Implementation of E-learning in an Electrical Engineering Study Program

Infrastructure, Experiences, and Lessons Learned

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***Abstract*—This paper reports on the development of e-learning material for a blended-learning part-time study program in electrical engineering and information technology. It is focused on the entire process of creation, from the perspective of instructors and higher education professionals supporting the production. In the design of the program, the development of effective study material including e-learning content for the target group was one of the main objectives. Associated with the development of this material, various challenges had to be overcome. In the following, we describe the development and implementation process of the material using results from a survey among lecturers who were contributing e-learning to the program. Different manifestations of e-learning are discussed, and the whole process of production is reviewed. In the current efforts for digitizing higher education in Europe, the findings may be relevant for universities' e-learning strategies.**

***Index Terms*—e-learning development process, e-learning strategies, electrical engineering, instructors' perspective, lessons learned, study program.**

I. INTRODUCTION

A blended-learning part-time study program in electrical engineering and information technology has been developed at a German University of Applied Sciences [1]. The program aims at non-traditional students as a target group, and was realized in the context of a research project supported by the German Federal Ministry of Education and Research under the initiative "Upward Mobility through Academic Training: Open Universities" [2]. In order to achieve the intended learning outcome, the study material with e-learning content for the target group was essential. In the following we investigate the whole process of its creation. Since blended-learning scenarios and the flipped-classroom method [3,4,5] seem most efficient for learners, a more systematic approach towards the creation of e-learning material for programs is to be expected [6].

Our findings may be useful in this context for the next initiative of digitalization in learning at higher education institutions [7,8]. Strategies for implementing digital elements into learning at university level will also have to take lecturers' preferences into account. We are aware of the fact that most likely the discipline of a lecturer may play a role, not only as far as teaching methodology is concerned, but also due to the affinity of his or her field of expertise with teaching technology. In our situation, contributing lecturers originated from electrical engineering, computer science, physics and mathematics. When Thrun's MOOC enthused the community in 2012 [9], some of them became excited about the new ideas, and started discussions how to adapt these concepts as first followers. In this favorable situation, the here-reported initiative for developing e-learning study material was able to pick up pace.

II. DEVELOPMENT AND IMPLEMENTATION PROCESS OF E-LEARNING

A systematic approach was needed since e-learning was meant to be a common thread of the entire study program. Therefore, quite a number of lecturers and subjects had to be handled in a limited time span. Fig. 1 illustrates our process model for development and implementation of the e-learning study material, consisting of six phases. These phases will be explained in the following sections.

A. Opening Workshop on E-learning

The process started with an opening workshop for interested lecturers who planned to be involved in the study program. The name of the project 'Open e-University' indicates that e-learning was meant to be an integral component of the proposed instructional design, needed to meet the time constraints of the target group. By joining the program, lecturers committed themselves to provide e-learning material for use on a learning platform, in this case *moodle*. The first workshop was mainly used to motivate the participants to create innovative blended-learning course designs. A presentation of various e-learning tools (e.g. screen-recording tools, software for interactive e-learning, short e-lectures, chat, and discussion forum) gave basic information to the lecturers and was meant to trigger ideas for realization. Every participant of the workshop was informed when the material for the new study program was needed.

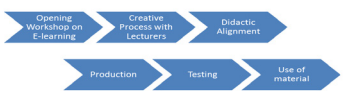

Figure 1. E-learning development and implementation process

B. Creative Process with Lecturers

A questionnaire concerning e-learning was developed in order to get information from the lecturers, who were facing the challenge of using the possibilities of new media. They were asked about their ideas for using e-learning content within the modules, their preferences, assistance needed, their experiences with e-learning, and worries. At the end of the opening workshop, potential lecturers (N=12) of the new study program filled out the questionnaire as a basis for further development. The results are summarized in Fig. 2. The answers show that only a small number of the lecturers had e-learning material ready which could be used in their courses. Moreover, the answers indicate that half of the lecturers have already used e-learning in their courses, whereas the other half of the lecturers have not. We were furthermore interested in the lecturers' experiences with the learning platform *moodle*. The majority of the lecturers had already gained experiences with *moodle*; only a small number lacked experiences. Although a fair number of the lecturers were experienced with the learning platform and had already used e-learning in their courses, they wished to get more information on e-learning, and in particular, wanted to discuss ideas for potential e-learning applications. However, the majority of the lecturers had concrete ideas for potential e-learning applications. The last question shows that all participants of the workshop needed assistance for the development of e-learning applications.

For planning the e-learning production process, support structures, and the purchase of appropriate hardware and software, the project team was furthermore interested in the e-learning applications that the lecturers had in mind. Therefore, they were asked about their preferred tools and e-learning applications they planned to use in their courses.

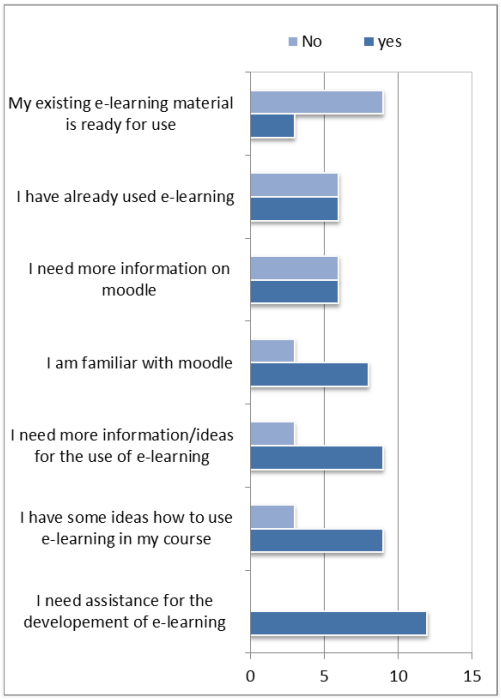

Figure 2. Lecturers' experiences with e-learning and the use of the learning platform moodle (N=12)

Fig. 3 shows which tools the group of lecturers (N=12) intended to use in their courses towards an electrical engineering degree. The "top five" were online-tests/e-exams, online training tasks, video sequences, online surveys, and digitization with a visualizer. At this point the lecturers could hardly imagine using podcasts, special subject-specific applications, e-lectures, wikis, interactive tutorials, animations, chats or virtual classrooms. These are the items that received less consent.

The lecturers' answers helped the project team to obtain a good overview of their plans for e-learning material, which could be used for the next steps in the process.

C. Didactic Alignment

Based on the results of the questionnaires several didactic consultation sessions followed. In a first step, lecturers were introduced to the didactic design of the study program. It is based on a blended-learning concept, consisting of self-study phases at home, when students learn with e-learning material in combination with a subject-specific textbook, and phases of attendance at the university once a month.

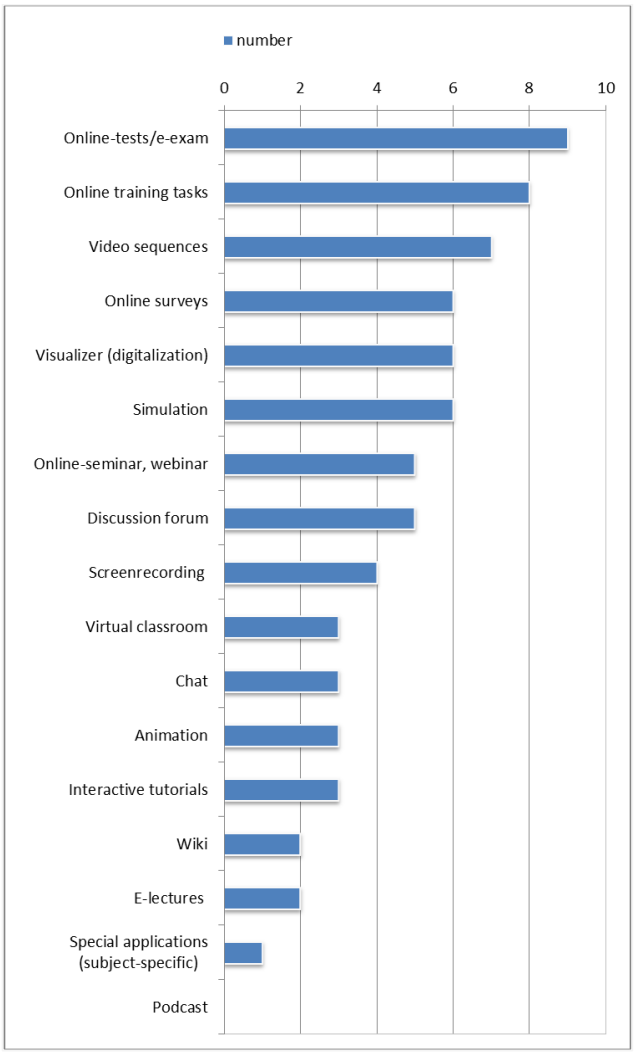

Figure 3. E-learning tools that lecturers plan to use

The three learning channels – e-learning, face to face, and reading – should be mutually coordinated in order to get a well-rounded didactic concept. Therefore, in-depth interviews with the lecturers helped to clarify the intended didactic concept and to prepare the development of the e-learning material: Higher education professionals discussed didactic concepts along the lines of media didactics [10] with the lecturers. The following questions served as a basis for the discussion with a focus on learning outcome: 1.What is the difference between daily classes at the university and distance-learning courses? 2. How can e-learning support distance learning? 3. Which content and which structure have proven to work for my module (in class)? 4. What can be transferred to distance learning, and supported by e-learning? Based on these questions new concepts for distance learning were developed jointly between lecturers, experts of their subject, and e-learning professionals. As a result, a detailed plan was drawn up for each distance-learning course and for its supporting e-learning material. Several sessions were needed to plan the production phases with the necessary equipment.

D. Production

Subsequently the production phase of the learning material followed as a two-fold (parallel) process. On the one hand teachers were writing down the textbook material; on the other hand they started the production phase of the e-learning material, both closely coordinated. A guide consisting of several documents was provided for all lecturers to make sure a consistent program would be developed. These documents encompassed not only the module manual but also information on the didactic structure of the textbook and on its design for a uniform look. Similar guides are best practice in established distance-learning centers, such as Oldenburg University [11] or at the ZFH - Centre for Distance Studies at Universities of Applied Sciences, situated in Koblenz [12]. For the actual development of the e-learning material a small team, consisting of an e-learning expert (member of the project team), the lecturer, and a few student assistants, was formed for collaboration in the experimental production phase. The various tasks during the production phase can well be assigned to different team members. The lecturers being the experts of their subjects provided content-related input, the e-learning experts gave didactic guidance and directed the technical realization, and the student assistants supported the realization and took care of the post processing of the e-learning material. Depending on the intended didactic concept of the module, a variety of e-learning tools and technologies, e.g. screen recording software, authoring tools, and video-recordings, were used for the production of the material. Screen recording software was frequently used. Serving the module “Mathematics for Engineers” we recorded small explanation videos for several topics. Screen recording was also used for the module “Principles of Electrical Engineering”, where short lecture recordings were subsequently organized in small learning units. Video recordings were used where experiments are in the main focus, for example in “Physics”, or in the module “Learning from Engineering Solutions”. For the module “Programming with C++”, screen recording software was used; additionally an authoring tool was applied in order to produce small interactive learning units with integrated questions and adaptive comments. Depending on the nature of the module several meetings were necessary to get all recordings done.

E. Testing

As soon as the material for a module was ready for deployment, a testing phase followed. Full-time students of an existing program in electrical engineering tested the e-learning materials’ functionality and content. Mainly writing errors, wrong text passages or recording errors were found. Thus, trouble shooting could be done, and the material could be improved in a feedback loop.

F. Use of Material

Finally, the e-learning content for each module was put on the *moodle* platform and made accessible for the target-group students. Their use of the material has been evaluated [13].

III. CHALLENGES

During the development and implementation process several challenges had to be mastered. In the beginning a lot of organizational matters had to be settled, which will be described in the following section.

A. Learning Management System

Initially it had to be decided whether to use the existing learning management system *moodle* [14], which was already installed at both universities of applied sciences (Darmstadt and Aschaffenburg) or whether to establish another one, possibly specialized for distance-learning purposes. After consideration of advantages and disadvantages the decision was made in favor of *moodle*, because it was already in use at both universities, it is generally well-known, and most lecturers were familiar with this system.

B. Purchase of Appropriate Equipment

In the beginning we had to decide which hardware and software we should purchase for the e-learning production phase in order to realize the lecturers ideas. We started from scratch because the study program was developed as a project. No equipment was available for producing e-learning material. That’s why the above-explained process structure seemed most appropriate to us in order to be able to realize the lecturers concepts later on.

C. Concerns of the Lecturers

Furthermore, concerns of the lecturers who were not familiar with putting their learning material online had to be taken seriously. A major fraction of the lecturers was not used to distributing their learning material via the learning management system only. Similarly, communicating with the students over a distance via the learning platform was really new to them. The production of the e-learning material was a new experience which resulted in different general concerns: Some of the lectures did not like to be filmed: they were either afraid that the material was not safe on the learning management system, or they anticipated that the online material could replace them.

D. Time Limitations

Tough time limitations were present during the project: the study program was scheduled to be launched in the fall of 2013, imposing a strict requirement for development of the e-learning material. Since e-learning material for the whole study program had to be produced in a comparatively short period, work took place in parallel. Since the study-program development was a joint project between Aschaffenburg and Darmstadt University of Applied Sci-

ences, with lecturers of both universities involved, the work was broken down and allocated to lecturers of both universities. Each e-learning production team at one site provided support for the lecturers belonging to the respective University of Applied Sciences.

IV. E-LEARNING IN USE

A. The Way E-learning Material is Used

The e-learning material in question has been in use since fall semester of 2013. The following section shows in detail how we are using e-learning material for distance learning in the program "Electrical engineering and information technology". Evaluation of the different modules shows that students are satisfied with the learning material [13]. We attribute this to the suggested process-oriented model that was applied to the production of the different modules coming from different authors.

In total, the study program consists of 34 modules. However, because of time limitations, capacity problems, and lesser suitability of some modules, it was not possible to produce e-learning in an extensive way for all of these modules. Our experiences in producing e-learning content showed that some modules are more appropriate than others, depending on the structure of the module. Lecturers of application-oriented modules often set other priorities (e.g. project work, team work) rather than focusing on e-learning development. In these cases e-learning is mainly used for support. Lecturers of basic modules often produce e-learning content to convey information or to explain something. Altogether, we stuck to the ideas that each module should have its own *moodle* course, and all material is provided via the learning management system.

B. Basic Structure of a Module

In order to achieve a degree of uniformity within the *moodle* courses, a template was generated for these courses, regardless of the amount of e-learning used in the module. The basic structure mainly consists of communication channels which are crucial in distance learning. The "news forum" supports communication between lecturers and students over a distance. Within this forum instructors can send messages to students, but students cannot reply. This is an example for one-way communication: lecturers can inform all participants of the course. Typically, they would use this channel for general information important to all course participants. A further communication element is the "discussion forum", which offers two-way communication between students and lecturers. It is mainly used for questions concerning the module's content. Every course participant is allowed to post in this forum. Beside these functions, an online-feedback opportunity is included within each *moodle* course. In addition to the summative evaluation at the end of the semester, students are encouraged to give feedback during the semester, asynchronously and anonymously.

C. Currently Used E-learning Material

The following section shows how lecturers implement the e-learning material in their courses. Since the start of the study program, six semesters with a total of 21 modules have been carried out. Within these modules e-learning is used in different forms. Some modules contain a high proportion of e-learning, others a lower one. Fig. 4 gives a detailed overview of the material in use within the N=21 modules.

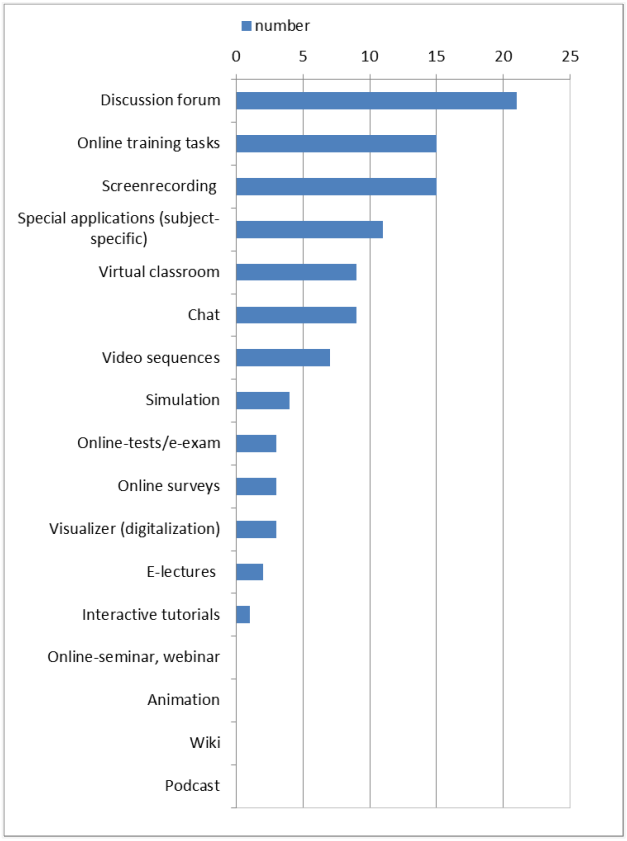

Figure 4. Currently used e-learning within the study program modules

Fig. 4 shows that a discussion forum was placed in each module as a standard feature. They are the main communication channel for distance-learning students besides
e-mail communication. Online training tasks are also used very often. These tasks – of which different forms exist – are made available online. For feedback, students send their solutions to the lecturer via e-mail or upload to the learning platform.

Screen recordings are preferably used for short recordings of a few minutes up to 20 minutes. This technique is preferably applied for detailed explanations combining video and audio. The term "special applications" summarizes dedicated electrical-engineering software and hardware, lab@home applications, and audio-recording tools for language training. These applications offer a wide didactic variation for the lecturers. The students like these applications because they can use them on their jobs and at home.

Some of the lecturers prefer the possibility to communicate with the students via virtual classroom application. Displaying the screen of the instructor's notebook while he or she explains something, students can interact from home via chat with microphones or post questions. Lecturers mainly used the virtual classroom application for tutorials or exam preparation. In conjunction with the virtual classroom application lecturers use chat, but none of them uses chat alone. Some lecturers recorded short video sequences, mainly for modules where physical experiments are the main focus of the subject. Fig. 4 shows that simulations, online-tests (with answers analyzed automatically), e-exams, digitalization by visualizer, e-lectures, and interactive tutorials are less popular among the majority of the

lecturers. However, some of them do implement the different tools successfully in their courses. For example, simulations are preferred mainly in mathematics for demonstrating mathematical functions and laws. Likewise online-tests are characteristic for the mathematics modules. Actually, nobody uses e-exams or online exams, neither at home or in class. Digitalization of handwritten content (visualizer) is also characteristic for the mathematics modules. For the operation of e-lectures – recordings of larger lecture sections – only a small usage can be noted. We favor short recordings because of the decreasing attention span. One of the lecturers developed interactive tutorials, which are a mixture of short e-lectures and interactive tasks with feedback. Online seminars, animations, wikis or podcasts have not been chosen by the instructors until now.

V. RESULTS AND FURTHER PLANS

In this section the initial lecturers' plans and the finally produced e-learning material are compared and discussed. Fig. 3 shows the ranking of e-learning tools in the planning phase of the study program. During the development process of the study program more lecturers were interested to contribute to the program, so that in some cases the team changed. As a result, other ideas concerning the development of e-learning were pursued, which can be seen in Fig. 4. The initial ideas do not correlate very much with the actually realized ideas. Besides the team changes, a further reason for this could be that some of the teachers recognized that writing a textbook and producing e-learning material besides the daily university routine was rather time-consuming. Thus they changed their initial plans for e-learning production. Further potential for the development of e-learning material can be identified by comparing the current status with the initial ideas. Good experiences with the distance-learning study program and the feedback of our students make us confident that a great variety of e-learning material is desirable. We imagine that doing the same type of exercise over and over again in different modules would be boring.

Since traveling to university premises for an exam of just 90 minutes is rather time-consuming and cost-intensive for distance-learning students, the development and introduction of e-exams is an interesting alternative. This could be a chance to rethink the existing formats and to create innovative designs for examination which rather support the testing of competencies than the testing of knowledge. Questions concerning the technical realization, technical support, safety reasons, legal aspects, security, and comparability with usual examination formats need to be further investigated. Besides the e-exams we see potential in online tests, which can be used not only for examination but also for purposes of practice during self-study phases. The use of online-tests with an automatic evaluation function (e.g. mediated by the learning management system) has only been taken into consideration by few lecturers until now. This effective way for self-assessment should be promoted in the next e-learning development process. In order to implement these ideas further consultation and support of the lecturers is needed. Additionally, didactic training courses, e.g. on the construction of online test questions, on the design and organization of e-exams, and on competence-oriented test formats would be helpful. This is in line with recommendations (no. 5 on p.54) of the European Commission on new modes of learning and teaching in higher education [15].

Finally, it is planned to evaluate lecturers' satisfaction with the development process and the application of the e-learning material [16]. While giving support during the e-learning development process, a lot of experience was gained that is now useful for further program development in other areas. Thus, the reported development of e-learning for a Bachelor's program can be seen as a means to introduce e-learning into the organization. Strategically, it paid off to start e-learning in a systematic way with a distance-learning/blended-learning program obviously in need of innovative digital study material.

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