

Potential of cross-university developed learning materials in Engineering Design Education

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Abstract: This paper investigates the long-term potential and challenges of the development and use of teaching and learning materials using a cross-university development project for providing an Engineering Design Education course or rather OER as an example. The study examines how these materials are currently used, adapted, and perceived by lecturers five years after their initial implementation. Data sets were collected through semi-structured interviews with project participants from different universities. Results show that the materials are widely used in introductory and advanced engineering courses, mainly to support self-study and heterogeneous student groups. Lecturers value the modularity, adaptability, and high quality of resources, which reduce development effort. However, meaningful integration into courses is necessary to motivate student use, and the exchange of materials beyond academic networks remains limited. These findings allow generalization for future cross-university development of learning materials, like the importance of high modularity which allows easy selection of individual materials.

Keywords: Engineering Design, Design Education, Cross-university development, E-Learning

1 Introduction

New technologies such as AI offer opportunities for innovative teaching and learning concepts and the required materials. One example is assessments with an automatically evaluation of Technical Drawings with AI (see examples for Engineering Design Education in Fastabend et al. (2024) or Ant et al. (2024)). The development of these digital teaching and learning environments and digital learning materials in general requires a high initial effort. But after that they can be used by a high number of students without a high expense (Schönwald, 2007). For reducing the effort per user one strategy is increasing the number of users with distribution at several universities. For this purpose, it seems obvious to develop digital learning materials across universities or share existing materials. However, this requires a high level of similarity in application context, e.g. the same intended learning outcomes are addressed with similar teaching and learning activities, universities provide same software opportunities, lecturers have similar experience and competencies, as well as motivation to be able to modify and use the materials (examples for relevant factors in the development of multimedia learning environments in the instructional design according to Niegemann et al. (2008)).

A similarity in courses and general intended learning outcomes appears in engineering degree programs like mechanical engineering at German universities for first study year Engineering Design Education courses addressing Technical Drawing and Machine Elements, see our previous study by Kossack et al. (2024). Standardization concepts with framework suggestions (e.g. Metraglia et al. (2011)) or guidelines (e.g. Bender et al. (2025)) might lead to an even higher similarity in the future. These courses addressing intended learning outcomes in the field of Technical Drawing are attended by many students as they are mandatory in the degree program mechanical engineering and included in degree programs like economic engineering or logistics (Dillenhöfer, 2023). Due to the high number of participants, typical teaching and learning activities are frontal lectures and a high expense on self-study time up to 60 % of the total expense for the students (Kossack and Bender, 2024). This identified similarity led to the project *TZ digital* (TZ for “Technisches Zeichnen”, which means Technical Drawing). In the project lecturers with their research and teaching assistants from seven German universities developed digital learning materials for teaching Technical Drawing for the widely used teaching and learning activities (Dillenhöfer et al., 2023). The project *TZ digital* is an example for cross-university development and use of learning materials in Engineering Design Education.

The project evaluation allows the investigation of the potential of cross-university developed teaching and learning materials and especially its long-term benefit. Therefore, this paper includes lecturers' point of view years after the development and initial use. The insights help to understand challenges and benefits from cross-university developed materials and define requirements for further materials or projects in university Engineering Design Education. The investigation section two describes the project for cross-university development of learning materials for Technical Drawing *TZ digital* and specifies the requirements for the materials and shows some exemplary materials. This description allows deriving two research questions for this paper. The last subsection details the method of structured interviews used

for the investigation. Section three consists of the results and is clustered in different evaluation aspects, like users of the materials, adapting the materials and opinions about cross-university development and use of learning materials. Section four discusses the results and provides further research ideas as well as a list of recommendations for developing learning materials cross-university in Engineering Design Education.

2 Project description and research clarification and method

Learning materials are all kinds of resources which support the learning process and include, for example, books, lecture notes and e-learning resources (Adamina, 2014). E-learning describes an arrangement of digital learning media and virtual learning rooms (Arnold et al., 2018). It often has the advantage of an interactive learning support without manual support by lecturers; however, the initial development expense is high (Schönwald, 2007). This characteristic is especially relevant for large student groups. To reduce the development expense per user materials can be shared e.g. in Massive Open Online Courses (MOOC). MOOCs are courses free to use for many participants, often from all over the world. Often materials and guidelines like timetables are provided and participants decide how many materials they use (Pfäffli, 2015). Another sharing format for lecturers is Open Education Resources (OER). OERs are educational materials with licenses that allow free use and modification, and these materials can comprise individual materials like worksheets or full courses (Butcher, 2013). This requires easy adjustable data formats with open-source programs for the data (Arnold et al., 2018).

TZ digital is a project for developing a MOOC for Technical Drawing, which can be used by students, and offering individual materials as OERs as well for lecturers. The following sections describe the exemplary project for Engineering Design Education *TZ digital*, the existing evaluation results, the demands with concrete research questions for this paper and the research method.

2.1 Project background and development process

The use of same books for teaching Technical Drawing led to the idea to participate in a large German project about the development of OER provided in MOOCs at the specific platform ORCA.nrw with a subproject about materials for Technical Drawing. In the planning phase of the project students were asked about their needs. They wish for more digital learning support in Technical Drawing, especially for understanding Tolerancing (see survey results in Dillenhöfer (2023)). Additionally, common topics in Engineering Design Education were identified. Based on this, project partners teaching these topics in higher education were found with seven universities and universities of applied science. Due to the funding guidelines all partners are in the state North Rhine-Westphalia, Germany.

The development in the consortium is based on the alignment of intended learning outcomes, teaching and learning activities and assessment tasks according to the didactical approach Constructive Alignment (see Biggs and Tang (2011)), which is suitable for the development of curricula, courses or individual lectures or activities (Jungmann et al., 2016). For the development of materials for teaching and learning activities in this project firstly a detailed analysis was conducted. The analysis of the existing courses with their intended learning outcomes for the identified common topics, the teaching and learning activities and the assessment tasks, specified the requirements of the materials. These requirements for the new material are:

- It needs to address different levels of detail for the intended learning outcomes, because they vary at different universities or need to be easy adjustable from the lecturers for the intended learning outcomes of their courses.
- It should fit into courses with many frontal teaching formats like lectures and a high expense of self-study time.
- It should prepare mainly for summative assessments which include paper-based Technical Drawing tasks, as well as online exams with closed question types.

The lecturers have courses with up to 500 participants. These participants have varying prerequisites for acquiring competencies in Engineering Design, e.g. spatial thinking skills, caused by differing secondary school education and additional experience like vocational training. Therefore, the materials need to work automatically, e.g. without any manual corrections of Technical Drawings, and should offer different materials for students' individual level of knowledge.

In addition, the technical resources were analyzed (as suggested in Niegemann et al. (2008)) to identify suitable software and formats for the materials as an important step in the development (compare Arnold et al. (2018)). All lecturers work with a learning management system, mostly Moodle (Moodle Contributors, 2026b) to provide students with materials or get in contact with the students. Therefore, the interface of the materials to Moodle seems reasonable for easy integration in the existing courses. Additionally, the goal to provide materials as OERs in a MOOC over the ORCA.nrw portal requires specific licenses (CC BY-SA 4.0, CC BY or CC 0) and digital formats, which are compatible with the learning management system Moodle as ORCA.nrw is based on it.

Teams with 3-4 members from different universities developed the materials for each topic. Lecturers and their teaching assistants became members of teams for topics they have special interest in or had specific needs in their teaching they wanted to address. The development started with the definition of the intended learning outcomes for individual materials according to Biggs and Tang (2020). The addressed intended learning outcomes for individual materials are refined common learning outcomes of the courses (Pfäffli, 2015).

Continuous meetings in the teams on the different topics as well as in the whole consortium helped to face common technical challenges and ensured the development suitable for all needs in the consortium of the subproject. In addition, ORCA.nrw provided information sessions and exchange events with other projects to introduce necessary meta data for finding the materials later, sharing implementation ideas and explaining the legal frameworks of OER. Such support from higher education institutions with providing guidelines is common and key for successful OER development and use (Reinken and Kalinovich, 2022).

2.2 Learning materials developed in the project

In the project, materials for 12 common topics in Engineering Design Education courses about Technical Drawing were developed. All the materials are published in a MOOC at ORCA.nrw for students to use in their self-study time. They can navigate freely between the topics. However, every topic has a final test implemented with the Moodle activity Quiz (Moodle Contributors, 2026c), which is available for varying levels of difficulty. The Moodle activity Quiz includes closed question types like the digital exam formats in the analyzed courses. If students pass a test on a certain topic, they see their progress. Figure 1 shows the main page with the 12 topics and a suggested learning path between the topics symbolized with houses having characteristics of the topics.

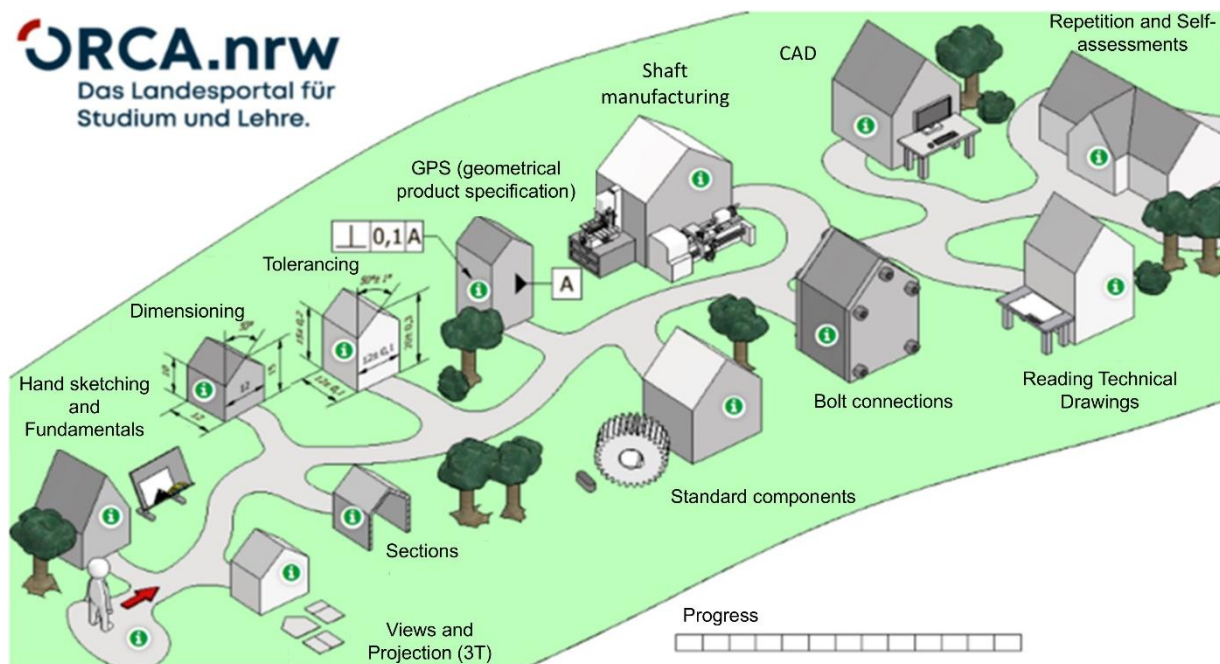


Figure 1: Overview of the topics in the Massive Open Online Course about Technical Drawing at ORCA.nrw

There are a lot of materials on the different topics, in addition to the self-assessment Quiz activities. The most used data format of these materials is H5P, an open-source-software for interactive learning materials, which can be used, shared and adapted (H5P Contributors, 2026a). Learning management systems like Moodle or Ilias often have Plugins for embedding the different H5P element types (Moodle Contributors, 2026a). The mainly used H5P elements are Course Presentations. Course Presentations have different pages, which can include texts, videos and interactive content like closed questions, e.g. short answer or single choice (H5P Contributors, 2026b). Users can navigate to the next page or jump to certain contents.

Figure 2 shows an exemplary page (24 of 42) of a H5P course presentation. The shown element is part of the topic Dimensioning and deals with the Dimensioning for Manufacturing. It addresses the intended learning outcome “*Students can dimension a component with geometry manufactured by drilling.*” For reaching this learning outcome, students need to reach learning outcomes on lower taxonomy levels in Blooms taxonomy reworked by (Krathwohl, 2002). For example: “*Students can describe the manufacturing process of a shaft with shoulders, chamfers, tapers and threads.*” The shown Course Presentation explains the whole manufacturing process and highlights all important details. The page includes an about one-minute-long video showing one manufacturing step of the geometry of the shaft with voice explanations and

highlights the reasons for the dimensioning on the Technical Drawing in red. In addition, the 3D model extends the description of the process on the lathe. This Course Presentation is especially interesting for students who do not have any practical technical experience like a vocational training and have never seen manufacturing processes before, because manufacturing processes are not detailed in the lectures for several different components and geometries.

Even though the full course is provided and can be used at ORCA.nrw as MOOC, lecturers can download all materials individually. That allows selection of individual materials like a Course Presentation and importation into the own course in the learning managements system e.g. Moodle. Every element in the Course Presentations on the pages can be changed easily without additional software by lecturers. Videos are included in rather short sequences, and the original data is provided as well to allow quick adjustments. The developed Course Presentations in the project consist of up to 140 pages.

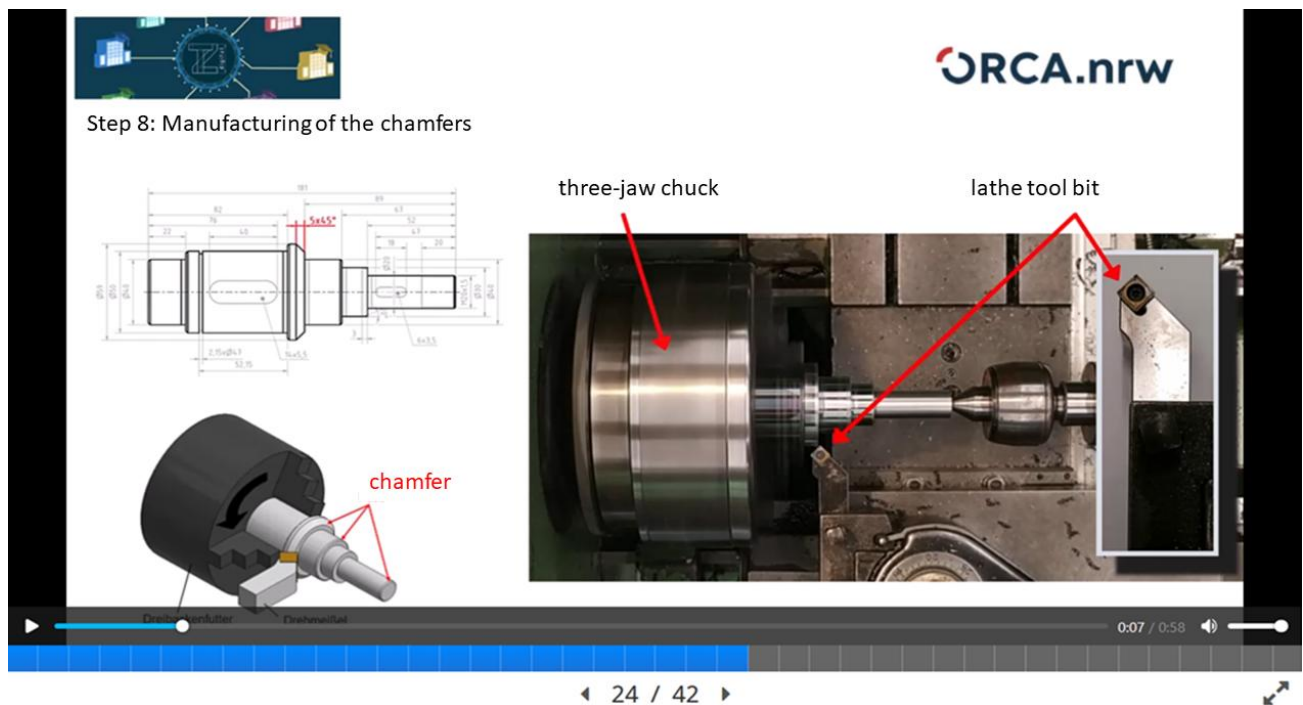


Figure 2: Exemplary H5P Course Presentation about Dimensioning for Manufacturing of a shaft with the explanation of chamfers and its manufacturing process on page 24 of 42

In addition to the Course Presentations, more materials, e.g. Microsoft Office data with tasks for hand sketching, are included in the different topics. Detailed meta data for each piece of data helps lecturers to find suitable materials for their search quickly and provides information about context, intended learning outcomes and short summaries.

2.3 Evaluation of the materials

After the development of the materials all project members reviewed the materials and adapted them as necessary. Then the materials were provided to students at all universities in winter term 22/23. Students were informed about the materials and a link to the MOOC on the platform ORCA.nrw was provided. In an evaluation with a questionnaire only 54 of 1000 students participated. The participating students liked the materials and enjoyed the variety of interesting content and multimedia formats (detailed evaluation in Dillenhöfer (2023)). At that time, it was uncertain how many students used the materials. Due to guest accounts, it was not possible to get number of users from the system. During this first evaluation, the lecturers agreed that more integration into existing courses was needed to encourage students to use the materials.

Current data can be used to evaluate the potential of the cross-university developed materials in the project *TZ digital*. It is interesting to know, if lecturers use and adapt the materials as planned, how they integrate the materials in the courses, if the materials still fit to the curricula and current needs are addressed as e.g., the COVID-19 pandemic changed higher education (Brunner et al., 2023; Dittler and Kreidl, 2023) and the project was planned and started before. Therefore, this paper investigates the two following research questions:

- To what extent do the lecturers use and work with the materials from the project today?
- What are opinions about developing and using learning materials cross-university (based on the experience in the project)?

These findings based on the exemplary project might support future cross-university development of materials for Engineering Design Education and allow deriving recommendations for the future.

2.4 Interviews for further evaluation

The research follows an empirical research design with the development of an interview guideline for the lecturers to investigate the two research questions. The test group consists of all seven participants of the project. All participants were contacted by email and asked for a 30-minute individual video interview for evaluating the project materials after four years of usage. All the lecturers (all holding at least a doctoral degree) agreed and scheduled an appointment for themselves or their teaching assistants in January 2026. The role of the interviewees varied a little bit; some lecturers invited their teaching assistants as they mainly update the learning management system and provide materials for self-study times every year. This ensures that both the content-related evaluation of the materials and the technical perspective are considered in this study. The interviews started with an introduction and a clarification about the collected data and the publishing plans. For the data collection an interview guideline was developed based on the project documentation and discussions of three research assistants from three universities in the project. The guideline includes 16 open questions. So, the criteria for a half-structured interview according to Döring and Bortz (2016) are fulfilled. The first five questions record the courses the materials are used for, like main topics, targeted student group, and degree program. The next five questions ask about the concrete application of the materials, which topics are mainly used, how the content is provided and adapted, and integrated in the courses. Three questions collect data about students' feedback and technical or other challenges with the materials. The concluding three questions focus on the overall experience of using and sharing learning materials, e.g. as OER. All questions were asked by the same interviewer, and the same recording secretary collected the data. Both are researchers, who worked on the project and developed the used interview guideline. The data is anonymized and concluded with the results in the next section.

3. Results

The first results section addresses the first research question, if and how lecturers use and adapt the materials and the second section addresses the second research question and capture lecturers' opinions about cross-university development and use of the learning materials.

3.1 Use of the materials and adaptation

Lecturers use the materials for different courses at their university. The materials were developed for first year courses about Technical Drawing fundamentals and are used for courses in this field at every university. However, at five universities the materials are used for advanced courses as well. Often for repeating the fundamentals of Technical Drawings, but at four universities for specific courses as the materials include details that go beyond the intended learning outcomes in the first study year.

The estimated number of users varies between 40 and 400 first year students in courses about Technical Drawing fundamentals. Table 1 shows the data from the different universities (U). The variation is based on the number of degree programs with such courses at each university and the number of participants in each degree program. For example, at U2 and U3 the degree programs mechanical engineering and economic engineering include courses about Technical Drawing fundamentals or at U5 the degree programs mechatronics include topics about Technical Drawing and at U7 the degree program technical design. These first-year courses are mandatory for all students in the degree programs. Due to the application of the materials in many advanced courses, the students, especially in the mechanical engineering degree programs with the focus on Engineering Design, use the materials over the whole degree program. For example, at U1 the students in the degree program mechanical engineering start to use the materials in the first semester in a course about Technical Drawing and continue using selected elements of the materials over the second to fourth semester in courses about machine elements. At U5 the materials are highly recommended for repeating fundamentals about Technical Drawing in a project work in Engineering Design Education in the third study year. In addition, some students (about 10) select a course about design methodology in the sixth semester and use the materials about that topic. Lecturers at U2 include materials about Geometrical Product Specification (GPS) in a specific advanced course. The course is about the use of the ISO-GPS system to describe technical components according to ISO 8015 for industrial applications with about 20 participants (details of the course can be found in (Sersch et al., 2025)). All the courses mentioned have 5 ETCS, however not all topics (the full 5 ETCS) are supported by the material.

All lecturers use materials for teaching Technical Drawing. However, lecturers at all universities mention focusing on the materials about certain topics or excluding the materials about specific topics. The reasons for this vary. Often the materials include topics which are not included in the intended learning outcomes of the course. Additional reasons are that lecturers recommend materials for topics students find especially challenging, lecturers exclude the materials about topics they are used to providing other materials e.g. own sheets, books or e-learning content, lecturers tend to use the materials which they developed in the project. Reasons might be that these materials best fit the own course. In addition, one lecturer

mentioned knowing these materials much better, which makes it more accessible to integrate them in the course for the lecturer.

The use of the materials varies at the different universities. Lecturers at all universities recommend the content for the self-study time in first year courses about Technical Drawing. For the recommendation most lecturers show an overview of the materials (like Figure 1) in their lectures and provide links or the materials themselves in their courses in the learning management system for self-study time. Two lecturers use selected content in the lectures in detail. For example, the lecturer at U3 show and explain an animation about bolted joint diagram in frontal lectures about machine elements. The way of providing the materials for self-study time varies. Most universities provide a link to the full MOOC at ORCA.nrw. Most lecturers recommend individual learning materials with specific links. These links are integrated into lecture sheets and help to find further information about the specific topic on the sheets at U1, or links recommend whole topics at U5 and U6.

Table 1: Relevant items of the interviews

	Estimated different users per year (number of courses)	Focused topics	Use in the on-site study-time	Use in the self-study time			Modification of the material
				Link to ORCA course	Link to selected material	Selected activities in own course	
U1	400 (5)	Views, Sections and Assemblies, Dimensioning, Tolerancing	Introduction to the material	Yes	Yes	No	No
U2	100 (3)	Views, Sections and Assemblies, Dimensioning, Tolerancing and GPS	Introduction to the materials	Yes	Yes	No	No
U3	200 (2)	Dimensioning for Manufacturing, Views, Bolts	Introduction to the materials & Use in lectures	Yes	Yes	Yes	Sequencing and selecting
U4	40 (1)	Tolerancing, Views, Standard components	Introduction to the material	Yes	No	Yes	Selecting, adding and renewing
U5	140 (1)	Fundamentals, CAD, Views, Tolerancing	Introduction to the material	No	Yes	Yes	Sequencing and selecting
U6	150 (2)	Fundamentals, Views	Introduction to the material	Yes	Yes	No	No
U7*	70 (1)	Reading Technical Drawings, Tolerancing	Exercises and tasks discussed in frontal lectures	Yes	No	No	No

*The course is currently taught by a different lecturer than the one interviewed. Therefore, the data are from previous years.

Three lecturers selected individual activities or parts and imported them into their courses in the learning management system. Some universities import whole activities in their own Moodle courses, e.g. import H5P Course Presentation as developed in the project. Other lecturers adjusted the content for their special needs. One lecturer highlights the use of materials in the Moodle activity Quiz. Existing Quizzes are expanded with individual questions from the Quizzes in the materials of the project. At one university some H5P elements are integrated in a Moodle based adaptive learning environment. The H5P elements are integrated on pages in the Moodle activity Lesson. Depending on students' answers

at branching pages in the activity Lesson the decision tree-based activity provides H5P content if recommended. For example, if students have a mistake in a question about dimensioning, the system provides the H5P content about dimensioning. The detailed description of the adaptive e-learning environment is described in Kossack and Bender (2023).

All lecturers, who provide selected materials, adapted the materials at least by sequencing them into various sections. Only one lecture adjusted the materials more by renewing and adding content. It is hard for the lecturers to motivate students to use the materials. Important approaches for rising motivation are remembering the students is the integration of exemplary materials in the lectures and the integration in the course in the learning management system.

The absence of modification of the materials is at one university caused by technical challenges. The university uses a learning management system without a Plugin for H5P, therefore the only way of providing the materials is the use of the MOOC at ORCA.nrw. Lecturers at this university try to recommend individual materials by linking specific content but wish to provide students with modified content. Other lecturers do not mention any technical challenges and see most reasons for less modification in lack of time.

The lecturers report positive feedback from the students for providing the materials. In evaluation forms of the course students highlight the benefits of providing the materials. Lecturers appreciate the variety of materials, so students can work on their individual challenges or interests in their own learning-pace. That makes the materials especially helpful for knowledge heterogenous groups of students in the first study year, because the students have due to varying secondary education varying prerequisites for acquiring competencies in Engineering Design Education (Kossack and Bender, 2022). However, students find it challenging to identify suitable materials for their level of knowledge or which is relevant for their own course. That makes lecturers e.g. at U1 integrate specific links on the lecture sheets.

3.2 Opinions about cross-university development of learning materials

All interviewees assess the materials developed in the project as helpful for their courses. Developing materials with the existing quality and scope is impossible for most of the lecturers on their own due to the high development expense. The high expense makes all lecturers interested in developing more materials cross-university. Therefore, four of the lecturers informed colleagues about the existing materials from that project which are free to use and adapt. The distribution is mainly among colleagues at the same university. However, lecturers inform colleagues cross-university e.g. in small-talk at conferences. Only one lecturer reported that the materials are used at another university because of the recommendation. In addition, some project reports were published and presented to other lecturers of all disciplines interested in teaching and not to inform lecturers in the field of Engineering Design Education. Two universities mention the materials in research publications about Engineering Design Education.

All lecturers would appreciate continuing working together in developing teaching and learning materials. The preferred topics of all lecturers are dimensioning machine elements. This topic is taught similarly across universities (see our previous study in Kossack et al. (2024)). In addition, a lack of materials for non-software-specific CAD teaching is mentioned.

Despite the positive experience in the project, lecturers tend to be cautious about using other people's materials or sharing own materials. Most lecturers seem not to search for OER when preparing a course. If they use existing materials, it is from their predecessor or well-known colleagues. One lecturer mentioned the importance of working together in the cross-sectional group education of the Scientific Society for Product Development ("Wissenschaftliche Gesellschaft für Produktentwicklung"). The materials exchange in Engineering Design Education seems to be more about personal contacts than open education resources platforms. However, it is emphasized that the materials from other universities always need adjustment for their own course and the individual intended learning outcomes of the course and the targeted student group to fit in the curriculum.

4. Discussion and Outlook

The interview results show the benefit of the materials for today's Engineering Design Education as all lecturers appreciate using the materials after the initial development and evaluation. Lecturers recommend the materials for self-study time and integrate individual materials in varying ways in the courses, e.g. with concrete links to the ORCA.nrw course or the integration in courses in the own learning management system, e.g. provide individual H5P elements for certain topics or integrate questions from Quizzes. In addition, lecturers use selected materials in frontal lectures or exercises to explain and discuss with the students. The adjustment of the materials is mainly limited to selecting and to sequencing instead of adding or changing content. From this, it can be concluded that modularity is an important characteristic of materials. A project about the development of a modular teaching concept for the design of sustainable products in Engineering Education highlights the importance of modularity for an easy integration in existing courses as well (see Kattwinkel, 2026).

Whereas in this study the easy changeability of the materials seems to be less important, even though it is a main characteristic and mentioned as an important success factor of OER (Arnold et al., 2018). However, Technical Drawing has a high standardization in higher education teaching caused by using guidelines and the relevant guidelines have not changed significantly since the initial development. Such changes might lead to necessary changes in the materials. However, literature recommendations are also typical in Engineering Design Education (see Kossack and Bender (2024)) and are often valid for many years.

Interviewees enjoyed the cross-university development of learning materials and highlighted the benefit from exchange between lecturers and the benefit of providing high quality learning materials without having all the initial development expense. This positive experience led to interest in further cooperation. However, lecturers do not provide materials beyond the project on ORCA.nrw or similar platforms or even search there for materials, even though all lecturers are allowed to upload content with their university identification at ORCA.nrw and only need to provide some required meta data. The lecturers interviewed have more exchanges with other lecturers they are in contact with. This finding supports the importance of marketing efforts and promoting OER as a success factor as described in Reinken and Kalinovich (2022). The results are limited to the test group of lecturers at universities involved in the development. The extant data does not provide any information regarding whether lecturers from other universities have found the materials at ORCA.nrw, nor does it indicate the way they utilize them in their courses

The findings are subject to some methodical limitations. The interviewees represented a range of functions within the university and roles in the project. One interview partner was not at the university at the time of the project but has courses about Technical Drawing now and uses the materials with support of the research assistants. In addition, lecturers use the materials in varying contexts. Universities with mechanical engineering degree programs have a basic course about Technical Drawing, which are very similar to the learning outcomes of all topics in the materials. At other universities degree programs are more specialized like mechatronics. These degree programs include different topics of Technical Drawing, but not all. Therefore, the learning materials might be less suitable, which influences the use. Technical resources at the universities, in detail if they use learning management systems that have a H5P Plugin, influence the using possibilities.

The evaluation in this paper is from lecturers' point of view. It would be interesting to get feedback from the students and get information about how many students use the materials both at ORCA.nrw as well as in the courses in learning management systems at the different universities. In addition to students' overall feedback, it would be beneficial to ascertain specific interests of the students, the type of data which they use most frequently, and the topics for which they prefer more materials. Furthermore, it would be advantageous to investigate whether the students have any suggestions for the optimization of the materials, and to determine whether they are able to locate the required materials by means of the various distribution methods.

The interviewees are lecturers involved in the project and the development of the materials. It would be interesting to know if the informed lecturers about the materials use it as well or if any lecturers found the materials with the meta data at ORCA.nrw. If lecturers beyond the consortium use the materials, their feedback would be interesting. Special questions are, does it fit also for their courses, do they have technical challenges with the use or the adaptation, how do they use it in their courses.

Despite the limitations of the results the experience from the exemplary project shows that...

- ...cross-university developed learning materials can be used at different universities, if they match the topics with intended learning outcomes.
- ...due to varying details in the intended learning outcomes, a modularity with easy selection and sequencing is important.
- ...the general changeability, e.g. for editing individual texts or adding and renewing details in the drawings seems less important.
- ...a meaningful integration in the courses is important to motivate students to use the materials. That might need selection and individual delivery from the lecturers.
- ...data with an interface to Moodle like Quizzes and H5P elements are suitable data types, as most lecturers could easily adapt the materials as they wanted.
- ...the distributions between lecturers needs special attention and maybe specific platforms or at least lists for materials about Engineering Design Education would be helpful.

The findings from the exemplary evaluated project allow some recommendations for future projects about cross-university development of learning materials for Engineering Design Education. The learning materials should focus on common intended learning outcomes and allow specifications from different lecturers. Modularity for choosing and selecting individual parts of the materials is key. Whereas the adaptability of individual content in the materials seems to be less

important. Interfaces to the learning management systems are useful to integrate the materials meaningfully in the course concept, which is necessary for students' motivation. The exchange of materials between lecturers needs new concepts and ideas to inform about the materials and distribute them.

5. Conclusion

The paper shows the potential of cross-university development and use of digital learning materials. The evaluated project which developed learning materials for Technical Drawing is in use by approximately 1,000 students. The lecturers consider the materials an important addition to their courses, mostly for self-study time. The materials are not only appropriate for the first-year courses about Technical Drawing, but also highly recommended for higher courses in Engineering Design Education e.g. as a repetition for project work or for specific courses about certain topics like the ISO-GPS system. Lecturers do not see all the content relevant for their own courses and appreciate the modular design, which allows lecturers to use only parts of the materials and combine them with their own. The lecturers get positive feedback from the students; students find the materials helpful and full of variety. However, it is hard for the lecturers to motivate students to use the materials and meaningful integration in the course is key. That makes easy adaptability an important characteristic of cross-university use of learning materials. Even lecturers appreciate the learning materials and see the benefit of cooperation for creating learning materials, they told only a few colleagues about the materials and do not share own materials beyond the project or search for available materials regularly.

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References

- Adamina, M., 2014. Lehr- und Lernmaterialien im kompetenzorientierten Unterricht. Beiträge zur Lehrerinnen- und Lehrerbildung 32 (2014) 3, S. 359-372. Beiträge zur Lehrerinnen- und Lehrerbildung 32. 10.25656/01:13875.
- Ant, J.; Doksanbir, A.; Dillenhofer, F.; Kunne, B., 2024. AI Object Detection of Parts in Engineering Drawings and a Concept of Integration in Engineering Education – AssistME In: Proceedings of NordDesign 2024, Reykjavik, Island, pp. 342–351.
- Arnold, P., Kilian, L., Thillosen, A.M., Zimmer, G.M., 2018. Handbuch E-Learning: Lehren und Lernen mit digitalen Medien, 5th ed. W. Bertelsmann Verlag, Bielefeld.
- Bender, B., Husung, S., Kirchner, E., Kletzing, U., Kossack, F., Lohrengel, A., Mayar, B., Riedel, O., Stahl, S., 2025. Universitäre Lehre in der Produktentwicklung/Academic teaching in product development. Konstruktion 77 (10), 54–65. 10.37544/0720-5953-2025-10-54.
- Biggs, J., Tang, C., 2020. Constructive Alignment: An Outcomes-Based Approach to Teaching Anatomy, in: Chan, L.K., Pawlina, W. (Eds.), Teaching Anatomy. Springer International Publishing, Cham.
- Biggs, J.B., Tang, C.S., 2011. Teaching for quality learning at university: What the student does, 4th ed. McGraw-Hill/Open University Press, Maidenhead.
- Butcher, N. (Ed.). (2013). Was sind Open Educational Resources? Und andere häufig gestellte Fragen zu OER. UNESCO. http://www.unesco.de/fileadmin/medien/Dokumente/Bildung/Was_sind_OER_cc.pdf
- Brunner, G., Degenhardt, M., Menzer, C., 2023. Veränderung der Lehre durch die Corona-Pandemie aus Sicht der Hochschulleitung: Ein Blick zurück nach vorn am Beispiel der Pädagogischen Hochschule Freiburg, in: Dittler, U., Kreidl, C. (Eds.), Wie Corona die Hochschullehre verändert: Erfahrungen und Gedanken aus der Krise zum zukünftigen Einsatz von eLearning, 2nd ed. Springer Fachmedien Wiesbaden; Imprint Springer Gabler, Wiesbaden.
- Dillenhofer, F., 2023. Entwicklung einer KI-Objekterkennung für technische Zeichnungen im Maschinenbau. 10.17877/de290r-24140
- Dillenhofer, F., Kunne, B., Frye, S., Haertel, T., Altland, L., Kossack, F., Bender, B., Sersch, A., Gust, P., Lattner, Y., Müller, M., Hinse, D., Pantke, K., Bechthold, J., Frank, J., Richard, T., 2023. Development of Modular E-Learning Materials as OER for a MOOC, in: , 17th International Conference on E-Learning Springer International Publishing, Cham.
- Dittler, U., Kreidl, C. (Eds.), 2023. Wie Corona die Hochschullehre verändert: Erfahrungen und Gedanken aus der Krise zum zukünftigen Einsatz von eLearning, 2nd ed. Springer Fachmedien Wiesbaden; Imprint Springer Gabler, Wiesbaden.
- Döring, N., Bortz, J., 2016. Forschungsmethoden und Evaluation in den Sozial- und Humanwissenschaften. Springer Berlin Heidelberg, Berlin, Heidelberg. 10.1007/978-3-642-41089-5

- Fastabend, J., Müller, B., Roth, D., Kreimeyer, M., 2024. Conceptualization of an artificial intelligence-assisted tutoring system for teaching technical drawing skills to undergraduate students. *Proc. Des. Soc.* 4, 2835–2844. 10.1017/pds.2024.287.
- H5P Contributors, 2026a. H5P. URL: <<https://h5p.org/>>.
- H5P Contributors, 2026b. H5P Course Presentation. URL: <<https://h5p.org/presentation>>.
- Jungmann, T., Ossenber, P., Wissemann, S., 2016. Begriffsklärung zur Kompetenzorientierung, in: Frerich, S., Meisen, T., Richert, A., Petermann, M., Jeschke, S., Wilkesmann, U., Tekkaya, A.E. (Eds.), *Engineering Education 4.0*. Springer International Publishing, Cham, pp. 863–868.
- Kattwinkel, D., 2026. Review of a modular and scalable course concept for sustainable product development: a multi-institutional case study. In *Proceedings of the Design Conference 2026* 10.1017/pds.2026.10659
- Kossack, F., Bender, B., 2022. Heterogeneous groups of students as a challenge in engineering design education, In: DS 119: Proceedings of the 33rd Symposium Design for X (DFX2022). Proceedings of the 33rd Symposium Design for X. 22 and 23 September 2022. The Design Society, p. 10–10. 10.35199/dfx2022.07
- Kossack, F., Bender, B., 2023. Individualization in Engineering Design Education: Implementation of an Adaptive E-Learning Environment (ADE-LE). In *Proceedings of the International Conference on Engineering Design (ICED) 2023*, 2295–2304. 10.1017/pds.2023.230.
- Kossack, F., Bender, B., 2024. Engineering design education at German universities: potential for a common basis to create personalized e-learning content. In *Proceedings of the Design Conference 2024*, 2885–2894. 10.1017/pds.2024.292.
- Kossack, F., Neumann, M., Bender, B., Dillenhöfer, F., Kunne, B., Sersch, A., Gust, P., 2024. Learning Content in Engineering Design Education: An Analysis for Developing Learning Materials Used at Multiple Universities, In: *Proceedings of NordDesign 2024*, Reykjavik, Island, pp. 115–122. 10.35199/NORDDESIGN2024.13.
- Krathwohl, D.R., 2002. A Revision of Bloom’s Taxonomy: An Overview. *Theory into practice* 41 (4), 212–218.
- Metraglia, R., Baronio, G., Villa, V., 2011. Learning levels in technical drawing education: proposal for an assessment grid based on the european qualifications framework (EQF), In: *International Conference on Engineering Design ICED. ICED11*, København. 15.8-18.08.
- Moodle Contributors, 2026a. H5P. URL: <<https://docs.moodle.org/501/de/H5P>>.
- Moodle Contributors, 2026b. Moodle. <https://moodle.com/about/>.
- Moodle Contributors, 2026c. Quiz. URL: <https://docs.moodle.org/501/en/Quiz_activity>.
- Niegemann, H.M., Domagk, S., Hessel, S., Hein, A., Hupfer, M., Zobel, A., 2008. *Kompodium multimediales Lernen*. Springer Berlin Heidelberg, Berlin, Heidelberg.
- Pfäffli, B.K., 2015. *Lehren an Hochschulen: Eine Hochschuldidaktik für den Aufbau von Wissen und Kompetenzen*, 2nd ed. Haupt, Bern.
- Reinken, C. and Kalinovich, A. (2022), “Success Factors for the Use of Open Educational Resources - A Quantitative Survey with Students”, in Bach Tobji, M.A., Jallouli, R., Strat, V.A., Soares, A.M. and Davidescu, A.A. (Eds.), *Digital Economy. Emerging Technologies and Business Innovation*, Lecture Notes in Business Information Processing, Vol. 461, Springer International Publishing, Cham, pp. 55–69 10.1007/978-3-031-17037-9_4.
- Schönwald, I., 2007. *Change Management in Hochschulen: Die Gestaltung soziokultureller Veränderungsprozesse zur Integration von E-Learning in die Hochschullehre*. Zugl.: St. Gallen, Univ., Diss., 2007, 1st ed. Eul, Lohmar.
- Sersch, A., Sauder, C., May, D., Gust, P., 2025. Interdisziplinäre und kompetenzorientierte Vermittlung der Geometrischen Produktspezifikation (GPS) im Kontext vernetzter Produktentwicklung, In: *Gemeinsames Kolloquium Konstruktionstechnik*, Bayreuth.