Asynchronous and synchronous distance learning in STEM education, using the example of the Online Master Program Wind Energy Systems

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Abstract. This paper describes the 100% online teaching concepts of the degree program Online M.Sc. Wind Energy Systems. These are the synchronous teaching concept, the asynchronous learning concept and a combination of synchronous and asynchronous learning concept. The challenges that students and teachers have to face in the implementation of these teaching concepts are described here.

Introduction

The development of new technologies created new ways of teaching via distance learning. Students get the opportunity to make their learning more very flexible with regards to the time schedule and the scientific profile. Students do not have to be physically present, or even in the same place at the same time, when lessons take place. Learners can now decide for themselves when, how and where they want to learn. However, the instruction of a 100% online teaching requires special didactic concepts. In this paper different teaching strategies and online media that are used for the study program Wind Energy Systems are described.

Synchronous and asynchronous teaching

Distance learning is often used as a teaching concept, especially in US America and Canada for students in rural areas. Asynchronous online teaching is particularly preferred by virtual US schools. In Canada a significantly higher proportion of schools teach synchronously [1, 16]. In Germany, blended learning is used as the teaching concept, which combines class lectures with eLearning elements. This teaching concept is mainly used in tertiary education, preferably in advanced study programs. Teaching in a 100% online format, however, is very rare. This online format is used in STEM education for the occupational master’s program Online M.Sc. Wind Energy Systems at the University of Kassel. The program Wind Energy Systems will be presented here as an example for those courses in which teaching takes place exclusively online.
**Synchronous Teaching Concept**

In synchronous teaching students and teachers are at different locations and communicate with each other in a virtual classroom via video conference software. With this it is possible to use a webcam and talk together via headsets or write via chat. The synchronous teaching is therefore always taught live [12]. In the master’s program Wind Energy Systems online sessions are performed regularly, for example in a one-week cycle. Therefore, teachers and students meet at the same time in a virtual classroom. The online sessions are also recorded, so that the students can watch them at a later time. For this, the conferencing software Adobe Connect is used. In this environment, content, e.g.
slides or a desktop, can be shared and participants can talk to each other and see them live via webcam and via microphone. Furthermore, a chat is available for a synchronous communication, which students of the master’s program preferred to use during the online sessions. The knowledge that students preferred the chat function instead of using microphones to communicate also coincides with the results of Nippard [14]. The reasons were that students felt that they did not know their fellow students well enough and therefore did not dare to talk with the microphone [14]. In the program Wind Energy Systems, lectures taught online generally do not differ from the classroom teaching with students present. Here, as in a lecture hall, the teacher makes a presentation or writes using a virtual whiteboard, while the students listen. The teacher is always seen through the camera. Meanwhile, students have the opportunity to sign up to ask questions at any time. In addition to regular online sessions, students receive homework assignments, exercises and references. These teaching materials are provided on the learning platform Moodle, for students to download and reference. The advantage of synchronous online teaching is that they involve personal participation, whereby the personal motivation of participating is clear. The personal online presence enables synchronous communication, thereby promoting social relations and the exchange of information with a lower degree of complexity than, for example, in the asynchronous teaching. This is accompanied by an increased convergence of understanding, because ambiguity of information can be prevented by the immediate feedback [12]. In addition, it proves difficult with a purely online presence to attain the mental proximity that develops through interpersonal communication. In his ‘immediacy’ theory, Mehrabian [15] describes the degree of attenuation of the immediacy and intensity of an interaction between a communicator and the object of their communication in a verbal message. He assumes that in the ‘immediate’ communication, social attitudes towards the communication partner are received by verbal communication. Woods and Baker [20] emphasize that if interaction is encouraged in the virtual classroom, this leads to positive communication behavior, i.e. a psychological proximity to teachers, social presence and a sense of community within a virtual classroom. The speed of feedback from teachers to students also facilitates ‘online’ proximity between teachers and students [10]. Feedback from the students in the study program Wind Energy Systems where the lecturer used the synchronous teaching concept suggests that the teacher could create a psychological closeness to the students through non-verbal and verbal immediacy. They pointed out that the lecture was motivating, had interesting content and the teacher gave his students attention. Challenges became apparent in technology. Students described that they felt slightly overwhelmed trying to follow the proceedings of lectures in Adobe Connect, switching between the open windows. Even in the study of Gedera [9], students noted that they required technology briefings and exercises, before applying them. Falloon [6] states that students need multiple skills to get the most out of a virtual classroom. These skills are technical (set up the microphone and the camera, orient oneself in the virtual classroom), procedural (conventions and codes of behavior when they interact with fellow students) and operational knowledge (best use of the tools that are available for communication in the virtual classroom). To meet these needs in the study program technology introductions to the software Adobe Connect are given at the beginning of the semester and manuals are also provided for users. A disadvantage is that teachers and students have to schedule their time so that they are in the virtual classroom at the same time [see 16, 2]. Meeting at the same time proves to be rather difficult, especially for international students from different time zones. Therefore to support the target group of the study program Wind Energy Systems, all online sessions were recorded so that they could see the recordings if they could not attend.

Asynchronous Teaching Concept

In asynchronous online teaching the teaching materials are provided to students so that they decide for themselves, when they want to learn with these teaching materials [7, 21]. Thus, the classes take place at different times and offline. The contents of the modules are made available to students in the form of electronic media, for example videos, scripts, slides, on a learning platform. To test their learning progress students are offered homework assignments or exercises. In the asynchronous learning concept, students never have to be at the same place and at the same time as their fellow students and lecturers. In this teaching approach communication takes place exclusively asynchronously. Communication tools could be for example, email or forums [2, 17]. Thus, students can complete the learning phases at their own pace and can be flexible in managing their study time themselves. Therefore, Bernhard et al. define [2, p. 387] asynchronous online teaching as "individual-based". Murphy et al. [17] also describe this teaching concept as a very independent way of learning: “These forms are self-paced, largely self-regulated and highly independent forms of learning” [17, p. 587]. In the master’s program Wind Energy Systems, the Moodle learning platform is also used for asynchronous teaching. There, all teaching materials are available to download or to look up. Communication is also asynchronous, via Moodle forums. If a post is published in the Forum, the participants of the course will automatically receive this post by email. According to Palloff [zit. by 10] forums can help to initiate discourse and
reduce the feeling of social distance. Maintaining the discourse in the forum can promote the participants’ interest and motivation, which is crucial to the learning community, according to Garrison and Anderson [8]. Hrastinski [13] found in his study that asynchronous communication increases the cognitive participation, because students have more time to reflect on the forums texts. Thus, the communication has a much higher degree of complexity than in synchronous courses. The study by Flores Fahara and Lozano Castro [5], in which teacher-student interactions are studied in asynchronous discussion forums, shows that the psychological distance in the interaction between teacher and students can be reduced through the strengthening of immediacy. They determine categories that can increase the social presence through the didactic design (1), communication (2) and the teaching strategy (3) personal interactions, for example writing personalized messages, teachers are using the students’ names informally, the acknowledgement of attention and interest, welcoming students and efforts to answer the questions of students. This shows that the asynchronous concept presents a special challenge to both the teachers and the learners. The lecturer must organize the teaching so well that students learn the knowledge without the physical presence of the teacher. Hence, the quality of the instructional design is a decisive factor [2]. Furthermore, the teaching presence is relocated to the learners. They must now assume responsibility for the design of the learning process themselves [3].

Combination of synchronous and asynchronous Teaching Concepts

The synchronous and asynchronous teaching concepts of the program Online M.Sc. Wind Energy Systems are expanded through a combination of synchronous and asynchronous elements. Here, students always have the opportunity to organize their self-study time flexibly according to their own needs, despite synchronous elements. For example, an online session is offered at the beginning and at the end of the module, while between these two online sessions the students learn asynchronously, using videos. Another synchronous element is, for example, the online consultation during the semester, in which participation is voluntary. The aim of this teaching concept is to balance the lack of social presence of asynchronous teaching with the use of synchronous elements [cf. 4], because, as already described, studies show that synchronous learning and interaction can promote students’ motivation to learn among others 9, 18]. The combination of synchronous and asynchronous teaching concepts represents the most common form of teaching in the program Online M.Sc. Wind Energy Systems. Here, the concepts regarding the characteristics of synchronous and asynchronous elements are different. An example of this teaching concept is the module Mathematics. In this module 14 units are offered. Each unit includes an instructional video (about 45 minutes) with presentation slides for download as well as exercises, reviewed homework and detailed references. The exercises are calculated in a synchronous online tutorial in Adobe Connect using a SMART Board at the virtual table. The students can ask questions about the exercises and the contents of the units. Participation in the online tutorial is voluntary. In addition, the tutorials are recorded. The duties of the homework, however, are mandatory. Only when this is rated as passed, may the student move on to the next unit and consult the teaching materials. The evaluation of this module shows that the students rated the combination of teaching the theory and confirming it using homework as positive. The individual correction of homework helped them categorize their learning level. Nevertheless, students also reported that the amount of work was higher for this structured learning than for purely synchronous teaching. It is assumed that the higher workload was created because the instructional videos show a significantly compressed representation of the learning content, because the instructional video reflects a perfect reproduction without slips or interruptions with questions from students. By contrast, the transfer of knowledge in online sessions can be interrupted by scientific discourses on the content [9]. So with instructional videos students learn more content in less time. Experience also shows that teachers tend to adapt this teaching concept to offer more teaching material than in the purely synchronous teaching. The advantage is that students got more diversity in their own design of learning. A disadvantage is that when students used the full range of teaching materials, their workload increased significantly. A second observation is that the communication in the asynchronous style has a much higher degree of complexity than in the synchronous style [13]. Students thus have significantly higher cognitive participation; at the same time also takes more time.

Summary and Outlook

The Online M.Sc. Wind Energy Systems offers three online teaching concepts of how teachers can make their lessons: the synchronous teaching concept, the asynchronous learning concept and a combination of synchronous and asynchronous learning concepts. Learners can thus decide which approach they want to apply for this course themselves, according to their own preference. Often a combination of synchronous and asynchronous learning
concept is used by them. All concepts have their advantages and disadvantages. Teaching in various teaching styles also represents an attempt to meet the needs of teachers with their different preferences of teaching, and students, to meet with their different preferences of learning. Since the University of Kassel is just starting to develop online teaching, over the next few years we will evaluate the satisfaction of students and teachers and thus the attempt to improve online teaching continuously.

REFERENCES