DEVELOPMENT OF MODULAR E-LEARNING MATERIALS AS OER FOR A MOOC

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ABSTRACT

This paper is (I) a report about the development of modular E-Learning materials as OER for a MOOC and the changes regarding the creation surrounding Covid-19, as well as (II) an evaluation of the changes on the initial situation of higher education met in 2019 in contrast to the current situation for teachers and learners that is given through the availability of the developed modular MOOC. Advantages and limitations for the creation of E-Learning materials within a syndicate are discussed and a survey conducted at six German universities is evaluated in order to indicate the encountered changes precisely. Moreover, the framework including the modularity of the learning materials in combination with the principle of Constructive Alignment is described and analyzed. The empirical data regarding the students and teachers experience with the framework and learning materials collected through the survey are discussed elaborately. Last but not least, a conclusion on the consolidation and continuous use of the learning materials is drawn, which shows that transparent learning objectives help to raise the students' motivation.

KEYWORDS

E-Learning, Higher Education, Creating E-Learning Courses, Engineering Education, MOOC

1. INTRODUCTION

Technical drawings are a fundamental tool for communicating technical product specifications (TPS). In times of advancing technological development, digitization and globalization, clear communication continues to gain in importance. Not only engineers, but also designers, production employees or employees in quality assurance have to deal with them. The field of technical drawings is usually a basic subject for engineering students at undergraduate university level.

Since the teaching topic of technical drawings is basic and mostly standardized, it is well suited for Open Educational Resources (OER) and an overall Massive Open Online Course (MOOC). Open Educational Resources (OER) are educational materials under an open license that allows free access as well as free use, editing, and redistribution by third parties without or with minor restrictions (Unesco, 2019). For this reason, six German universities united to create and advocate an MOOC consisting of modular OER.

The aforementioned project was planned before the Covid-19 pandemic to promote OER, while the project itself started during the pandemic. This led to various changes relating different groups and factors that are described within this paper. At the same time the number of MOOC across the world doubled, according to C*lass Central*, from around 10,000 in 2019 to over 20,000 in 2022 (Shah, 2021).

The work described in this paper is (I) a report about the development of modular E-Learning materials as OER for a MOOC and the changes regarding the creation surrounding Covid-19, as well as (II) an evaluation of the changes on the initial situation of higher education met in 2019 in contrast to the current situation for

teachers and learners that is given through the availability of the modular MOOC consisting of OER. For this purpose, students, teachers and didactic experts have been included in the pretest and the final evaluation to get a complete overview. Moreover, it is analyzed in what way the OER are compatible with a MOOC and a modular framework that fulfill the needs of numerous professions covering some topics at various levels in different depth. The aim is to give an overall view of the extent to which the above concepts can be combined and what conditions must be in place in order to fulfill certain framework conditions based on empirical results.

2. STATE OF THE ART

The teaching of technical drawing in the academic context is influenced in many ways and "a shared technical drawing assessment grid" was proposed in 2011 (Metraglia, 2011). This proposal plans to design a "grid for the evaluation of Technical Drawing learning levels" for the European Qualifications Framework (EQF) (Metraglia, 2011). Didactic concepts could base on these learning levels. To design competency-orientated learning, the principle Constructive Alignment is used to align learning objectives, assessment tasks and teaching/learning activities (Biggs, J. & Tang, C., 2011). Teachers have generally planned their courses from the perspective of subject content - students, based on their learning on the concrete requirements for the examination. These different perspectives can lead to a situation where learning and teaching are not aligned and this is perceived as unsatisfactory by both sides. The concept of Constructive Alignment helps not only to coordinate learning objectives and learning methods, but also to include the examination in the planning of a course. These learning objectives are the basis for the design of all learning and teaching activities and learning outcome assessments (Biggs and & Tang, 2011). The different cognitive levels (learning objectives taxonomy) are defined according to Bloom's origin and range from pure knowledge through understanding to evaluation and judgment (Bloom, 1974; Anderson et al., 1994).

Another framework for planning phases and work steps for designing virtual learning modules is provided by Arnold et al. to create E-Learning material (Arnold et al., 2004). Here, a chronological procedure with the different aspects of the concept like professional needs, the didactic structure, formal structure including the learning space and the operational structure are taken into account. Also, some important requirements that need to be addressed are mentioned: accessibility, necessity for quality management, adaptability, metadata, evaluation, didactic concept, and a concept for consolidation (ibid.).

The combination of e-learning and learning on-site is a central didactic task in the design of modern, education. "Blended Learning is the strategic combination of online and in-person learning" (Picciano et al., 2021). It is a successful learning and teaching concept if it works to coordinate those formats both in terms of content and organization. This was also established by the 2016 Horizon Report, which highlighted blended learning as a leading key trend in higher education (Johnson et al., 2016, p. 18). Blended Learning combines positive effects of both learning strategies showing "improved outcomes, though blended conditions tended to involve more instructional time, instructional resources, and elements encouraging peer interaction among learners" (Picciano et al., 2021). In contrast, the hybrid learning concept uses presence and digital learning taking place simultaneously (Liat and Einat, 2021).

Blended learning concepts can allow students more flexibility and individuality. They have the opportunity to work through the e-learning content on their own schedule and at their own pace. And teachers can also benefit from more flexibility in the execution of their teaching, which cannot be created in this way by pure face-to-face teaching. An analysis of national and international lecturer and learner surveys conducted by the University of Marburg revealed that lecturers want to provide more digital teaching opportunities for students in the future (Breitenbach 2021).

Nevertheless, a transformation phase of digital teaching is going on and further measures need to be taken to promote the integration of digital teaching into university teaching and to ensure the quality of the developed concepts, especially with regard to increasing the digital competence of teachers as well as addressing clarity, didactics, infrastructure, and legal issues (Krempkow et al. 2022; Marchwacka et al. 2023; Breitenbach, 2021). The provision of digital teaching and learning content with orientation aids represents a first step toward structured digital teaching. Some work to create sticky MOOC (Oakley et al., 2016) and discussing the challenges of creating a MOOC (Sánchez-Vera et al., 2015) were established among others.

3. INITIAL SITUATION, PRE-EVALUATION AND SHIFT

Considering these challenges, the learning and teaching content for technical drawing was to be digitized within the framework of a project of various German universities, described in this paper. In addition, making the content available as OER on the state-wide, cross-university online portal for study and teaching (ORCA.nrw) is a goal of the consortium. The target group consists of both teachers and learners in higher education at undergraduate level from engineering faculties.

Two surveys were conducted to assess the status quo according to the subject of technical drawing and to derive a framework for content development. First, 259 students from six universities of the consortium were surveyed about the difficulty and scope of the content as well as media use. On the other hand, semi-structured interviews were conducted with members of the consortium as well as the members of the project monitoring committee to obtain an overview of the didactic concepts currently implemented.

In the following, the most important results of 2020 (see Dillenhöfer, 2022), based on the components of Kerres' framework model of didactics (Kerres, 2018), are explained in more detail.

Conditions: The involved consortium states that there is a wide range of courses with different technical depth in the field of technical drawing. The focus is on the undergraduate level, namely 1st and 2nd semester, and medium to large numbers of participants (from 20 to 500 per university module, over 10,000 students will be addressed state-wide) are expected.

Teaching/learning content: The amount of content covered is perceived by students as average. When evaluating the degree of difficulty of the content, the answers tend to scatter on the possible scale from 1 (low) to 5 (too high) with a normal distribution around the mean value 3. This can be attributed to the heterogeneous prior knowledge due to different educational biographies (e.g. training, basic internship, no prior knowledge).

Media used: Opinions also differ in terms of the media used. There is a basic satisfaction, but also a need for improvement. So far, video recordings, slides, scripts, and textbooks are among the materials used.

Organization of learning: In the surveys, traditional formats like lectures and other concepts of front-of-class teaching predominate over digital formats. Digital formats are already widespread in online semesters due to the switched initial situation as a result of the Covid-19 pandemic. However, they are geared to face-to-face teaching and are generally designed from the perspective of the lecturer.

These findings result in the following requirements for the teaching and learning materials to be developed:

- No presupposition of previous knowledge (because of the early stages of study)
- Introduction of categories for grading the technical depth of the content (because of the different courses as target groups)
- Reduction of support effort and planning for scalability (because of the large number of participants)
- Planning and designing self-learning materials from the students' perspective (to ensure student-centered teaching)
- Enabling diversity of materials and media (to enable individual learning paths)

Furthermore, the analysis of the current state of digital media revealed that, despite the university-specific differences in the content offered, most subject areas are similar. For example, the topics of freehand sketches, dimensioning, sectional views or fits are represented at each of the universities. Therefore, a modularization of the contents in the later procedure seems to make sense. Also, very few universities have formulated concrete, competence-oriented learning objectives. However, these are essential for the Constructive Alignment.

However, the initial situation changed through the Covid-19 pandemic. Not only consortia meetings could only be held digitally, but also requirements for content creation switched. For instance, non-digital teachable skills like the creation of technical drawings by hand have become attentive. On the other hand, digital learning and the digital skills have become more common on both sides (teachers and students). Another driving factor was the variety of digital learning software that grew fast after the pandemic started. In conclusion, there were positive impacts for the creation of E-Learning materials.

There are some requirements restricted by the OER-portal ORCA.nrw, which overlap mostly with the E-learning requirements (see chapter 2). The most important requirements regarding the online course are listed as follows:

- (digital) accessibility,

- necessity for quality management,
- public license (CC BY-SA 4.0, CC BY or CC 0),
- compatibility with Blended Learning (see chapter 2),
- Constructive Alignment, compatibility with Blended Learning (see chapter 2),
- curricular integration,
- and a concept for consolidation (ORCA, 2022).

The consortium declared some hypotheses for the future work on the change on the situation regarding the technical drawing topic in higher education:

Hypothesis 1: By working in a large consortium with different teaching approaches, a versatility of learning materials is available. This simplifies the creation of modular teaching/learning content and ensures quality assurance for continuity. However, it is difficult to defy modular boundaries that are overall valid globally.

Hypothesis 2: Since metadata have become more and more important in times of fast-growing availability of OER-materials and MOOCS, it is crucial both that learners get the material they are searching for and that is suitable for them. Thornhill and Hyman mentioned user-focused metadata as making "the process of storing, sharing and tracking digital assets much easier" (Thornhill and Hyman, 2023).

Hypothesis 3: Through making teaching and learning goals more transparent, learners' acceptance on these goals are raising, which also elevates motivation.

It is expected that the misconceptions between teachers and students decrease, and the formulated competence targets coincide (Dillenhöfer, 2022). Metadata are important to find the well-suited material. Because the material was not fully created for the last winter semester, it was only an add-on to the teaching material at the universities and was not implemented inside the learning material. This will change in the future, where the material should be directly integrated into the topics the different universities deal with.

4. CREATION OF E-LEARNING MATERIALS

According to the structure plan, the data of both the participating project partners and some other statewide universities are collected, analyzed and processed. Afterwards, the main content topics will be developed in a structured manner, the lecture and examination framework conditions as well as common requirements and special areas will be defined. Content creation is assigned to all editors according to their expertise. Subsequently, the digital teaching/learning offerings are first conceptually created and then finalized before quality assurance measures are implemented. The project partners exchanged information and coordinated with each other. The requirements for the different stakeholders were then processed. Finally, work groups for each important topic were formed, so that the creation of the material could be done by means of their particular expertise. These groups then formulated learning goals with the help of didactic experts, which checked the compatibility with Constructive Alignment. While the topics are almost the same or similar at many universities across the board, there are some different focuses on certain topics, so it is difficult to define modular boundaries. On the other hand, many topics overlap and need to be linked together. Another challenge is that students have very different experiences when they enter university.

The aforementioned situation necessitates several levels of difficulty to meet the requirements. In order to do so, three competency levels namely easy (remember & understand), medium (apply & analyze) and difficult (evaluate & create) have been formulated according to blooms taxonomy (see chapter 2, see table 1). With these subcategories it is possible to adapt the learning materials to the different levels of experience and to the extent of dealing with a certain topic in different levels of complexity, according to the student's needs. Thereby, teacher can build their own course with the elementary topical components without losing actual eference to the main topic and learning goals.

The whole course focuses on a high level of interaction. Students should be able to evaluate themselves. To achieve this goal, tests are used to test whether the student reached a complexity level regarding a special topic or not. Another part where these tests are used is a learning map. This has been created so that (I) the students are able to get an overview of the learning landscape, as well as (II) the progress they made overall and to see clearly what is coming next or what are the future goals to be achieved. The progress is being tracked via different h5p-elements fading in and out, where the students see both a progress bar and a student icon going down a progressing learning path. Additionally, the tests for the taxonomy level reached fade in

and out if one has completed the previous test with over 90 % of correct answers successfully. This gives the whole course a touch of a gaming approach, which should lift the students' motivation. Also, new (partially) virtual learning scenarios, namely Blended Learning, Inverted Classroom (Flipped Classroom) and Game Based Learning, considered were, so teachers are able to combine the material that they take from the course offer with the scenarios they use.

Table 1. Taxonomy levels according to Bloom divided into three subcategories in terms of modularity

Complexity level ↓

Remember	Copying, defining, finding, locating, quoting, listening, repeating, retrieving, …	easy
Understand	Annotating, associating, tagging, summarizing, relating, categorizing, …	
Apply	Articulate, reenact, loading, choosing, determing, displaying, judging, executing, …	medium
Analyze	Calculating, deconstructing, linking, organizing, attributing, explaining, …	
Evaluate	Arguing, validating, testing, assessing, criticising, debating, grading, predicting, …	difficult
Create	Building, adapting, composing, directing, simulating, solving, managing, negotiating, …	

5. EVALUATION

The evaluation is categorized into two layers: macro-evaluation (general MOOC/OER) and material-evaluation. The aim is to get reliable empirical results on the acceptance of learning goals and the perception of the whole course. Other factors besides acceptance that are being evaluated are: learning goals, didactics, and media related. In order to determine the degree of agreement regarding the questions, the Likert scale, developed by Rensis Likert (1931), from one to five (strongly agree-strongly disagree) is implemented (e.g. Croasmun and Ostrom, 2011; Gay, L. et. al., 2009).

The survey was conducted online and is structured into five parts:

1. General information (e.g. number of semesters)
2. Topic OER
3. Importance of the topics and personal assessment of the abilities with regard to the topics
4. Use and rating special topics
5. Personal comments

51 students participated in the final evaluation survey. Most of them are inside the first semester and the majority are studying mechanical engineering. Most of the students have no experience or previous knowledge regarding the topics. In general, the students think OER are positive and should be used more frequently in higher education. This is where teachers strongly agree. But in contrast, only 20 % of the students worked through the given topics, although the topics were important for the exam. Therefore, there are some limitations of part 4 of the survey structure (use and rating special topics) regarding the scalability of these results because less students answered these questions.

The evaluation regarding the learning material shows that every student agreed or strongly agreed, because these materials are coherent and a good support for the exam, well interactively designed, raised the knowledge, presented good in terms of media and well-suited for the lecture, except for one topic out of ten. Likewise, the results were positive for the acceptance of the learning objectives and the quality of the learning materials (see Fig.1). Few students (25 %) mentioned that the topic of creating technical drawings by hand is rather unimportant. This changed compared to the initial survey, where the majority (> 80 %) of students stated that drawings by hand are unimportant. The scope was judged as appropriate in each case. Exactly the same results as at the initial survey are reached regarding the scope for the topic CAD (Computer aided design), where the students wish a higher availability of learning material. Students also want more learning material for other topics, even though most didn't use the offered OER materials. The students also estimated their abilities and knowledge regarding all topics mostly as quite good or very good, so they estimate their ability as good.

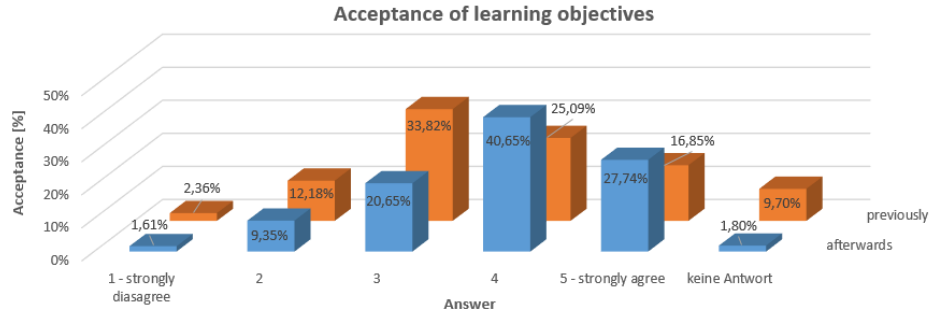

Figure 2. Acceptance of learning objectives by the students previously in 2020 and afterwards in 2023

Teachers stated in interviews that the modular learning material kit is transparent and easy to understand. They are satisfied with the extend of the offer, the structure and the division, how the material is split into subtopics of different taxonomy levels. However, the students found it more difficult to find the right taxonomy level that is needed for their study.

6. DISCUSSION

According to the initial survey, many factors and circumstances have changed. This led to digital skills that students and teachers have developed over the past few years. With respect to the media both teachers and students are more open to new possibilities and technologies, as well as better in adopting new skills for new software solutions (Raju, 2021). This also reflects in the final evaluation survey, where almost everybody agreed that the media used are good to work with and helped to reach teaching/learning goals. Furthermore, the acceptance of some topics have been grown because of transparent learning objectives. That means that the implementation of the Constructive Alignment to tackle the problems found in the initial survey worked quite well. Now students seem to understand, why certain skill sets are not only crucial for future topics, but also for professional skills needed in the workforce later on. However, students and teachers review OER material good in general. The positive status could be explained by the expansion of available learning materials as well as the possibility of free use and public discussion.

On the other hand, using OER materials voluntary is not working well, because according to the final evaluation, only few students used these learning materials. Course administrators stated that over 300 students are registered in the course and many other students use the experimental course without authentication. The tracking of activities shows that many students executed the test for checking the taxonomy level. It seems that the students who used the material did not participate in the survey and vice versa. At this point, it can be recognized that voluntary surveys do not work fine as they should be. Reinforcing factors are needed to raise the participation. Moreover, when the material will be integrated into a special lecture, it is assumed that more students attend in the survey, as well as the overall OER learning material.

Another result described in chapter five is that students wish more learning materials in terms of some topics, but they do use the offered OER materials. These must be put inside the official teaching material; otherwise, Students will disregard these topics since it may seem unimportant for the exam. Therefore, the students focus more on preparing for the exam instead of trying to achieve skills for future profession. In this course, this topic is only discussed inside the motivation/introduction, which many students skip. A possible solution would be making the introduction mandatory, so that the following topics/material only fades in, when the introduction is finished.

Metadata are an important tool to help finding the material one is searching for. These Metadata were prepared but have not been entirely applied yet. These will be included fully when the course will be uploaded to the ORCA.nrw platform where also OER-searching indexes are implemented. Then it should be also easier for students to find the material that fits their needs.

In general, it was an advantage to create the MOOC/OER learning materials with many partners, because of the impact of different perspectives and experiences. All topics are covered, and the work can be split according to each expertise. Splitting the work helps to cover the whole topical landscape, so that the offer is complete, and every teacher is able to serve themselves. Building work groups helps to effectively editing

and produce the learning materials. The partners can then start a review process on the learning material so quality is being ensured.

Besides the assurance of quality, consolidation is important for future use. This is mainly complied through the complete topical landscape that is covered, the consideration of various requirements of different groups involved, the quality provisions and measures such as evaluation, offer materials with public license so one can edit and adapt it, and publishing results. Moreover, all universities need to be informed that these offers are now available and open to use freely.

The creation of an E-learning MOOC a lot of work at the beginning, but if it is used frequently and the tests are evaluated automatically, development is worth it. Then, there is less work for teachers to assess the students. Using learning analytics can also help both teachers and students to obtain interesting information about the learning progress, so they are able to supervise precisely and quickly if problems occur.

Moreover, it is difficult to create modular learning materials that are coherent. When someone picks out the parts they need for their degree, there is a risk that the materials lose the connection to the other materials or the course. This has to be taken into account when creating modular learning materials.

7. CONCLUSION

This paper presented a framework on how to integrate OER into MOOC with regards to modularity. At the beginning, the initial situation including the requirements of the various groups was demonstrated and how this situation shifted through the Covid-19 pandemic. Furthermore, it is shown how the modular aspect can be realized with the didactic model of Constructive Alignment. Creating E-Learning materials or respectively a MOOC with many partners is a big advantage and should be supported, so that hypothesis 1 is correct.

Hypothesis 2 deals with the importance of metadata. It was not possible to analyze this hypothesis fully, because the MOOC was not implemented into the learning portal where many education offers are present. Thus, the searching and finding have not been evaluated yet. But since teachers found these metadata helpful in pretests, and students had difficulties finding the right material, it is estimated that hypothesis 2 can be confirmed. However, further work needs to be done when the learning material is actually implemented inside the lectures. Students hesitate to use it according to interviews, so it should not be available as a coexisting offer.

Last but not least, according to hypothesis 3, misconceptions, such as the acceptance of learning goals, between teachers and students decreases and the formulated competence targets coincide, if the goals are made more transparent. This can be confirmed, because the acceptance regarding some not accepted learning objectives in 2019 has been grown (see chapter 5).

Another factor is the omnipresent license information and logos. These ever-appearing distractions could impede the learning process. It should be researched how these influences on the learners when they access the material and see these information everywhere at the beginning or at the end.

Finally, the course will be published on ORCA.nrw soon and should be available during the summer term 2023.

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