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ABSTRACT

Flipped classroom is a teaching concept in which the students go through an individual ICT-supported learning phase by using video clips at home and bring questions to the classroom for deeper discussions. In the TU Graz flipped classroom concept one lecture of 45 minutes requires the creation of one or two learning "nuggets" (videos of appr. 6 minutes) which, as experience has shown, can cover the main lecture's content in condensed form. The remaining part of the content are mastered by means of students' involvement in the subsequent attendance phase. In this seminary-type phase further consolidation of the subject takes place with active participation of the students. The experience with three realized courses shows the high efficiency of this method, especially when student collectives are less than 30 students. An indication of the effort on the side of the teacher concerning the production of the videos is given as well as the methodology in determining the teaching/learning efficiency. The curricular position of the flipped classroom is described by the guidelines of Graz University of Technology, by which, when using flipped classroom methodology, allow an optimal mix between online (up to 20%) and offline-lectures.

Keywords: e-learning, flipped classroom, learning efficiency, methodology, teaching efficiency

Introduction

Many universities declare "research-based teaching" as their goal. This includes the two essential components: research and teaching. Both are necessary for the further sustainable development of our society by educating knowledgeable and critical individuals. In contrast to research, which has developed rapidly over the last 200 years, little has happened in the field of teaching since the introduction of printing technology.

Only the introduction of information and communication technology (ICT) on a broad basis, in conjunction with a powerful internet, has made it possible to redesign a part of knowledge transfer: whereas in the past the simultaneous physical presence of teachers and learners was necessary, only now is it possible to make knowledge content asynchronously accessible and easily stored for many people in a simple form. Modern technology offers the possibility on a broad basis to store and transmit not only characters and sound, but also images and moving sequences. This is used in the so-called "Massive Open Online Courses" (MOOCs). In terms of concept, they are - as the name "massive" already defines them - designed for a large number of participants.

Due to the novelty of both the technical possibilities for recording and playback as well as the transmission medium "Internet", a variety of formats can currently be found in the educational scene that serve to convey highly qualified contents: To mention a few, these are webinars, Massive Open Online Courses (MOOCs), or simple case-related demonstration videos. Recommendations for realization regarding the framework, content and target groups for which a specific format should be preferred are discussed at the moment in the field of education. The following article is intended to further this discussion and to answer the question of how Massive Open Online Courses can be used in technically highly specialized fields.

In the following article, the literature review is followed by the methodology (assignment of the learning material, transmission of the learning material, description of the follow-up attendance phase, sustainability aspects). The findings/results concerning the curricular position, the pros and cons are concluded by a discussion of the students' and a peer evaluation that has been carried out. Finally, recommendations are given.

Literature Review

According to early preliminary considerations (Deimann, 2007), publications on the topic of "Teaching and the Internet" only appeared of a widespread scale from the second decade of the new century onwards.

In German-speaking countries Spannagel (Lucius, K., Spannagel, J. & Spannagel, C.) has already set the first accents in 2012 with the question why one should call 200 people together to give a lecture that one has already given a few times. Instead of a common mode of reception, he suggests that all students come together in a room to discuss and deepen the material together with the lecturer.

Subsequently, there have been some investigations regarding the Massive Open Online Courses (Wedekind, 2013) as well as several contributions to the Austrian MOOC platform iMooX (Ebner, Schön & Braun, 2019). They describe a classical MOOC, the learning material is developed in regular and multiple interplay between (asynchronous) preparation in the form of videos ("nuggets") and other materials and jointly (synchronously) conducted in-depth studies.

However, in university teaching practice, it has been found that an interesting alternative to this is to have the course participants first work themselves independently through the material concentrated on the videos and only after this phase to get together in the subsequent concentrated attendance phase. This form was presented in (Ebner, Schön & Braun, 2019). This concept is called "Pre-MOOC", whereas a MOOC is used beforehand of a lecture. Following the didactical concept of Flipped Classroom, students learn in a self-regulated manner the main content of the lecture (online phase) and bring their questions, thoughts to the following face-to-face lecture (attendance phase).

Applied Methodology of the Flipped Classroom

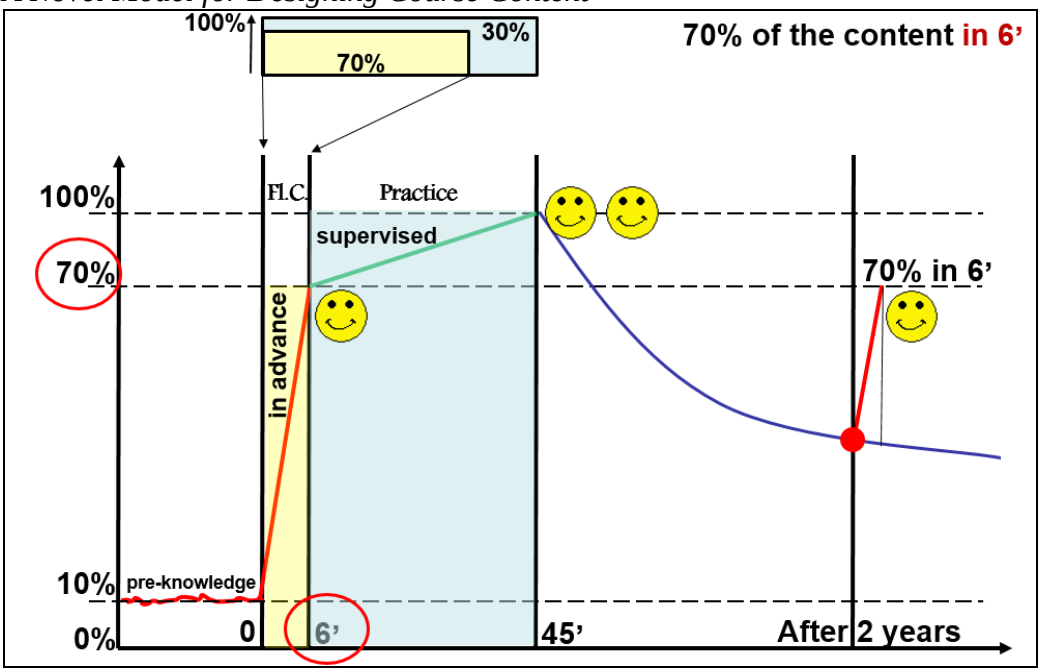
Assignment of the Learning Material

The planning of the distribution of the teaching material is based on the Pareto principle (Wikipedia, 2019). This means that – roughly speaking - 80% of the success can be achieved with only 20% of the use of the available resources. Conversely, this means that 80 % of the total effort and thus the majority of the work is required for the remaining 20 % of the requested results, and this with a significantly reduced degree of efficiency!

Following this idea, we developed a novel model for our course design. Due to the fact, that we know that the core input in one lecture is often very short followed by examples, experiences and discussions, we asked if it will be possible to produce learning nuggets for this short input. Our assumption is that this main content is about 70% of the whole input of a single lesson. This important part should be done as video and can therefore be watched by students as often as necessary. The lasting 30% of the necessary input will be done during the discussions in the classroom. Fig. 1 is pointing out this principle.

Furthermore, Lee und Genoveve (1988) defined the concept of pauses between learning and practical trials to foster new learning stuff. Consequently, we tried to avoid massive learning and strengthen distributed learning. Baddeley (1999) proved that daily learning of small pieces is more effective that massive learning in a very short time frame. In Fig. 1 the retention of learning content over time is assumed to be higher instead of using a traditional concept of classroom teaching.

Figure 1. *Performance and Benefits of the Flipped Classroom Methodology – A Novel Model for Designing Course Content*



Finally, the learning material of the subject "Protection Engineering of Electrical Installations and Networks", which is described here as an example, can be traced back to around 20-30 core topics, 21 of which have already been realized at the time of this report. These core topics are also known as "nuggets", since this term clearly stands for a concentrated high value.

Transmission of the Learning Material

Before the respective attendance phase, the learning nuggets are provided as a Pre-MOOC together with simple questions for self-control on the MOOC platform iMooX. According to the principle of the flipped classroom, everyone can work at their own individual learning pace. As detailed analyses of the learning behavior have shown, about half of each learning nugget is viewed a second time by precisely jumping back with the cursor key. In this process, the learners determine freely in place, time and even pace for the acquisition of the presented knowledge according to their individually different learning situations.

In addition, the professor provides a PDF file of the entire material available from the first lesson on.

Attendance Phase

The relatively small size of the cohort makes it possible to deepen the material in the subsequent attendance phase, in seminar style teaching (independent preparation, critical discussions, presentation, partly under support). In the concrete case - based on an e.g. interesting actual task of the subject area - the

learning relevant aspect is worked out and deepened in small groups of 2-5 persons. The progress of the acquisition of knowledge can now be continuously monitored by the trainer. In doing so, comprehension help is given and there are also digressions and additional information on the remaining 30 % of the subject matter (see above).

In this way the complete mastering of the material is achieved.

Follow-up to the Attendance Phase, Sustainability

Subsequent to the attendance phase the students learn independently, whereby tutorial times (Q&A) are also offered. An examination concludes the course.

Thus this form of flipped classroom contributes to the sustainability of the training.

Curricular Position

According to the guidelines of Graz University of Technology, when using flipped classroom methodology, it is allowed to use an optimal mix between online (up to 20%) and offline-lectures.

Findings/Results

Benefits for the Students

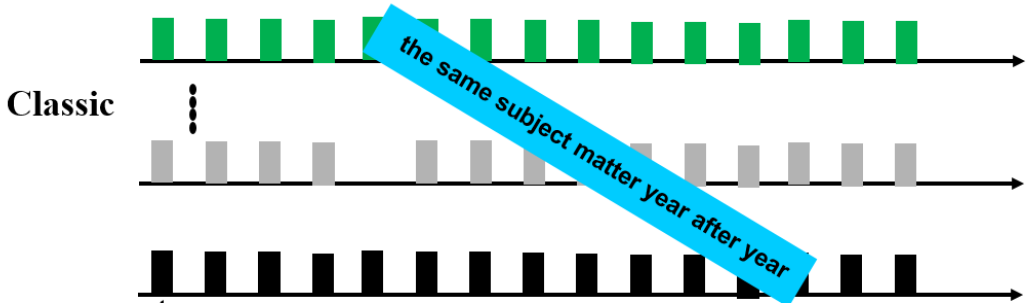
As extensive investigations of the learning and examination performance have shown, that appr. 70% of a lecture's content can be presented in a condensed form in the 6-minutes' videos. This requires some experience on the side of the teacher. As test entrance examinations have shown, the content of these nuggets was mastered by the students with a cognitive penetration depth of – again - 70% (Pareto's principle), see figure 1 above.

In the subsequent practice/seminar/attendance phase this cognitive penetration depth is further increased. If after some time, for example in order to prepare for the examination, the learners need a refresher, this can be achieved by watching the videos in a few minutes again.

Effort and Benefit for the Lecturer

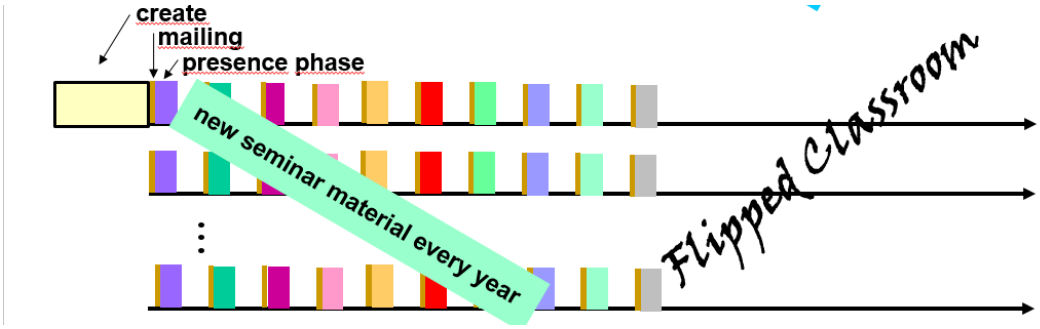
In contrast to classic lectures, the same content is recited year after year, thus becoming more and more – sometimes tiring - routine work (see figure 2)

Figure 2. *Classic Lectures*



In the new teaching methodology, a creation phase is obligatory which precedes the attendance phase. Before each attendance phase, the students receive the "content of the week" which they incorporate according to his/her individual learning speed (see figure 3).

Figure 3. *Flipped Classroom Methodology*



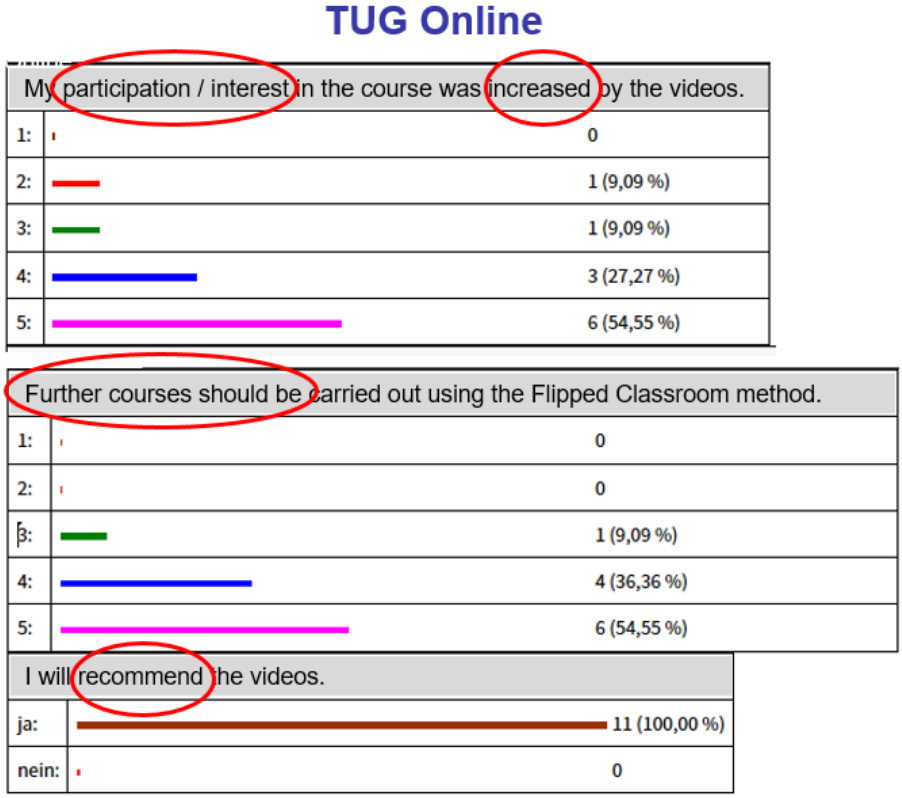
Since the routine part of the knowledge transfer has been carried out before the attendance phase, it is now possible to vary the in-depth studies of the subject in the sense of a seminar by applying of what has already been learned and adapting it to current tasks. This makes teaching more varied, exciting and interesting and colorful for the lecturer.

Discussion

Experiences – Students' Evaluation

After the course the students were interrogated to find out about their learning behavior and learning experiences. The answers clearly indicated that the videos were viewed by the students at home (over coffee or on the couch in front of the laptop/PC) and also even in university.
The feedback tool of Graz University of Technology gave further support to this concept of flipped classroom (see figure 4).

Figure 4. *Evaluation Result of the Flipped Classroom Methodology (excerpt)*



Experiences – Peer Evaluation

At a workshop at Graz University of Technology, the concept was presented to a peer audience who already had personal experiences in the field of e-learning. Afterwards the methodology was analyzed from the perspective of these persons (lecturers, university assistants, professors). Below are the results concerning

- the advantages - positive effects (table 1)
- challenges (table 2)
- items to be discussed (table 3)

Table 1. *Advantages - Positive Effects of the presented Flipped Classroom Method*

ADVANTAGES - POSITIVE EFFECTS
Advantages for the learners
- Sustainable learning
- **Your own speed**
- Serves **different types of learners** (personal supervision / audio / visual / both)
- Long-term learning effect
- Deepening of the subject is made easier (**group work**)
- Better retention performance due to **deepening and active actuation**
- You don't start **later in life** from scratch, because you can refresh the subject with the videos in a short time.
- **Refreshing** of learning with videos / **repetition** is possible **individually**
- Interface "Life Long Learning" < **TU Graz' commercial brand**> - Refresh possible - How could this be solved by accessing the documents?
- **Training of social skills** (collaborative work/development)
- You can watch the videos everywhere (**independent of location and time**)
- **70% Basic knowledge** - teaching objectives / exams - great synergy effect
Advantages for the teachers
- You don't have to read the same thing **over and over again every year** - a change for the teacher
- Facilitates **cooperation among teachers** (coordination of teaching content among the LVs)
- **Cross-linking** between the LVs possible
- Time in the **auditorium can be better used**
- **Creative design** of the LV possible
- The expense **pays off with** fixed, **annually recurring LVs** ("basics of ...")

Table 2. *Challenges of the Presented Flipped Classroom Method*

CHALLENGES
- Very large amount of **time required** (frequently mentioned point)
- **Focus on essential** content (What is included in the video and what is not?)
- Limitation to **basics** (difficult to keep up with fast changing fields)
- Clear tasks for **interactive phases** must be defined
- Scheduling of the different phases
- Is an implementation with **larger groups** possible? For LVs with many participants more difficult to implement
- Students must adapt to **new teaching/learning** methods
- Accustoming the students
- Adaptation of the difficulty to the audience (**not on-the-fly** adaptable)

Table 3. *Topics of the Presented Flipped Classroom Method to be Discussed*

TO BE DISCUSSED
- The role of **student numbers**?
- Role of the LV rooms and **equipment**?
- **Where** does the method make sense?
- Which **type of course** - compulsory attendance?
- Which **type of contents** - rather basics
- Impact on private life - to be seen **always and everywhere**?
- Is **quality** achievable?
- **Long-term access** to the documents?
- **Guidelines** for the creation of nuggets and example of creation
- **Possible replacement** for laboratory entry-level tests (MOOCs)

Conclusions

Flipped classroom is a highly effective teaching model in which the students learn in locations of their choice according to their personal situation, workload and speed. Approximately 70% of the content are summarized in short videos ("nuggets") of studio quality. This is followed by an attendance phase, which is seminary-type and requires active participation of the students. Thereby the remaining 30% of the content are mastered.

On the teacher's side considerable effort is required for the high quality nuggets, but the reward lies in more satisfying teaching experience.

For the students the possibility of asynchronous learning and the seminar-type lecture time are very attractive.

Future work should be invested into pedagogically validated guidelines or recommendations and to find a good ratio between virtual and face-to-face learning. Furthermore, we have to investigate if the retention of the knowledge is following our model described in figure 1.

Also should the commercial usage be investigated including the possibility to apply the flipped classroom principle in post-university training such as adult education or on the job training.

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