



Conception of an experimental laboratory for the digital and flexible design of research-oriented teaching

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Abstract

The experimental laboratory for the digitalization and flexibilization of teaching at TU Dresden is an interactive, flexibly configurable space consisting of various physical and virtual components. Lecturers receive support in the development and implementation of (partially) digital courses with a focus on research-oriented teaching and learning formats. Didactic concepts, such as flipped classroom or blended learning approaches, can be tested in the experimental laboratory, and media for use in research-oriented teaching can be produced easily e.g. by using a lightboard

The article presents the concept of the experimental laboratory as a teaching learning laboratory and relational space, discusses relevant theoretical constructs and derives scenarios for the use of the space and elements of implementation. Finally, the current state of implementation is described.

Das Experimentallabor für Digitalisierung und Flexibilisierung von Lehre an der TU Dresden ist ein interaktiver, flexibel gestaltbarer Raum, bestehend aus verschiedenen physischen und virtuellen Komponenten. Lehrende erhalten dort Unterstützung bei der Entwicklung und Durchführung von (teil-) digitalen Lehrveranstaltungen mit einem Schwerpunkt auf forschungsorientierten Lehr- und Lernformaten. Didaktische Konzepte, wie z. B. Flipped Classroom oder Blended Learning-Ansätze, können im Experimentallabor hands on ausprobiert, Medien für den Einsatz in der forschungsorientierten Lehre – u. a. mit Hilfe eines Lightboards – niedrigschwellig produziert werden.

Der Beitrag stellt das Konzept des Experimentallabors als Lernwerkstatt und relationaler Raum vor, geht dabei auf relevante Theoriekonstrukte ein und leitet daraus Raumnutzungsszenarien und Elemente der Realisierung ab. Schließlich wird der aktuelle Umsetzungsstand beschrieben.

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1. Introduction

'Work 4.0', 'Industry 4.0' or 'Administration 4.0' are terms that allude to current processes of change in society driven by digitalization. The massive change in fundamental areas of society signaled by these terms also has an impact on university learning and teaching and thus also on the associated forms of work and teaching. Analogous to the aforementioned terms, 'University 4.0' or 'Learning 4.0' has therefore been mentioned more frequently in recent discussions on higher education policy and didactics.

In addition to the digitalization of all areas of society and the associated changes in work, communication and collaboration processes, a change "from teaching to learning" [1, 2] has also been postulated for some time in the field of higher education, which - similar to the 'New Work' movement in the context of 'Work 4.0' - entails a development towards project-oriented, interdisciplinary and problem-based learning in group or project work [2]. The catchphrase "from teaching to learning" expresses renunciation from input control towards an orientation in direction of the results or products of learning (output orientation) and the skills and strategies that are used or required to achieve these goals [3].

Digital media and communication contexts can actively support this shift, as they change the view of teaching-learning processes [4]. In addition to a didactically meaningful digitalization of learning and teaching, the physical infrastructure at universities also needs to be redesigned in order to take the changing requirements and adequate spaces for realistic 'Learning 4.0' in the 'University 4.0' into account.

The experimental laboratory considers these aspects and opens up an interactive exploration space for (partially) digital teaching, in which researchers from DRESDEN-concept institutes and lecturers at TU Dresden can receive support in the design of digital and hybrid research-oriented courses and get assistance in the didactically meaningful use of digital media and learning materials.

It is part of the Teaching Synergies Program and contributes to the development and testing of innovative (partially) digital teaching and learning scenarios in the context of the University of Excellence *TUD 2028 - Synergy and beyond* [5]. It provides users with impetus and opens up exchange opportunities for the new and further development of innovative teaching and learning offers in the context of flipped classroom or blended learning concepts in general.

The opportunity to try out different spatial-media-didactic settings makes it possible to experience and make experienceable a wide range of design options and usage scenarios for teaching and learning locations at TU Dresden and their higher education didactic justification in direct interaction.

The experimental laboratory does not only offer a physical space for video production with a lightboard, but also two rooms for testing face-to-face learning spaces in the context of blended learning. Conceptually, it goes beyond a static room set-up. It is to be understood as a space in the broader sense, in which lecturers can develop, test and exchange (partially) digital and hybrid learning arrangements in a guided and/or free experimental manner. The focus is particularly on testing hybrid and digital implementations of research-oriented teaching. Conceptually, it is based on the idea of *teaching learning laboratory in higher education (German: (Hochschul-)Lernwerkstatt)* in connection with a *relational understanding of space* according to Löw [6].

Based on a close relation between research and teaching, the experimental laboratory addresses the following question:

Which digitalization and flexibilization options support in particular the linking of research and teaching?

In this context, offers in the experimental laboratory provide answers to numerous questions relevant to higher education and media didactics:

- How can interactive learning settings being oriented towards blended learning approaches be implemented in physical and digital space?

- Which teaching-supporting digitalization and flexibilization options can be used in particular to address the respective subject-specific form of research in teaching?
- Which digitalization and flexibilization options can be used in particular to support research activities or the understanding of research processes?
- Which digitalization and flexibilization options can be used in particular to implement the basic pillars of research-based learning [7] in teaching?
- How can the room design and use of space in face-to-face and hybrid settings be particularly well combined together linking teaching and research?
- What teaching-supporting presentation and digitalization options does the respective form of research offer?
- Which analog/digital media can be used to support the research activity or the understanding of the research process?
- How do the range of materials, media, furnishings and equipment effect the use of the room?

Subsequently, relevant theoretical concepts from the areas of learning space design, teaching learning laboratories in higher, relational understanding of space, research-oriented learning and teaching and the use of digital media in university teaching are presented before the components of the concept are explained in more detail.

2. Presentation of relevant theoretical concepts

Various relevant theoretical concepts emerge from the considerations. For example, the concept and design of the experimental laboratory includes educational theory principles on learning and research, media didactic considerations and concepts for research-oriented teaching/learning formats. The conceptual and physical design of the space is based on considerations of spatial sociology, learning space development and teaching learning laboratories in higher education (German: Lernwerkstatt).

The aforementioned change of perspective from teaching to learning goes hand in hand with a critical reflection on the relationship between science and society or profession and society [3]. Education at a college or university takes place in the "medium of science" [3, 8] in the sense of this cognitive strand. Following Wilhelm von Humboldt [9], science is understood as a problem that has not yet been fully resolved, which rather requires active learning via a 'deep approach' - and consequently implies learning that is oriented towards problem solving competence and self-organization [3]. Research refers to the same driving force as learning and strives to generate new knowledge [10]. Research-based learning (according to Healy & Jenkins [11]) is a macro method and at the same time an implementation of research-based [12] or research-oriented learning and teaching [13]. Depending on the degree of active involvement of students and the way in which research is addressed (content or process), a distinction is made between research-tutored, research-led and research-oriented learning [11] (in addition to the above-mentioned research-based learning).

Research-based learning as a macro method is a university didactic format in which students conduct their own research in seminars and projects. Learning and research are combined through the provision of learning arrangements. Ideally, research-based learning takes place in a successive research cycle and usually begins with the identification of topics or the formulation of questions or hypotheses, continues with the implementation and evaluation of the results and ends (always maintaining its open-ended character) with the scientific communication or application of the results.

In order to design the research cycle in a subject-specific way and to support it digitally, it is helpful to deal with research and science in general and to take different disciplinary cultures into account. The German Science and Humanities Council [14] identified six distinct forms of research: the experimental form of research, simulation, the observational form of research, the hermeneutic-interpretative form of research, the formative form of research and the conceptual-theoretical form of

research. Subsequently., Reinmann [15] formulates concrete cognitive activities such as qualitative or quantitative data collection, design or experimentation.

Research-based learning is procedurally based on five pillars: project management, feedback structures, reflection, documentation and presentation [7].

Based on various approaches [11, 12, 16] in the field of research-oriented teaching, which relate to the core idea of education through science, the three University of Excellence programs developed a common understanding to strengthen research-oriented teaching at the Dresden University of Technology. The aim of this TUD-specific understanding, which is referred to as "research-oriented learning and teaching (in German: Forschungsorientiertes Lernen und Lehren, FoLL)", is to develop research skills (in accordance with the European Competence Framework for Researchers [17] adopted in 2023) and to promote a research-oriented attitude. This involves combining research as content, research as a path forward and reflection on these activities as knowledge. Thus, students should be enabled to learn to conduct research and to educate themselves through the self-efficient practice of science, as well as to acquire relevant research skills, become familiar with research content and critically reflect on the chosen approach in order to gain knowledge, either as part of courses or in the course of their own research projects.

Based on that, asking about the potential of digital media, it has to be considered, what opportunities digitalization offers for the respective form of research or the cognitive activities assigned to it. The question then arises as to what "potential digital media offer as teaching and learning tools or in the form of learning and educational spaces for research activities in the context of specific events or on one's own responsibility" (original: "Potenziale digitale Medien als Lehr-Lernwerkzeuge oder in Gestalt von Lern- und Bildungsräumen für Forschungstätigkeiten im Rahmen von konkreten Veranstaltungen oder in Eigenverantwortung bieten") [18, p. 72]. This leads to three further questions:

- At what point in time can digital media be usefully employed (→ when)?

- Which digital media or processes are suitable for the specific situation (→ what)?
- How and with which digital media can the respective pillar be addressed (→ how)?

In this context, digital media are understood as tools to support research-oriented teaching [18].

In order to answer the aforementioned content-related questions in the respective context of specific courses, the experimental laboratory is to be set up conceptually as a teaching learning laboratory (German: Lernwerkstatt) and, based on their actual demand, offers lecturers the opportunity to explore the topics associated with teaching implementation and to work on them successfully for their research-oriented teaching.

This approach being focused on implementation follows the trend that teaching learning laboratories have become in recent decades an innovative way of training future teachers in didactic and pedagogical subject areas by providing them with a curated space for action and experience [19]. Historically, teaching learning laboratories in higher education are more likely to be found in the field of teacher's training and the didactic design of learning spaces at elementary school and nursery school but are also increasingly being used at universities and colleges to develop students' capabilities. However, this idea of teaching learning laboratories can now be adapted not only to teacher's training and the development of students' competencies, but also to the qualification of university lecturers. Through the principle of the didactic double decker (= learning on two levels, which includes both subject-specific and social/emotional aspects) being inherent in the learning workshops, the teachers of a university are understood as learners in teacher's training and the pupils as students.

As a basis for the conceptual considerations, it is helpful to use the German term *Lernwerkstatt* and break down the term 'Lern-Werk-Statt' into its basic meaning units and to assign specific meanings to each of the three single word components. For example, learning (lernen, hier: LERN) in a 'LERNwerkstatt' refers to an innovative concept of learning as "self-

learning construction" [19, 20]. The focus is shifted to the explorative learning (and away from instructional teaching) of learning content [21]. The meaning of the term WERK in sense of an artifact, output or piece in the German term 'LernWERKstatt' refers more to a product being created through explorative learning and self-directed learning. However, the work is rarely clearly defined and can also be seen as an abstract construct in the sense of changing/improving an initial situation or in the development of declarative and procedural knowledge. The element 'STAT' in the term 'LernwerkSTAT' refers to the physical (digital, hybrid) space [22] as a lab or studio [23] and thus describes a high-quality equipped physical space [24].

Teaching learning laboratories can be understood as an environment that encourages activity, i.e. provides impetus for active interaction with people and objects. This way, they provide the basis for learning through research and discovery [25, 26].

In order to align the experimental laboratory with the target group of university lecturers as learners, it also seems sensible to focus on their learning in the context of a space (or more specifically: a teaching learning laboratory). The focus here is particularly on the subjectivizing learning path and in the transactional relationship of the teachers (= learners) to the physical space as a three-dimensional condition and to the objects in the space. Beyond the space being equipped in a certain way, university workshops also become other spaces that emerge through the interrelation of learners, things, spatial structures and learning content [6, 27].

Thus, it makes sense to look at the space of the experimental laboratory and the processes taking place in it in terms of a relational understanding of space and thus to understand social construction as an additional space-forming momentum. In this way, the processual emergence of space is conceptually taken into account [28]. Accordingly, spaces do not simply exist as a material condition, but are also produced and constructed through social action [28]. Vice versa, spaces in turn influence the actions of the people who use them.

Consequently, space becomes a "hybrid of material conditions and social use" [29], i.e. a mix-

ture of objects of the elements *social goods* and *living beings*, which are perceived by the acting persons and combined to form a space [29]. Social goods are the non-human elements in a space, which in turn can be divided into primarily material goods (e.g. furniture) and primarily symbolic goods (e.g. signs). Living beings, i.e. people and animals, are therefore also elements of space. The process of *spacing* (i.e. the targeted preparation of a space) involves placing and situating the elements, whereby the *synthesis achievement* is shown in the merging of these into a coherent perceptual space [30]. From a spatial sociological perspective, the "process of spacing [...] comprises the placement of social, primarily material goods and people (or other living beings)" (original: „Vorgang des Spacings [...] das Platzieren von sozialen, primär materiellen Gütern und Menschen (bzw. anderen Lebewesen)“) [6, p. 158]. It includes processes such as the erection, construction and positioning of elements [6]. The synthesis achievement consists in "combining social goods, people, groups of people, plants and/or animals into spaces via processes of perception, imagination and memory" (original: „Zusammenfassen von sozialen Gütern, Menschen, Menschengruppen, Pflanzen und/oder Tieren zu Räumen über Wahrnehmungs-, Vorstellungs- und Erinnerungsprozesse“) [6, p. 159].

Against the background of being able to describe processes in spaces with the help of the relational understanding of space and thus also to focus on the learners, the experimental laboratory should be set up according to the elements it contains (spacing) and the creation of relationships between these elements (synthesis).

In order to create a teaching/learning offer that enables learners to make their own learning experiences on the one hand and to transfer these to the students as learners on the other, it is necessary to take a comparative look at different learning space realizations and principles of learning space design. From this systematic comparison, conclusions can be drawn for the establishment of a space that is appropriate to the qualification objectives. It is important that the space unobtrusively invites users to experience higher education di-

dactic inspiration and to accept opportunities for exchange that promote the new or further development of innovative teaching and learning opportunities in the context of the flipped classroom or in the context of blended learning concepts in general.

In addition to the derivations from the aforementioned concepts, considerations and conclusions of the Stifterverband on the topic of learning space design are also included in the implementation. Based on expertise in higher education, media and spatial didactics, the association formulated ten guidelines for future-oriented learning space design in 2022. Among others, the following characteristics are formulated for the design of learning spaces: Learning spaces should be adjusted towards active learning settings, allow autonomy for learners and offer universities a variety of different types of learning spaces. Furthermore, spaces for hybrid teaching/learning settings are required [31].

However, In addition to the implementation of digital spaces with the help of digital media, , physical space is also to be taken into account in modern university teaching, as the physical space represents space of perception of digitally inscribed central context of experience in learning, which should also be taken into account when learning with or via digital media [2]. Conceptually, for the experimental laboratory this means "developing hybrid teaching and learning space constellations" (original: „hybride Lehr- und Lernraumkonstellationen zu entwickeln“) [32, p. 301] and making the experience gained there usable for the context of research-oriented learning and teaching.

The experimental laboratory thus offers the opportunity to test digital media in a physical space context, to develop implementations for hybrid learning spaces and to reflect on the use of digital media.

As the experimental laboratory focuses in particular on the use and production of digital or partially digitalized teaching/learning content in the context of research-oriented learning and teaching, the media perspective is to be taken into account. Digital media are considered in the experimental laboratory in the tradition of 'technology-enhanced teaching', whereas digital media are understood "as a

component of a complex teaching-learning arrangement, which is characterized by the totality of different (digital and analogue) offers " (original: „als Bestandteil eines komplexen Lehr-Lernarrangements, welches durch die Gesamtheit unterschiedlicher (digitaler und analoger) Angebote [...] gekennzeichnet ist“) [4, p. 1042]. The experimental laboratory takes up this consideration and therefore always addresses the didactic embedding of digital media in a broader overall setting.

In the following section, conclusions will be drawn from the conceptual considerations and the equipment (spacing) of the room will be specified.

3. Implementation of the concepts in the experimental laboratory

In order to progress from conception to concrete implementation, the experimental laboratory addresses both teachers as learners and students in accordance with a didactic double-decker.

As a result of the design of the experimental laboratory as a teaching learning laboratory in higher education the learners and the associated "product" in the sense of a (learning) result are taken into account on the one hand, derived from the supporting sensory units of the 'LERN-WERK-STATT', and on the other hand a physical place with additional digital elements is set up, which stimulates an active construction performance and is characterized by a relational understanding of space.

This enables teachers (= learners) to tackle with content independently and to build up new knowledge themselves.

The sense unit 'STATT', which relates to the physical learning location, is extended by a relational understanding of space and set up in such a way that both the processes of spacing and synthesis are supported.

Based on the consideration that the laboratory space actively contributes to learning through spacing and synthesis and that learning processes can be initiated as a result, various requirements can be derived for the physical space.

On the one hand, flexible social goods (i.e. non-

human elements or objects) such as flexible furniture, mobile walls, blackboards etc. have to make it possible to design the room in a way that is appropriate to the learning objectives without big additional effort. The items selected for this purpose should also enable a variety of teaching and learning situations in order to create spatially, socially and didactically appropriate arrangements (e.g. for group or individual work).

Following the guidelines of the Stifterverband, the flexible furniture is supplemented by hybrid-capable equipment. With regard to the furnishings (elements of spacing), a distinction can be made between *materials/media* and *furnishings/equipment* in order to systematize the approach.

The range of materials and media within the experimental laboratory room is made available in analogue form and digitally via a cloud. Texts and other media, such as videos, are offered on the following topics: Instructions for using digital media, texts and advice for incorporating digital media into university teaching, texts on learning space development (regarding didactic conception as well as spacing), on supporting learning processes as well as on research-related teaching.

Thus, the experimental laboratory provides a variety of digital media and options for media production that may be relevant for use in teaching. The centerpiece is the lightboard (95 inches), which enables the interactive design and recording of digital course materials in a special way and creates a direct visual link between research content and the researcher.

In addition to the non-human elements, the social use by people is also relevant for the constitution of a space, following Löw [6]. In this understanding, the teachers become elements in the space that the respective individual incorporates into their perception and thus constructs a relational space. In order to initiate social use, *workshops*, *exchange* and *networking formats* and *accompanied opening hours* are offered.

As part of the experimental laboratory, e.g. workshops on the lightboard and the use of lightboard videos as teaching/learning videos or explanatory videos (with associated OPAL self-study course including accompanied video

shooting) can be offered, or workshops on the topic of "research-oriented learning and teaching with the help of digital media" can take place.

The experimental laboratory is open at certain times being attended by student assistants. During these opening hours, it is possible to work independently with both the materials and the media, prepare teaching and learning materials or enter into an exchange with other lecturers. In this respect, the experimental laboratory also functions as an *open space* that can be accessed both digitally and in the room itself. Here, for example, experiences in teaching can be reflected upon or best practice examples can be presented, collected and exchanged.

It is also possible for researchers from the DRESDEN-concept institutes and lecturers from TU Dresden to work in tandem to design smaller research-oriented courses in the rooms of the experimental laboratory and have them evaluated at the same time.

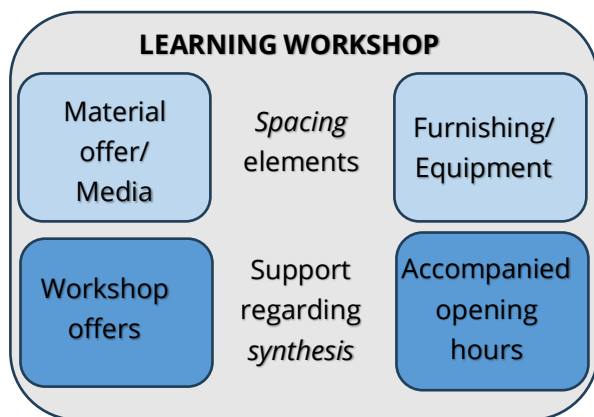


Figure 1 : Schematic representation of the concept and its components

Based on the conceptual considerations made so far and the conclusions drawn from them regarding the furnishing and use of the experimental laboratory, various room usage scenarios can be derived.

4. Room utilization scenarios for the experimental laboratory

The experimental laboratory is set up for different usage scenarios and should therefore allow for the most versatile use possible.

Teachers here have (1) the opportunity to develop innovative teaching/learning concepts by working independently with the available materials. In addition, teachers can (2) experiment with the variable furnishing of the room and its spacing and (3) exchange ideas about the materials and concepts they have developed in order to test their own settings (e.g. blended learning concepts) and exchange ideas with higher education didactics experts or other lecturers.

However, the experimental laboratory can (4) also be used as a higher education didactic teaching and learning location and thus for regular teaching and/or for special learning and study projects. An application procedure can be implemented here, within which interested lecturers submit a utilization concept, discuss it with university didactics experts, reflect on it and then evaluate it.

The experimental laboratory (5) can be booked as a learning space at certain times (by both lecturers and students). In this context, the room is then used as a university learning space for project and problem-based teaching and learning by students and project groups. The room (6) can also serve as a location for formats such as hackathons in the field of digital/hybrid teaching and accommodate research-oriented teaching projects.

In addition to the scenarios mentioned above, the experimental laboratory will also (7) be available as a didactic teaching, learning and advisory space. In this context, TUD's Center for Interdisciplinary Learning and Teaching will be responsible for further training, workshops and consultations on blended learning concepts and university and media didactics (including tool training), which complement the thematic focus of research-oriented learning and teaching.

In the future (8), the experimental laboratory will also be accessible as a networking space for university-wide communities of practice and learning communities.

5. Current status of implementation and outlook

The technical setting currently consists mainly of the lightboard, which interested lecturers can use to film explanatory videos. There are

also various microphones and wireless headsets, a 360° camera and a document camera. The asynchronous support offer consists of a self-study course on the learning platform OPAL, which covers the theoretical basics of creating teaching/learning videos and coordinates the scheduling of the accompanied production.

A spatial change and expansion of the experimental laboratory and the technology it contains is planned. By separating the lightboard and technology room from the other room components, disruption-free video production can be guaranteed in the future. The range of materials and the flexible and innovative furnishings will then be located in two additional rooms.

In completion to the spatial changes, the equipment will also be expanded to include additional digital media, which will particularly support the linking of teaching and research, as well as the interweaving of synchronous and asynchronous teaching.

The next step is to establish workshops on topics such as blended learning or research-oriented learning and teaching and to work with users to develop offers for learning space design and the didactically appropriate integration of teaching/learning videos into their didactic scenarios.

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