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COMBINING ONLINE COURSES, METHOD PORTAL AND ONLINE EXERCISES FOR EDUCATION IN ENGINEERING DESIGN

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ABSTRACT
The education of future engineers is a challenging task. The altering requirements regarding engineering design (ED) graduates demand for adapting teaching and learning concepts. One possible way to cope the challenges caused by those demands is the integration of online media for self-study and distant learning purpose, which is slowly arising in design education. Due to the additionally required social and methodical competencies, like working in a (virtual) team, a stand-alone online course is hardly suitable. Thus, this paper presents a framework how to integrate different media based teaching and learning formats into the present courses. In addition, possibilities to contribute to an effective self-study phase are proposed and demonstrated by 3 examples from different fields of ED education: the first format is an online course dealing with methods and tools, which is completed with a method portal (second example). The third example is a learning platform on design for acoustics.

Keywords: Design Methods, Design for Acoustics, Design Education, Online Course.

1 INTRODUCTION

Online courses, e-learning material and other online-based learning and teaching formats become increasingly interesting due to their easy and permanent accessibility. Furthermore, the modern style of the presented media as well as the low-cost for the consumer support the intrusion of online media into classical teaching concepts. However, there are high dropout rates in online-based courses and the missing teaching person remains a challenge for some of the students. Especially in ED, where a high amount of practical work and team projects are helpful to develop professional but also social competencies, online courses and e-learning can only be found to a small extent. In respect to the increasing challenges of digitalization in the engineering industrial practice, the handling of online-based material and virtual communication is an important part of daily engineering practice. Thus, design education should additionally address these challenges. To do so, online courses and presence projects are adequate formats. However, the question remains how these online formats can be integrated into existing face-to-face teaching and learning environments and how the single elements can be arranged in a combination. This paper will give a first answer by presenting a framework for integrated education in our ED teaching combining web-based elements and present teaching.
First, basic challenges of teaching in ED are presented in a general sense. Thereafter, method teaching as well as design education with respect to acoustic problems will be displayed in greater detail. In addition, the challenges of online courses and self-study are described since these elements become relevant for the following framework. In particular, the specific characteristics of online courses in the field of ED are examined. The presented framework then provides a structure how to combine different elements to set up modern and suitable teaching and learning contexts. Single elements are introduced in detail, namely the interactive *method portal 'Methodos'*, the *Learning Platform Acoustics* and a *Massive Open Online Course (MOOC)*. Based on the framework, we describe the practical application of these elements within different teaching environments. Subsequently, the feedback from the participants of different courses is presented. The benefit for different target groups like students and professionals is also discussed. Based on the experiences made and the feedback gathered, lessons learned are formulated and future work is introduced.

2 STATE OF THE ART

Since the mid of the 20th century, circumstances and working conditions in ED practice have been changing a lot, which has to be accounted by design education. Thus, one of the major challenges of teaching in ED is to meet the current requirements of industrial practice and also enable the becoming engineers to participate in the design of future. At both, national and international level, teachers come together to discuss recent challenges and suggestions how to arrange design education [1, 2]. Besides professional knowledge for instance about designing machine elements or sketching, soft skills as well as process knowledge are important elements of teaching and learning environments. Therefore, team projects are seen as one of the major elements to gain experience like designing, working and discussing with others in (multidisciplinary) teams [e.g. 3, 4, 5]. Referring to a German study from 2011 among 46 professors, 40% of the actual design education consists of lectures and only 29% of team projects or other practical design tasks [6]. Hence, there seems to be the need to adapt the current teaching formats to more modern and suitable ones. On an international level, several approaches have already been introduced like complete e-learning environments for product development [1] or e-galleries and wikis making the students discuss their ideas and results on design tasks [5]. In addition, Dym et al. [4] dealt with the question how to enhance project-based learning. One of their answers is the involvement of different disciplines and cultures in (e-) learning environments.

Regarding teaching design methods and thus, the process how to solve certain tasks, first steps were taken at the beginning of the 21st century when web-based portals were developed and provided to students in order to teach methods. An example with mainly teaching purpose is 'CiDaD' [7]. More recently, the ‘InnoFox’ application has been used within student projects to provide method knowledge [8]. Furthermore, explanatory videos for methods like proposed by Reiß et al. [9] are supposed to make the learning experience more interesting. Complete online courses prepared with videos are quite rare in the field of teaching design methods. TU Delft provides a MOOC on the topic of ‘Product Design’ [10].

A special field of ED and a research field at the Institute for Engineering Design is the acoustics of products and acoustic-appropriate design. The importance of acoustics in today’s engineering education is shown by recent publications of the German Acoustical Society as it requests the maintenance and extension of education in acoustics on university level [11, 12].

Acoustical phenomena cannot be perceived visually. Thus, often physical models are used. For example, in [13] Arai proposed the use of physical tongue models in the education of speech science. Furthermore, he suggested the combination of different media types in order to form multimodal media for the use in acoustics teaching [13]. Arai composed a framework, consisting of textbooks, simulations and physical models in order to increase the learning efficiency. Another approach is given by Kob et al. [14], who propose an interactive and multimedia presented script for the teaching of engineering basics.

A general framework for setting up teaching material in acoustics with the use of computers is given by Rahkila and Karjalainen in [15]. The authors subdivide the field of ‘computer based education (CBE)’, [15, pp. 680], into three layers: content, interaction and platform. They point out that, for the content, aspects such as the appropriate selection and illustration are crucial. Furthermore, the linkage (interaction layer) of different contents (‘hypermedia’) is of importance. Both, illustration and linkage are greatly supported by the use of computer-based teaching methods.

As presented for the method teaching, a recent approach for online teaching in acoustics is a MOOC. One particular MOOC is described by Möller et al. [16]. The subject of this MOOC is the field of communication acoustics and it is dedicated to an introduction into acoustics at undergraduate level.

For both, process knowledge like design methods and technical knowledge like design for acoustics respectively, the challenges of online teaching and learning formats are similar. The students often face a decreasing motivation to participate in or to use online-based material, whereas the former may lead to high dropout rates and the latter reduces the learning outcome. Furthermore, missing contact persons like supervisors provide an obstacle for students. Nevertheless, these difficulties may be overcome by means of blended learning techniques [17]. These formats combine different modern teaching methods such as MOOCs and learning platforms with traditional, lecture based courses. Blended learning is advantageous compared to a teaching concept solely based on either lecture or online formats. As the advantages of online teaching such as time independency are combined with the possibility of face-to-face-interaction, that is still required for giving feedback, it is possible to prevent misunderstandings and assure the student’s learning progress.

3 FRAMEWORK FOR INTEGRATED EDUCATION IN ENGINEERING DESIGN

Due to the above-mentioned challenges of teaching within ED and the wide field of involvement in education, we developed a framework for an integrated education in ED at the Institute for Engineering Design of TU Braunschweig. The aim was to identify repeating topics and to form synergies. Considering this, similar topics were clustered and several additional teaching and self-learning materials were developed to fill gaps and to build up an integral and consistent picture for the students. Among these newly developed materials there are videos, online platforms as well as online exercises (see Figure 1, right). Regarding the students, the idea's framework is to transfer knowledge course-independently but still with close contact to professors. The self-learning material builds a bridge between the individual courses offered by the institute. In this way, the students can gain insights and deepen their knowledge on particular fields like design for acoustics or certain design methods like Quality Function Deployment. The students can also use the additional material during team projects, for preparing exams and during the final thesis. Regarding the professors, an advantage of the framework is the flexibility to compose courses with single elements like lectures as usual and adding videos or other self-learning material to introduce these to the students. Hence, the professors can influence the self-learning phase of the students. Important topics can be emphasized by providing specific material. The concept of the framework is presented in the centre of Figure 1. Above and below, there are two examples for specific courses: 1. the online course *Methods and Tools for Engineering Design* consists of lecture videos, team projects, method videos and the involvement of the method portal Methodos. 2. *Applied Engineering Acoustics* consists of lectures, exercises, laboratories and the Learning Platform Acoustics. The single elements are described in more detail in the following.

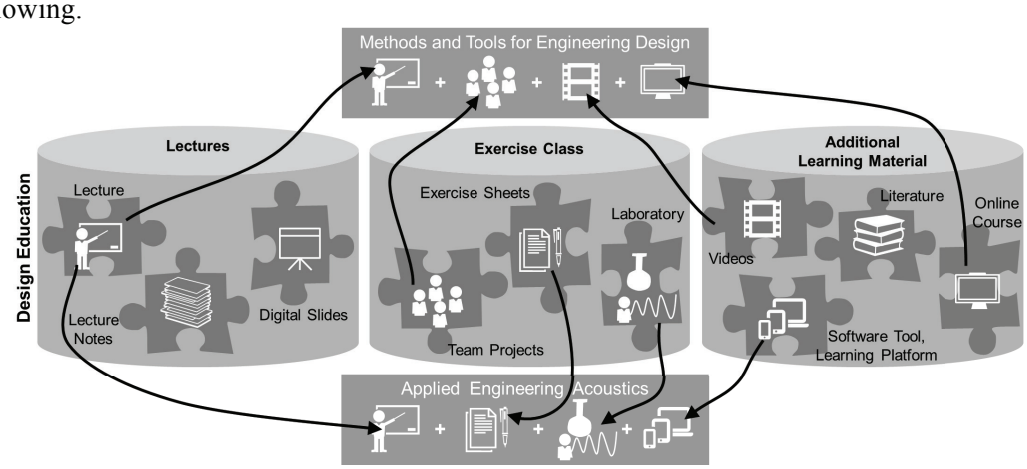

Figure 1. Framework with modern elements for engineering design education showing two examples of courses at TU Braunschweig

3.1 MOOC – Massive Open Online Course Methods and Tools for Engineering Design

As introduced in section 2, a modern way of teaching is offering online courses like a MOOC. We developed an online course dealing with methods and tools for ED in general. The idea was to present an overview of basic understanding of technical systems and to introduce basic procedures and different methods to support the development of products. The MOOC contains nine chapters with basic video lectures to introduce e.g. procedure models and gives an overview of different methods that can be applied to support several working steps within the engineering and design process. Further chapters explain functions in ED and introduce specific methods like function modelling. Additionally, within each chapter there is an exercise video demonstrating the method application and a homework exercise, which can be used by the students to practice what has been learned so far. In order to allow further learning of the introduced methods and tools, an interactive method portal is interwoven into the MOOC (see next paragraph). The interaction between the students and / or professors is managed via a discussion forum and additional e-mail contacts.

3.2 Methodos – Interactive Method Portal

During the past years, an interactive method portal called 'Methodos' has been created to collect and provide method and tool descriptions at one single place for students [18]. Within this portal, methods are described in a structured manner and information for their application is provided, for instance,

team size or required materials. To support the interaction between the students and professors as well as among students, the use of methods can be commented upon and examples of results can be uploaded similarly to online forums. This also serves as a feedback tool for the professors to gain an understanding for the quality of the method descriptions. The portal is used during the self-learning phase. The professors can also integrate the portal in single lectures or use elements like method videos [9] to diversify the class.

3.3 Learning Platform Acoustics

The Learning Platform Acoustics (LPA) is a stand-alone website which hosts teaching material used in the acoustic lectures of the institute. The front page is organized in a chord diagram. Thus, the entire material including in-between linkages is visible. Each sub-node leads to a website, on which different objects, such as teaching videos, sound examples, 3D-models and interactively animated diagrams are presented. For every object a supporting text is provided and links to other objects concerning similar topics are given. The Learning Platform is used as a tool during the self-learning phase of the students as well as during lectures. Furthermore, a wiki-based online dictionary is available which provides acoustic-specific content, such as definitions and explanations. The work on this wiki still is continuing. All contents are licensed under a Creative-Commons-License (CC-BY-SA-ND).

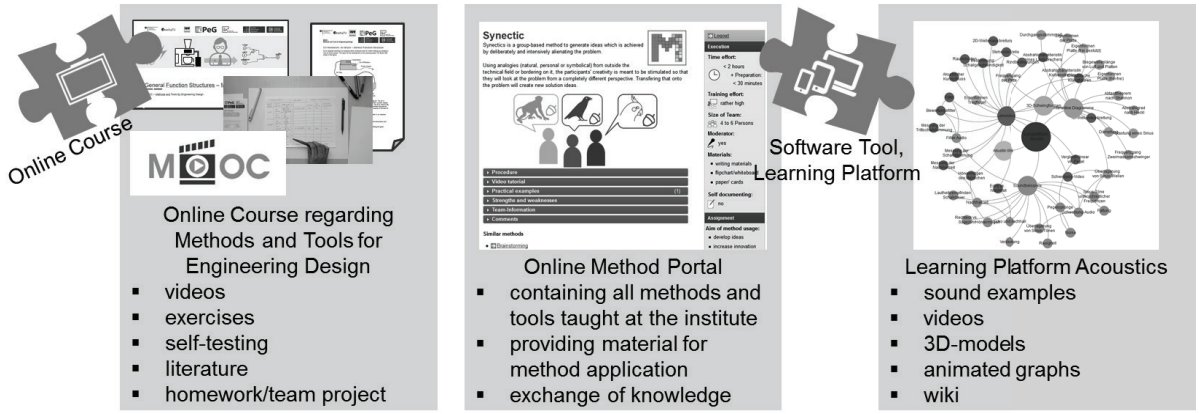

Figure 2: Elements of the framework: MOOC (left), Methodos (middle) and LPA (right). URL: https://www.tu-braunschweig.de/ik/lehre/{ methodos; bsmooc; lernplattformakustik }

4 EVALUATION AND LESSONS LEARNED

In order to assess the impact of the framework, an evaluation has been conducted among the students of the past semester. The aim of the evaluation was to gather information about the usage of online-media in general and furthermore usage, usability and benefits of the above mentioned online tools. The posed questions were designed to fit the needs of an assessment of online teaching material.
Since the total number of students that got in touch with more than one of the above-mentioned tools is still low, the tools have been evaluated separately. Therefore, the results may be seen as a first indicator for the framework as a whole, but cannot be transferred directly.

4.1 Structure of the evaluation and population

The evaluation is structured and divided into four topics. First, the general attitude of students regarding the usage of digital media is evaluated, measured by the availability of personal mobile devices and its frequency of usage. Furthermore, the preferred way of consuming information is asked. The second part of the evaluation relates to the actual importance of e-learning material for the students. These questions furthermore distinguish between the role of e-learning material within lectures and the self-learning-phase, respectively. The third part focuses on the specific online tools ‘Methodos’, the MOOC and the LPA. It is questioned which advantages, compared to offline material, the tools have. Furthermore it is evaluated which reasons might lead to the non-usage of the material and if and to what extend the content matched to the related lectures. The last part gathers information about the surveyed persons, for example the age and field of study.
During the evaluation, a total number of 58 questionnaires was returned to the authors. Thereby, 30 forms are concerned with the evaluation of Methodos. The majority of this group is located in the late

phase of the Bachelor degree. The Learning Platform is evaluated by 23 students, nearly entirely located in the first semesters of the master study. A group of 5 students answered the questionnaire regarding the MOOC. Only one person is a distant learner from another university.

4.2 Results

Since the results of the three aforementioned groups do not differ much, they hereafter will be presented together. Differences regarding specific online tools are discussed. As the population is small, the results may not be of statistical significance but rather represent a general opinion regarding e-learning material.

In general, the test persons entirely own mobile devices which are being used hourly (74%), up to minutely (21%). This frequency is found rather high, (36%) or high, (29%). Therefore, the test persons can be indicated as generally technology prone. Nevertheless, the question in which way information is preferably consumed was answered by the majority of the participants with print media in both, hardcover (67%) and digital version (78%) as well as videos (69%). Regarding the self-learning phase, the same question was answered equivalently. In general, the test persons expect e-learning material to be more of an extension to classic teaching models (88%) rather than a replacement. This is found for both, the presence phase as well as the self-learning phase. Support for the latter one by the teacher is asked by 95% of the group.

That the usage of e-learning material is advantageous for the learning progress in several fields can be seen in Figure 3, which presents the cumulated results of all groups. The results show, that the high availability, the self-determination of the learning speed as well as the possibility to download the material are found to be the main advantages of e-learning material. These results apply to the general advantages of e-learning material as well, which have also been questioned.

Another question was given in order to investigate the reasons why the e-learning materials were not widely used. Most of the participants named the missing need for using the provided tools (65%). This may indicate that there is still potential to further integrate the tools into classic lecture-based teaching.

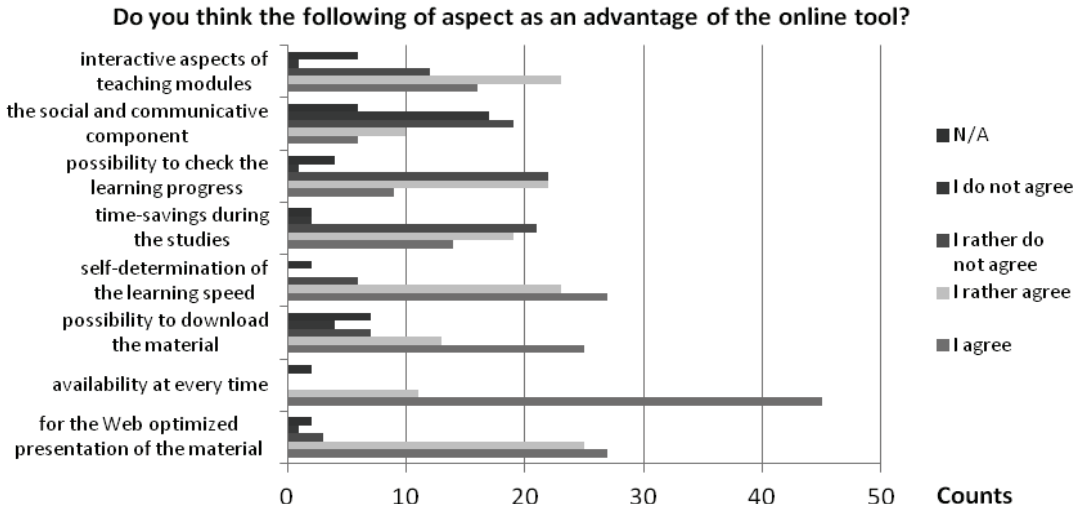

Figure 3: Results of the question to the advantages of the evaluated Elements

4.3 Lessons learned

The evaluation shows that the test persons are willing to anticipate and use e-learning material. The high availability enables the students to work in their own speed and own time. It can be expected to increase the motivation of the students and thereafter increase the teaching success by using e-learning material. Furthermore, as the students request guidance during the self-learning phase, online tools offer a possibility for the teacher to give help without the necessity of being personally available.

On the other hand, the majority of the students still preferably uses print media to gather information. Therefore, in order to design the self-learning-phase efficiently, it could be advantageous to provide print media as well as online tools, which extend the provided knowledge or open another viewpoint.

The main reason for not using the provided tools was named to be the absence of the need to use the material. Thus, an extended linkage between the classic lectures and the online tools could be helpful, for example, by providing a specific amount of information via and only via the online tools.

5 CONCLUSION AND FUTURE WORK

In this paper, we present an approach to combine online teaching elements with classic lecture-based education in ED. The approach refers to a blended-learning technique, as elements of online- and presence-courses are being integrated into a framework enabling more efficient teaching concepts in ED education. Our framework consists of present lectures, exercise classes, and additional learning material, including online elements. Three of these elements, a MOOC, an interactive method portal and a learning platform are introduced in detail. The elements are evaluated and the results are presented. The results show that stand-alone online formats do not fit the students' needs but the combination of both, online and present teaching seems very promising. Therefore, we plan to extend the framework in the future and further material will be developed and included into the framework. It may then serve as a first step to update ED education in a way that enables becoming engineers to deal with actual and future challenges.

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