently, a lecturer can easily change to the plenum conference and interrupt all group discussions—similar to an on-site message to all students. Afterwards, students can easily continue their discussion. This is as fast as in the offline context; it is not necessary to wait until students changed any video conference channels. Another important feature is the ticket system, which fulfills the organization requirements: students can ask questions (F1, F2), see and know the questions from other students (O4, O5), can ask to join a breakout sessions where a question is answered (F5). Moreover, the tickets allow a fair order of the students' questions (O2). This is highly valued by lecturers/tutors as well as by students. In the same way, tutors can give feedback. A separate breakout session allows quick and easy coordination between tutors and lecturer (F3) so that students get fast feedback (O3).

6.2 Implications

Evaluations show that moving on-site academic discussions and group work to an online format is not only feasible, but also well received by students. The COVID-19 pandemic has equipped both students and faculty with the necessary skills to use these digital platforms effectively, recognizing and taking advantage of their features. This adaptability paves the way for the use of digital tools to create new learning opportunities. It's therefore recommended that proven face-to-face teaching methods be adapted to online environments in order to exploit their pedagogical potential. Such generic concepts as peer discussion and group work can be applied across disciplines, provided that lecturers are willing and able to integrate digital technologies into their teaching.

To facilitate initial adoption, collaborations across disciplines and universities are envisioned. Technically skilled academics could create sophisticated yet user-friendly systems and help faculty from different disciplines to use these platforms. In turn, these faculty could identify new applications and requirements, enabling the development of versatile systems. With the increasing specialization of professions requiring specialized courses, the importance of appropriately sized learning groups, including those in different locations, becomes paramount. Thus, the requirements outlined and the concept of the digital classroom provide valuable guidance and a viable solution framework.

The digital classroom concept developed in this work serves as the foundation for future advancements. By utilizing a free, open-source tool, we are facilitating its accessibility to a vast number of academic institutions. The incorporation of particular organizational functions

enables the application to be tailored to diverse pedagogical settings. The application is published on GitHub [II24], thereby facilitating the extension of its functionality by other individuals or project teams.

The digital classroom provides the fundamental functionality necessary for digital teaching, and it can be adapted to suit a variety of individual requirements through different implementations. The development process must be centered on the users' needs and requirements. This is the only viable approach for optimally addressing the needs of both students and lecturers. In order to enhance the appeal of the system to other educational institutions, it is essential to facilitate greater flexibility in the visual elements. This includes the option of uploading one's own logos and selecting individual colors. By integrating additional functions such as the distribution of lecture notes or exercise sheets, the digital classroom can be further developed into a comprehensive overall solution for digital teaching. It is important that all developments are made in the existing GitHub repository [II24] so that the results can also be made available to other institutions.

6.3 Limitation and Future Research

The main issue is the relatively small sample size of the evaluation. Due to this, we could only analyze the data descriptively and not with a statistical approach to identify significant relationships. However and although the evaluation can only be a starting point, the results already point in a very positive direction. Nevertheless, for future research, more participants' responses will be collected to get more reliable insights also into further usage behavior data (e.g., how participants behave during the usage of the Digital Classroom or the impact on students' final grades). Concerning future research, it will be interesting to investigate the combination of a digital classroom and its tickets with a FAQ wiki. Additionally, we think about a combination of our digital classroom with an intelligent tutoring system (ITS) for two reasons: (1) If a student does not understand the feedback given so some exercise from an ITS, then all information with the exercise and the answer of the student can be linked directly to a ticket. (2) An ITS can help to answer tickets if there was a similar ticket and a lecturer recorded an answer for that ticket.

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