

Teaching Statistics with the Inverted Classroom Model

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Abstract – Statistics, a field of mathematics, plays a central role in many fields of study, including the social sciences. Nevertheless, many students who attend statistics courses experience feelings more of horror than of joy. In addition, students who fail in these courses often have to drop out. The present concept presents a new teaching method in an attempt to constantly improve the statistics courses and increase the quality of teaching.

The paper gives an overview about how the concept was evaluated and the results. The choice fell on a combination of qualitative and quantitative methods. The results show a positive picture: For the seminar participants, the self-learning phase posed no problem. The free time division did not cause any difficulties. For example the students were able to make their ideas clear without asking questions, as is otherwise usually done in seminars.

The concept seems to be suited to students with good as well as poor knowledge of mathematics. With the videos, the inhibition threshold in dealing with statistics apparently sinks, even though it is judged to be difficult.

Keywords – Didactics of Statistics, Innovative Teaching Methods, Flipped Classroom, Inverted Classroom.

I. INTRODUCTION

Students visit courses about methods of quantitative social research, especially statistics, with a feeling of fear rather than joy. In addition, non-attendance leads to the breaking up of the studies; at the same time it is known that the increasing the quality of teaching can contribute to a decrease in the dropout rate. [1-2]. In order to improve the statistics lectures, make them more demonstrative, and to improve the teaching quality, this work aims to create an experience-orientated course. The main focus of this work is to develop a new concept for the lecture “descriptive statistic” through educational concepts, based on the mathematics, ‘eLearning-Didactic’ and expert interviews. It will aim to implement new teaching methods and create additional learning opportunities.

For the development of new teaching concepts, a few steps are undertaken: to begin with, the didactic concepts are analysed, which include the opinions of experts. Based on this, new teaching concepts can be developed, which need to be continually evaluated thereafter, on many levels.

II. METHODS

A. Didactic Concepts and Expert Interviews

To create a theoretical foundation, didactic concepts from mathematics didactics, university didactics and eLearning didactics, are being reviewed and verified as to whether they can be transferred to the statistics lectures.

As in this report, the focus is on the flipped classroom concept, and not all didactic concepts can be included at this stage. Only the main elements are reviewed, which can then be applied in lectures.

In a conversation with Professor Spannagel, one of the flipped classroom pioneers in Germany, he explained a concept which caught my interest. Instead of holding lectures through teacher-centred, ‘frontal’ teaching, students can find videos to prepare for the course or as homework, for all seminar topics. In the attendance phase, students are able to meet up with the lecturer in order to ask questions regarding the videos, discuss and compile the exercises.

But why is this method more useful than lecture-style teaching, and what are its advantages? Mr Spannagel explains this question clearly. “When I hold a lecture, then everybody has to follow me at the same pace. At this stage, there is no such thing as individual learning pace, personalization and internal differentiation etc. Noo! Everybody has to follow submissively at the same pace. If anybody steps out in between: that is his own loss! This means that he basically has to get over it and try to understand it at home. Would it not be better if the student is able to remind or pause the lecture of the professor in case he needs more time to rethink matters” [3].

In past semesters, eLearning components and the new didactics elements were successfully implemented. In order to take the next step forward and to get away from lecture-style teaching, it was about time to try out the flipped classroom.

B. The Inverted Classroom Model

One of the central aims of the didactic concept, is to create an additional benefit, in comparison to the traditional teaching methods. In the statistic lectures, major events are common, which are hardly accomplishable without the lecture-style teaching. However, through this type of learning, students can only learn factual knowledge, whilst social skills and personal organization of learning is neglected. The authority of the lecturer is foremost, and a democratic teaching style becomes less of a priority. Moreover, the individuality of each attendee and his individual learning pace is not taken into account, despite there being numerous types of learners. “No educational comprehension is focused on autonomy, self-determination, majority, the ability to self-reflect and identity winning, rather it is focused on the measured shift of status quo.” [4-5]. At this point exactly, the flipped classroom comes into play, which according to Reinmann [6] aims to change and dissolve the internal systematic structure within the lectures. Different forms of knowledge can be generated, because, instead of pure and absolute lecture-style teaching, there is time for several learning methods that mobilizes students - the quality of

the attendance phase is thereby enhanced remarkably (for more information see: [7]).

As reported by users of the Inverted Classroom Model the concept has a lot of advantages: Students can regulate the learning pace by the use of videos; these enable them to repeat difficult parts until they are understood. This leads to an individualization of learning pace and path. Videos are very popular, especially with the young generation that has been raised with the Internet. Notebooks, mobile and smartphones play an important role not only in private life, but also at school and university. The greatest advantage of ICM is that this teaching concept enhances the cognitive process, self-regulated studying and autonomy within the learning process. The sessions at university require students to make collective decisions, interact socially and study collaboratively and cooperatively so that important soft skills can be developed [8-10]. Despite all these advantages of ICM, there are, as always with any other teaching method, also some disadvantages. However, they are relatively few. Apart from the need for a fast internet connection, it is absolutely necessary for students to have the discipline to watch the videos. This should be encouraged by tests or question sheets guiding and structuring the self-study process. In order to give the students even more initiative and motivation for self-study, Reference [11] propose concluding learning agreements with the students. Another disadvantage is that students cannot immediately ask questions at the self-study stage, so questions cannot be immediately answered by the instructor [7-8, 12-13].

C. Activating Methods

Other elements which are applicable to be used the seminars, are exercises and the active plenum. Exercises are an important element, for example, in the form of group work or exercise tutorials, as well as small research projects, for both independent studies, and conceptual and procedural knowledge. Furthermore, exercises in statistics are central to success in learning, a fact illustrated by various outcomes. According to [14], practical exercises led to an effectiveness in learning to 75 % – only working something out by themselves (implementation of own scientific research projects for example) led to a higher effectiveness (80%) ([14 cited from [15]). Exercises should therefore play a central role, especially in the fields of research methods and statistics [14, 16-19].

In the active plenary method, targets are solved by the students together (at lecture hall): The lecturer sets a target, which is to be solved by the students in the course. One to three students go up to the board to act as moderators and the lecturer goes, for example, up the lecture hall. The moderators receive suggestions from the other students and write them as solutions on the board. The advantage over phases, which are moderated by the lecturer, is that students often dare to express and discuss together their understanding of problems and ambiguities. "It is assumed that for the purposes of the process-oriented teaching-learning situations in particular processes such as reasoning, communication and problem solving are

promoted here. The lecturer stays in the background and only intervenes in critical situations or when needed. This method is particularly dealt productively with errors [...] and that students gain with a low mathematical sense of competence (self-efficacy) more confidence in their own abilities" [20] Essential for this approach is the assumption of networked and process-oriented learning, which is represented by the methodologists of "learning by teaching" [20-21].

To guarantee the quality of the videos, obtain suggestions for seminar design and improve teaching, expert interviews were conducted with two Mathematics lecturers, in advance. In addition, there is a continuous discussion with users of this concept.

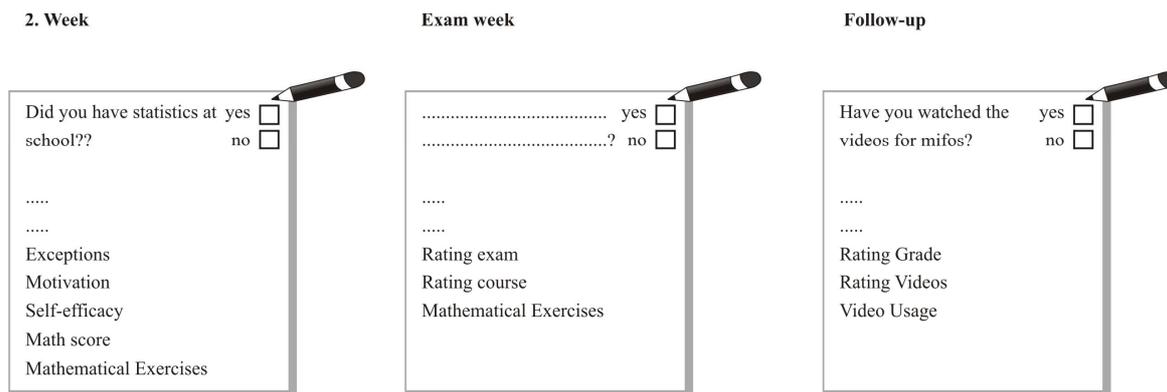
D. Didactic Scenario: Videos and Plenary Session

The statistic course is designed as a "Flipped Classroom": Bergmann and Sams described the concept of flipped classrooms as follows: "Flipped learning is when educators actively transfer the responsibility and ownership of learning to their students. It happens when the teacher's lecture is delivered to students via video outside of the classroom. Then traditional class time is used for active problem solving and one-to-one or small group tutoring with the teacher. The flipped class allows teachers to have more face-to-face time with students, fosters real differentiated or personalized learning, challenges students to take responsibility for their learning, and allows students to master material at their own pace" [22].

Instead of performing the statistics course in the form of frontal teaching, videos (around 35 minutes per subject) are available on the e-learning platform, to prepare and have ready all the seminar topics for the course. In the upcoming week, students have to prepare for the plenary/assembly session by watching the videos. In the subsequent attendance phase, students meet in the conference room as an plenum, with the teacher, ask questions about the videos, discuss and work together on exercises. Further issues are resolved in group work and then discussed together. The active plenary is established simultaneously; this method has already been implemented successfully in other courses.

Due to this diversity of methods and relocation of the lecture-style teaching into a plenum, complex content can be discussed and developed within the group. Valuable time that is not used extensively enough in lectures, can then be used for exercises and discussion. Studying and discussions done together promotes acquisition of knowledge and involves the students more intensively.

In subsequent meetings, the application of what is learned is practiced in small-scale research projects (secondary data analysis) on the computer, and as a voluntary offer, tutors are available to help with the project work and additional lectures. Furthermore, the attendance lecture is complemented by material and links to the e-Learning platform, tutorials and exercises with solutions and sample solutions. In addition, the tutor collects questions relating to the video or the meeting, which are then discussed afterwards via email or in the



**Qualitative Interviews:
to evaluate the concept:
Advantages & Disadvantages & Students' attitudes**

Fig. 1. Evaluation methods

next seminar. In summary, the variety of methods are suitable for different learning types.

E. Questionnaire Design and Evaluation

To evaluate of the concept, a separate questionnaire has been developed, to collect the opinions of the attendees, at three different time points. It will determine the motivation, expectations of the courses (including e-learning offers) and knowledge of students. At the end of the semester, the teaching methods and the e-learning offers are going to be evaluated. This knowledge serves for the test and improvement of teaching and the e-learning offer. Furthermore the seminar will be evaluated by the university once in the semester.

To test the growth of knowledge, four calculation tasks have been compiled, measured at two times, with a logic test serving as a control, where the answers should not be better in the second measurement. Furthermore, self-efficiency, high school mathematics grade, exam grades, complexity of the material and fear of statistics were available as third variable controls. Using various analytic methods such as non-parametric tests, analysis of the data is performed. In addition, qualitative interviews with participants are undertaken alongside evaluation of continual improvement of the system and the videos.

III. RESULTS AND DISCUSSION

The experiences from the meetings and self-assessment shows that the seminar attendees come well prepared in the course and the major content can be independently learned through the videos. In the lectures, the content becomes more intense, based on several examples and increased calculation exercises. However, if the last three winter semesters are compared, there is a marked improvement of grades shown through non-parametric tests, as one can see that the grade point average increases from 2.8 to 1.88 and the median grade increases from 2.7 to 1.7. The groups can be compared in both the written examination requirements as well as feedback from research projects.

The analysis of the videos indicates that the videos are

watched in a balanced way. These are signs that the topics are being studied and only a few students give up their studies, therefore it can be said that the quality can be evaluated as good. This assumption is reflected in the feedback of the videos, which are rated from very good till good (grade point average 1.52, median and mode 1, standard deviation 0.79).

In order to test an experimental design, only a group of students were given videos for their research projects, the other group worked without videos. Subsequently, the two groups (t- test) were compared. The group comparison showed important results: At a significance level of 10%, the video group was 1.5 points better than the comparison group.

Based on qualitative interviews and the analysis of the open questionnaires, a very positive response was received:

“I like the seminar concept for statistics very much”

“So I think that it is very positive simply for the reason that one has to function through the media establishment, that you wait - depending on – one can see the points again, that is to say, this really is for everyone...and it cannot be too fast, so to speak”

“So the threshold when one is demotivated, and that's probably in statistics courses, it happens to many people that they are not as insanely motivated to deal with it... And it is much easier then to sit down stop times to the PC and click Play to , and then stop the watching as squat and work through ' n book or ' n Text . So, so the motivation is somewhat different”

“I think it is really good and I find it very comfortable”
“Flipped Classroom is a super model!”

IV. CONCLUSION

Based on the results of the evaluation, and also by self-assessment, it seems that statistics courses can be made more clear and effective. A combination of different social

forms and new, activating teaching methods helps in that students learn more and achieve better results. In particular, exercise elements and practical work (small research projects) promote effective learning and application of what has been learned. Evaluations and scoring during the semester also promote continuous work and curb only learning facts for the end-of-semester exams.

For example, the active plenum helps in making even less motivated and weaker students to speak up. A major advantage of this method is to thereby obtain the perspective of the students. Different methods are in turn used to improve the design course. Overall, it is clear that a combination of different methods represent a profit for both the learner and for the teacher and thus help to improve the statistics courses.

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Andrea Breitenbach has a doctorate in sociology. In her quantitative-empirical dissertation, she has dealt with the issue of children and divorce. She is working as a senior researcher at the department of social sciences at the Goethe University in Frankfurt/Germany she is also working at the Center of Methods in Social Sciences at Frankfurt and teaching quantitative methods and statistics. Her research interests include didactic of statistics, new teaching methods, teaching statistics, educational sociology, family sociology, creating, supervising and analyzing surveys and multivariate statistical methods.