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INTEGRATED CLASSROOM LEARNING: HOW TO CREATE AN ACTIVATING AND SAFE ENVIRONMENT FOR ONLINE LEARNING IN KNOWLEDGE EXCHANGE AND INNOVATION EDUCATION FOR ENGINEERING STUDENTS

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ABSTRACT

The Covid-19 pandemic posed significant challenges for educators in higher education institutions to develop and implement online teaching formats at very short notice. Those challenges were felt especially in small courses such as tutorials or seminars that strongly rely on the close interaction and lively discussions among participants. In small courses students effectively develop future-oriented competencies. In order to foster learning, educators need to create an environment in which students can acquire the necessary knowledge exchange skills, innovation methods, and an entrepreneurial mindset. That requires new approaches to online teaching/learning. Educators need to use interactive learning formats to achieve those learning outcomes, yet they often lack the relevant tools or guidance.

Drawing on the experience of the past three 'creative semesters' (State Secretary for Science and Research in Berlin Krach), my paper develops four steps that educators can take to establish digital classrooms as safer spaces for students and teaching staff alike. The concept of safer spaces (Schutzraum) originated from gender-aware youth work in the 1970s. I adapt this concept to higher education didactics to address challenges for online teaching/learning by creating an activating and encouraging learning environment. Safer spaces can provide a framework in which students and educators interact openly. As the result of mutual respect and trust, the online classroom environment becomes a key factor in fostering deep learning.

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1 INTRODUCTION

1.1 Future-oriented competencies for STEM in higher education

Higher Education in STEM is changing. Graduates are less likely to have a career in a single profession. Higher Education Institutions (HEIs) face the challenge to adapt to this transformation from training for a specific career path to lifelong employability (from 'Berufsfähigkeit' to 'Beschäftigungsfähigkeit' in German) [1]. The past two decades saw the emergence of new skillsets and competencies that students need to acquire in order to be successful in their professional life. Although which competencies such profiles should contain remains object of a lively debate, it is widely recognized that graduates face increasingly complex challenges in their professional life that require adequate competencies [2]. Following the OECD, a 'competency is more than just knowledge and skills. It involves the ability to meet complex demands, by drawing on and mobilizing psychosocial resources (including skills and attitudes) in a particular context' [3].

In this paper, I propose to differentiate between hard skills (i.e. disciplinary knowledge and technical skills), soft skills (i.e. a combination of interpersonal and social skills), and transfer skills as a third category of competencies. The latter are based on a systemic perspective that is widely used in knowledge and technology transfer research, and refer to a systemic understanding and a norm-guided capacity to shape transformation while successfully coping with a situation in which there are unknow variables. Consequently, organizations tasked with the accreditation of programs in engineering, such as the ASIIN[2] in Europe or ABET[3] in North America, foster the integration of extra-disciplinary educational objectives in engineering education curricula. Among the most important competencies identified by studies into future professional profiles for engineering in Germany are: thinking in scenarios; systemic thinking; innovation competences; interdisciplinary understanding; and methodological competencies. Although these can be considered 'wicked competencies' because they resist precise definition, we can nonetheless identify intended learning outcomes (ILO) that are essential to master the competencies in question. To address these ILOs, educators have to implement learning and teaching activities, as well as a design of the curriculum that supports students' development of these future-oriented competencies [4]. I argue that a safer environment fosters the development of transfer skills among students thereby improving their metacognitive abilities and employability. To this end, I present a course design for online learning that catalyzes students' learning experience accordingly.

[2] Accreditation Agency for Study Programmes in Engineering, Informatics, Natural Sciences and Mathematics e.V.

[3] Accreditation Board for Engineering and Technology, Inc.

2 SETTING OF AN ACTIVATING AND SAFE ENVIRONMENT FOR LEARNING

2.1 Stunned by a global pandemic: the severe impact of Covid-19 on teaching and learning

In the wake of the unfolding pandemic in early 2020, teaching/learning needed to adapt to formats of online learning with little time to prepare. Generally, courses adapted pre-existing forms of online learning, such as live formats or pre-recorded on demand videos. Although higher education professionals were encouraged to be creative, due to multiple reasons – a rapidly increased workload being among the most prominent – they rarely succeeded. Initial studies confirm that small and interactively designed online formats, in particular, struggle to create an activating learning environment in which learning thrives. In comparison, more traditional and frontal formats such as lectures performed well, as they were more easily adaptable to online learning [5]. A representative student survey in Germany identified the lack of opportunities for discussion, social interaction, and exchange with other students as central barrier for effective learning, so that learning was often limited to self-guided learning within one's own room [6].

For this reason, it is essential to create a learning environment that prevents students' isolation. In online formats, in particular, students are often tempted to passively consume a course and withdraw from active participation. Active participation is further hindered if students from different programs and levels take part, as students outside their own disciplinary and social comfort zone are more reluctant to participate in order to avoid being exposed to potential criticism from others. Participation is also stifled if students do not receive any feedback on their contributions due to deactivated cameras ('the black wall').

2.2 What is a safer space ("Schutzraum")?

The term refers to a learning environment that forms a safer space for interaction and open exchange of ideas. Inspired by feminist and anti-discriminatory pedagogy and practice, a safer space is a protected environment as a result of a conscious set of decisions and actions that invites to experiment and explore one's own strengths. For this reason, a safer space has the potential to establish equal learning opportunities, and to ensure an open learning climate, to encourage to ask questions, to make mistakes, and even to zone out at times [7,8]. In other words, students are encouraged to put hypotheses and undeveloped ideas up for discussion. This, explicitly, includes displaying knowledge gaps (including the educator's), and a collective effort to address them. Generally, in-person courses meet these criteria to a great extent. Online formats, however, are prone to misuse. It is possible, to name just two examples, to record and document contributions of others, or there can be private conversations that exclude third parties. In-person formats are not immune to this either, but participants are less exposed. Other factors refer to social interaction. In in-person formats, an important part of a debate is body language and non-verbal communication. Without appropriate non-verbal indicators, it is more challenging to interact appropriately, as many participants of online learning courses tend to

deactivate their camera. These and other factors increase uncertainty and a lack of comfort among all participants.

In the next section I will introduce the course format 'integrated classroom learning' and adapt it to implement the concept, I will focus on activating measures because participation is the necessary condition to create those spaces, as safer spaces are a result of a conscious and collective practice.

3 INTEGRATED CLASSROOM LEARNING

3.1 Integrated classroom learning: *Engineering for Impact*

University regulations define integrated classroom learning as a form that combines different course formats such as lectures, seminars, practical training, and projects to enable theoretical communication of materials and practical application within the classroom. *Engineering for Impact*, the course outlined in this paper, is designed to train transfer skills and guide students who develop a concept of an innovative application of a given technology on a case basis in consecutive steps. It consists of a number of four integrated formats: a weekly 90-minute life video conference that has the character of (1.) a lecture, for which a guest expert from the field is invited, and a subsequent discussion of the lecture with the guest expert, (2.) a seminar, (3.) a workshop, or (4.) a group work session. In the lectures, students are encouraged to prepare questions and interact with an expert from the field. In the seminar-like environment, students interact with each other, and discuss and work out new problems and solutions. In the workshop-like environment, students use an online collaboration tool to apply methods or tools to a research problem. In their group work session, students have to self-organize and work on a case. For each class, students prepare by either

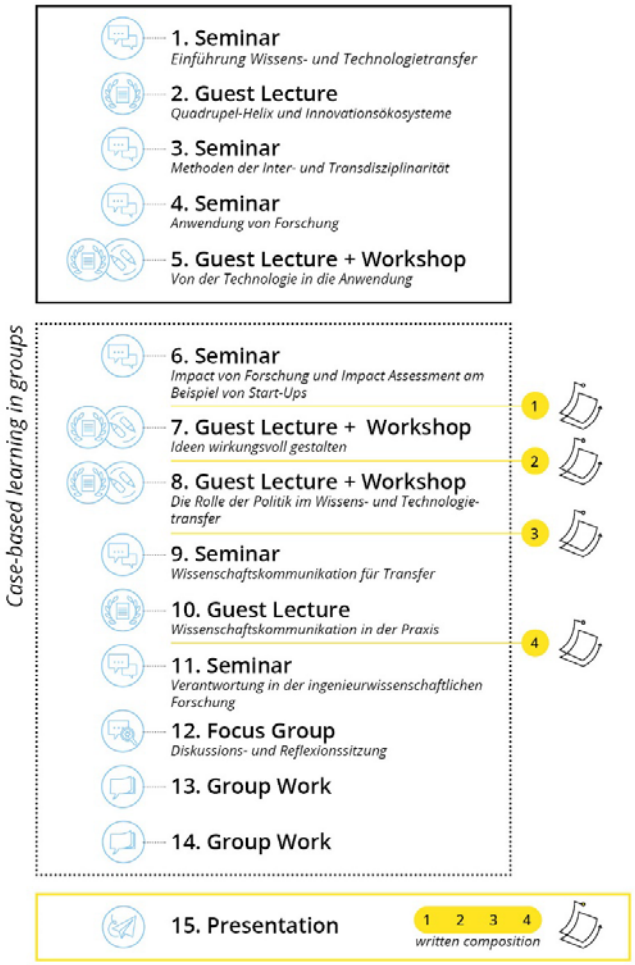

Figure 1: Course design

reading a text about the class topic, performing a small research task, or applying a given method or tool to their project. Beginning with session 6, students work on a case according to the sessions topics and compose four drafts on which they receive detailed feedback and which they revise for the final examination (cf. **Fehler! Verweisquelle konnte nicht gefunden werden.**).

The corresponding examination is a so-called portfolio examination: over the course of the semester, students complete and submit different types of work as exam elements within the course. At the end of the course, the marks from those elements are added up to produce the overall grade. In this course, two of those elements are results of group work (written composition and presentation), and one element is the result of an individual performance (learning journal). During the course, students are tasked to provide multiple written drafts and receive individual feedback and supervision. As a result, examination contributes to student development and the overall learning environment.

3.2 Conceptualizing learning and teaching (how the course is designed)

This section outlines the structure and ILO of the course *Engineering for Impact* that is currently being taught at TU Berlin. In the course, students develop future-oriented skills, i.e. transfer competencies, by using problem-based learning. Students apply theoretical content and different methods or tools (e.g. a stakeholder analysis tool) to bridge the 'gap between theory and practice, between declarative and functioning knowledge' [9]. Students research and analyze a real-world problem, and develop a strategy to solve that problem by applying an existing technology (among the choices are social technologies and self-chosen technologies or projects, cf. Appendix A) in groups of generally four. On completion, students are able to

- identify innovation and transfer opportunities within their discipline, and act on that potential by developing a strategy to increase the impact of research,
- model transfer processes, and shape transfer activities as mediators between different stakeholders, and
- apply declarative and functioning knowledge as well as models and methodology to analyze a complex problem, and develop a concept of technology-based solution.

In order to achieve the ILOs, students need to acquire and develop all three types of competencies: hard skills, soft skills, and transfer skills. As mentioned, transfer skills refer to future-oriented abilities to act successfully and efficiently in a (professional) field that is characterized by complexity and unknow variables. HEI, therefore, need to provide a favorable learning environment that is a prerequisite for learning new and developing existing competencies [3].

I argue that, to this end, a safer learning environment is an appropriate form. Higher education, however, to this day relies mostly on traditional pedagogy based on lectures, tutorials, and end-of-course tests [10]. As a result, assessment of students' learning progress and achievement of ILOs reflect that same traditional concept of pedagogy. Although evaluation is not the focus of this paper, assessment tasks and

course format contribute significantly to a successful development of competencies through activating learning activities and incentives.

In the next section, I will explain how an activating and safe learning environment can be created and sustained in online learning. To meet the challenge posed by the current pandemic, the course utilizes the concept of safer spaces and adapts it for higher education didactics. The following measures have proven effective to prevent barriers and create an activating and supporting learning environment.

4 HOW TO CREATE AN ACTIVATING AND SAFE ENVIRONMENT FOR ONLINE LEARNING

In this section, I describe in chronological order the individual measures required to establish a trust-based online learning environment. Most of the measures are to be introduced at the beginning of the course, and sustained using group work and interactive exercises throughout the semester.

4.1.1 Survey

At the beginning of each semester and before the class comes together the first time, a survey is conducted among all students who register for the course using the university's learning management system ISIS/Moodle (LMS). In the survey, students are asked to share their disciplinary background, existing knowledge about the topic of the course, their motivation to participate, and anticipated learning outcomes. In addition, the questionnaire contains a field for miscellaneous comments. Most students have little to no prior knowledge and take the course out of interest. Among the expectations and motivations, I identified four main clusters for all three courses held: the majority of students wanted to be able to apply aspects of Responsible Research and Innovation (RRI) and sustainability in their respective fields. Moreover, students were motivated to take the course in order to acquire a working knowledge of inter- and transdisciplinary methodology, a practical and theoretical understanding of the course's topic, i.e. transfer processes, as well as skills in science communication. The students'

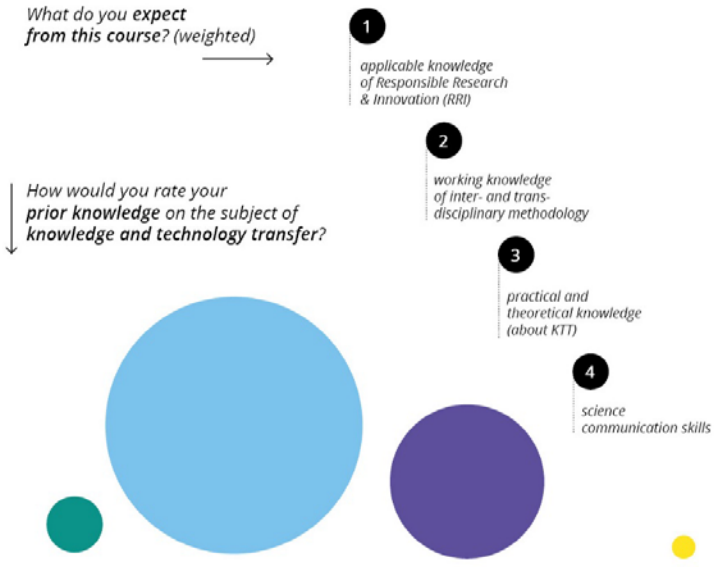

Figure 2: Results of pre-course surveys

intended learning outcomes are, thus, in line with the focus of the course on transfer skills.

The survey offers a first orientation for the educator, and allows an assessment of students' main interests and goals. In addition, based on students' expectations, teaching/learning activities and topics are aligned accordingly as the course proceeds. Most importantly, it informs the formative assessment process with the intention to guide students in their learning, as I will explain in the sections below.

4.1.2 The first session – to see and to be seen

The very first session is crucial. During this first encounter, participants decide how they are going to interact for the rest of the semester. It is therefore very helpful to agree on modalities, among which a formal arrangement is essential: at the beginning of each session, students often participate with their video camera deactivated, yet, antithetically, two-way communication is necessary to create an environment in which learning thrives. To this end, the concept of safer spaces is introduced to the students, and course participants agree to activate their cameras to establish the foundation for an activating and safe learning environment. Individual participants are addressed directly (verbally or using the chat function) if they do not react, and asked to activate their camera for the given reason: 'see and to be seen' promotes trust among all participants. In order to live up to the promoted standards, however, the educator must be sensitive to matters of privacy and the distinct, sometimes disadvantageous learning conditions among the student body [6]. It helps to keep in mind that students are asked to provide intimate insight into their housing and living situations, which can vary according to their socioeconomic standing.

4.1.3 Intended learning outcomes (ILO) and teaching/learning activities

In addition to formal measures, the course design, transparency concerning ILOs and teaching/learning activities are very important to authentically establish a trust-based learning community in the course. Relevant criteria of an effective online learning environment are thus intertwined with elements of the course design. At the beginning of the course, I therefore explain the formal set-up of the course by addressing ILOs, teaching/learning activities, examination, supervision, and feedback so that students understand how the elements of the course relate.

A good example of an effective teaching/learning activity is group work. It proved to be effective and received very good feedback from students. I have used buzz groups where students work on small tasks, and jigsaw groups in which each group works on a sub-task that is then put back together in the plenary to solve a main task. Group work in an online course benefits from online collaboration tools such as Miro (https://miro.com/). Miro provides a virtual board that students can use for simultaneous, collaborative work. In addition, virtual boards can be used to apply in-class activities to online learning, for example empty outlines which requires students to fill the outlines that an educator provided on a class topic:

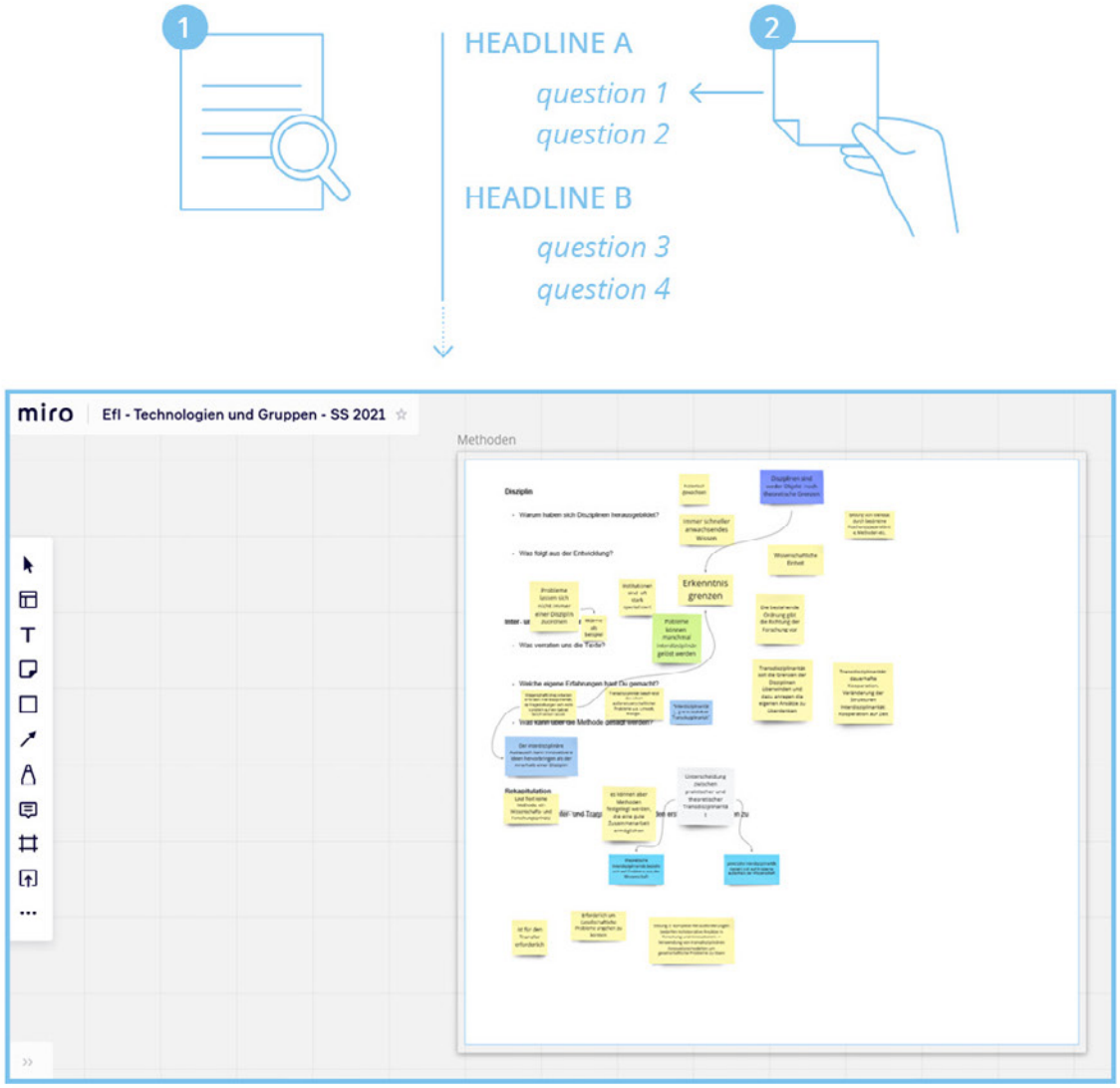

Figure 3 - Activating learning activity 'empty outlines' on the online collaboration tool 'Miro'

Over the course of the semester, students work on a case in an interdisciplinary group. The groups bindingly come together for the rest of the semester in the 6th session, during which students choose a problem of their interest. Each group then develops a case based on a real-world problem to which a given technology is applied. Students in each group are expected to coordinate and manage their work independently when not in class, thus developing social and organizational skills. For assistance, students are introduced to various tools and methods to collaborate online. Among the tools are the university's LMS, as well as multiple board templates for Miro.

4.1.4 Examination, supervision and feedback

Examination forms and assessment practices are chosen to allow for rich learning experiences that contribute to understanding rather than coverage [9]. In their written and oral examinations, students present their individual case in which they apply a technology to a real-world problem. Throughout the course, students consecutively apply methods and tools which require them to research the context and aspects of

an individual case in their groups. Applying these methods and tools, they need to research topic-related information. During this research process, they are closely supervised, receive advice and are – if necessary or asked for – guided in the process. Before they hand in their written examination at the end of the course, students will have written multiple drafts. They receive detailed feedback on each of their drafts, and are offered individual supervision meetings. This, however, is very time-consuming for the educator, and is not advised for large classes with more than thirty students.

In addition, students are tasked to keep a so-called learning journal to reflect their learning activities in respect to what they intended to learn, the course content, or design of each session. For each session, students are provided with optional questions that can help to relate each given topic to their individual experience. Obviously, it can be delicate to assess learning journals, as they contain personal content. Students, therefore, are strongly and repeatably assured that not their position, opinion, or experience is considered as part of the examination, but instead how thorough they reflect on their individual learning process. To ensure a maximum of objectivity, an assessment matrix with criteria is made available on the LMS. Students are encouraged to reflect on and criticize didactics and class design if they feel there is reason to do so. Incidentally, the most constructive insights into motivators and barriers for student learning were achieved through three questions from a Teaching Analysis Poll (TAP) that were integrated into the reflection in the learning journal and at the center of the focus group session at the end of the course which I will cover in the next section [11]:

1. What aspects of this course help you learn? Please be specific.
2. What aspects of this course impede your learning? Please be specific.
3. What suggestions do you have for improving your learning in this course? Please be specific.

In summary, portfolio examination with formative feedback allows students to focus on their interest within the course and encourage deep learning. Iterative feedback-loops and supervisions guide students' case-based learning which, as a result, combines declarative and functioning knowledge. Within this context, students' mastery of competences and achievement of ILOs is reflected and assessed repeatedly by peers and the educator, respectively.

5 EVALUATING ENHANCING AND IMPEDING ASPECTS OF THE COURSE

Utilizing three questions from a TAP and adapting qualitative research methodology for formative assessment and reflection processes, I was able to gather data that supports my hypothesis that the concept of safer space can productively be adapted to higher education [12]. Using focus group settings, students reported back on factors that enhance or impede their learning and made suggestion how to improve learning in the course. By documenting and analyzing these results, I identified the following clusters as illustrated in Table 1*: Cluster of course evaluation results*: learning activities,

activities to help students reflect on their learning progress, aspects based on the course design, formats for feedback, and transparency and structure of the course.

	What aspects of this course help you learn?	What aspects of this course impede your learning?	What suggestions do you have for improving your learning in this course?
Learning activities	• *workshop with tools* • *group work*	• *presence of educator in break out sessions* • *limited time of workshop phase* • *technical problems (IT)* • *isolated groups* • *lectures without activating learning activities*	• *longer workshop phase* • *activating learning activities in all sessions*
Reflection	• *learning journal* • *reflection of last session at the beginning of the next*		
Course specifics	• *(small) size of the course* • *familiarity with other participants* • *discussion (culture)* • *agency (for design and learning outcomes)*	• *discussion in online format* • *„COVID-19 lethargy“* • *timeslot (4-6 pm)*	• *reading guide for the preperation materials*
Supervision	• *supervision and feedback* • *writing drafts*		
Transparency	• *clear structure*	• *intransparent structure and intended outcomes* • *missing clarity on tasks for drafts*	• *clear communication of requirements and expectations* • *best practice examples*

Table 1: Cluster of course evaluation results

Generally, students profited most from activating learning activities such as workshops. Here, they were guided to apply knowledge from preparation material and their own research using tools in small groups in which they participated interactively. Although, limited time in the workshops and individual sessions without such

interaction were hindering factors, this nonetheless helped to create a safer environment within the course that drew from familiarity. Students identified with their project, their group and the course community. Guiding students rather than teaching them contributed significantly to their individual development and has been reported to be highly motivating. Given that most students have a background in STEM they profited from the experience that a statement (in the context of this course) is rarely right or wrong but rather depends on the strength of an argument. As one student reported, the barriers to participate actively in the course have been significantly lower compared to other courses.

Factors that impede learning, on one hand, mostly correspond with the aforementioned aspects. The absence of and suggestion to implement interactive learning activities in each session, for example corresponds with students' evaluation of workshops. On the other hand, and in accordance with recent studies, students reported that restrictions in line with the Covid-19 pandemic affected their learning significantly [5,6]. Online learning poses a unique challenge regarding concentration, motivation and interaction. Moreover, some students reported that organizing and structuring their studies and finding motivation engage in learning activities was challenging and often frustrating. A final cluster that impeded learning concerns transparency of the courses structure, expectations and requirements. Although this is controversial as not all students agree, it nonetheless is very plausible as students in the course are confronted with an approach 83% of them have little to no prior knowledge about and are expected to work a case addressing a real-world problem. Suggestions to address these problems cover best practices as well as a better, i.e. more frequent, communication.

6 LIMITATIONS

Online courses bring about new challenges for teaching and learning. Drawing on the concept of safer spaces and adapting it for higher education didactics contributes significantly to creating and sustaining an activating learning environment in which deep learning processes thrive. There are, however, limitations that have to be considered. Among those, the two most important ones are the sample size of the courses and the subjectivity of formative evaluation.

Most importantly, the sample size of the course described in this paper is too small to allow for statistically significant statements and generalization. Based on only three courses, the data collected and experience is too specific and cannot be generalized. In addition, using qualitative research methodology, especially drawing on formative evaluation of learning journal entries and the development of written assessments, results are partly subjective. In addition, data collected in focus groups is likely to be influenced by the educator-student relationship as the university did not have the resources to provide a neutral third party as intended for a TAP.

7 AVENUES OF FURTHER RESEARCH AND CONCLUDING THOUGHTS

In this paper I have presented an integrated classroom learning course design with didactical elements to create an activating and safe environment for (online) learning in higher education. Evaluation results and student feedback support the hypothesis that measures presented in section 4 are suitable for establishing digital classrooms as safer spaces and meet the challenges that online learning during a global pandemic bring about.

Given that the data reported is based on a small sample size and a specific course format further research is needed to establish whether these results can be reproduced in varying settings. Such research will benefit greatly from a common set of criteria for evaluation that allows for comparison. Furthermore, it needs to be investigated whether or not a correlation between learning/teaching objectives and learning activities and course design respectively can be established. As mentioned above, the course *Engineering for Impact* prepares for activities in the field of mission-driven and innovation-oriented knowledge and technology transfer with a special focus on transfer skills.

In conclusion, I have demonstrated that integrated classroom learning provides a format in which portfolio examination as well as teaching/learning activities can be adjusted to students' needs, and create and sustain an activating and safe learning environment. With this paper, I sincerely hope to inspire educators to reflect on the concept of safer space in higher education and implement learning/teaching activities (in courses with a larger number of participants) accordingly.

8 SUMMARY AND ACKNOWLEDGMENTS

Challenges of online teaching and learning can be addressed by creating an activating and encouraging, i.e. safer learning environment. Integrated classroom learning provides a format in which teaching/learning activities as well as assessment tasks can be used to foster deep learning by drawing on the concept of safer spaces.

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APPENDIX A

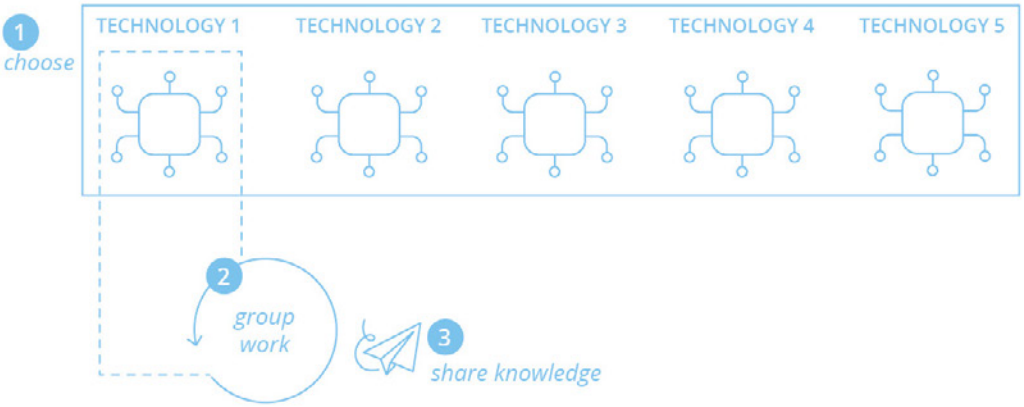
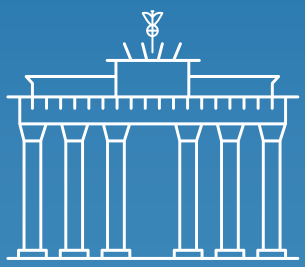


Figure 4: Miro board with technologies for case-work

APPENDIX B

Teaching/Learning methods	• *problem-based learning* • *group work* • *lecture* • *workshop/application of tools*
Course content	• *knowledge and technology transfer as research paradigm* • *innovation ecosystems and models* • *inter- and transdisciplinary methodology* • *ideation processes* • *stakeholder analysis* • *science communication* • *responsible research and innovation*
Learning outcomes	–o *On completion, students are able to **identify innovation and transfer opportunities** within their discipline, and act on that potential by **developing a strategy** to increase the impact of research,* –o *model transfer processes, and shape transfer activities as **mediators between different stakeholders**, and* –o *apply declarative and functioning knowledge as well as models and methodology to analyze a complex problem, and **develop a technology-based solution**.*
Assessment methods	① *Four written assignments (during the course with detailed feedback; formative assessment)* ② *Written composition (based on 1.; criterion referenced assessment [9])* ③ *Presentation (based on 2.; criterion referenced assessment [9])* ④ *Learning journal (written reflection of each session, including an adaption of TAP [11]; criterion referenced assessment [9])*
Evaluation methods	• *pre-course questionnaire* • *integrated TAP [11] (cf. learning journal)* • *focus group* • *post-course questionnaire*

Table 2: Course content and methods



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