



# FlippedDB: Applying a Flipped Classroom Approach in a Basic Database Course

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## Abstract

Long input phases in face-to-face courses can be very tiring. Activating methods can help, but they are time-consuming, and students must still engage for the full 90 minutes to absorb the material. These problems can be addressed by using a flipped classroom. Important information is taught using suitable self-study materials, allowing students to divide up the input phases independently. Attendance sessions focus on exercises related to the self-study content. As a result, only short input phases are necessary in attendance and students can participate much more actively in the course. This teaching concept was implemented as part of a basic database course. The self-study phases included learning videos and self-assessment tests. Exercises were conducted during the attendance sessions, with lectures covering advanced concepts and practical sessions focusing on application. A student evaluation was conducted at the end of the semester. Among the 17 students, most responded positively, while two were dissatisfied because they personally disliked the method. In addition, the examination results of the last courses were evaluated. The previous year's course did not use a flipped classroom, while this semester's course did. The comparison showed that the proportion of students who failed the module had fallen, while the proportion of students who achieved the top grade had risen. In summary, most of the students found the method supportive, which was also reflected in the exam results. These findings suggest that a flipped classroom approach can enhance learning outcomes in basic database courses.

**Keywords:** Asynchronous Learning, Blended Learning, Constructive Alignment, Higher education, Learning Outcomes

## 1 Introduction

Traditional face-to-face teaching in higher education faces various challenges. Difficulties in conveying content are associated with the reduced attention span caused by social media (Haliti-Sylaj & Sadiku, 2024). Activating methods, such as live polling quizzes (Haliti-Sylaj & Sadiku, 2024; Zhao, 2025), think-pair-share (Ganatra et al., 2021) and buzz groups (Avendo et al., 2024), can counteract this and have a positive impact on learning, but they also require a significant amount of time to prepare and implement (Cook & Babon, 2016).

In addition to the shortened attention span, general motivation to study also plays a decisive role for success in studies (Kegel et al., 2021). Students can benefit from supportive elements, especially in self-study. Various studies show a positive effect of gamification on student motivation (Alonso-Sánchez et al., 2025; Bai et al., 2020; Groening & Binnewies, 2019; Kherazi & Bourray, 2024; Mazarakis & Bräuer, 2023; Sailer et al., 2017). Mobile learning applications can also have a positive effect on motivation (Criollo-C et al., 2021; Pedraja-Rejas et al., 2024). At the same time, however, negative effects can also be observed, particularly in gamification. Bai et al. also describe negative effects of gamification, including, for example, the triggering of anxiety and jealousy (Bai et al., 2020).

The use of blended learning can help to overcome these challenges. As part of the teaching concept, parts of the teaching are transferred to the digital space, which encourages students to work independently and acquire knowledge (Alqarni, 2018; Baumann et al., 2019; Capone et al., 2017; Windasari et al., 2024).

A special form of blended learning is the flipped classroom, in which students acquire basic knowledge through self-study and then deepen their understanding of related topics in classroom teaching (Alqarni, 2018). The use of the flipped classroom has also shown great potential in past studies, for example in terms of student's performance (Akçayır & Akçayır, 2018; Alqarni, 2018; Farmus et al., 2020; Fisher et al., 2024; HEW & LO, 2018; Strelan et al., 2020). Video-based flipped classroom models are particularly promising (Shen, 2024), especially if questions are embedded in the learning videos that are discussed in classroom courses (Deng et al., 2024). Regardless of how the content is prepared, however, the motivation of the students is particularly important, as this is the basic prerequisite for a successful flipped classroom concept (Gutiérrez-González et al., 2024).

Based on the current state of research, this work presents the design and integration of a flipped classroom concept into a basic database course in the bachelor's degree program *Media Informatics and Interactive Entertainment*. The basis for the concept was the interlocking of learning theory (Model of Model-Based Instruction (Hanke, 2021), Bloom's taxonomy (Anderson & Krathwohl, 2001) and constructive alignment (Biggs, 1996)) and multimedia content for the transfer, review and consolidation of knowledge.

The implementation of the flipped classroom concept pursues three primary objectives. On the one hand, interaction with students in the context of classroom teaching is to be encouraged, thus increasing active participation. In addition, regular engagement with the module content is to be supported. These two objectives, in turn, should have a positive effect on students' examination results. In addition to the primary objectives, the flipped classroom should continue to be structured in such a way that the self-study content can be easily managed by the students in terms of time and the different course formats interlock well in terms of content.

The concept of the flipped classroom approach and the evaluation concept are presented in the following section. Section 3 presents the results, which are discussed in section 4. Section 5 summarizes.

## 2 Methods

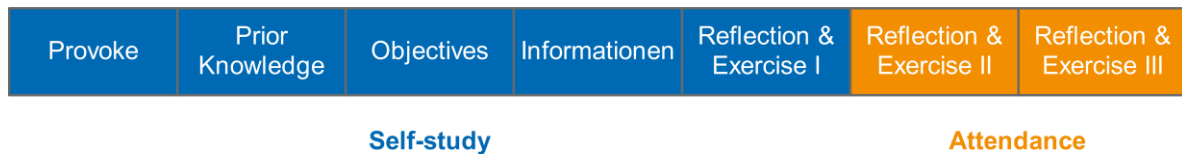
The methods used to implement the flipped classroom are explained below. First, the course structure based on the Model of Model-Based Instruction (MOMBI) (Hanke, 2021), Bloom's taxonomy (Anderson & Krathwohl, 2001) and constructive alignment (Biggs, 1996) will be discussed. This is followed by methods for evaluating the concept.

### 2.1 Concept of the flipped classroom approach

The flipped classroom concept implemented in this work is based on the Model of Model-Based Instruction (MOMBI) described by Hanke (Hanke, 2021). The model comprises six different phases: Provoke, activation of prior knowledge, definition of learning objectives, information transfer, reflection and exercise, whereby in traditional teaching models the phases of reflection and practice are part of self-study and the other phases are part of classroom teaching. In a flipped classroom, the phases of self-study and classroom teaching are swapped. The flipped classroom concept developed in the context of the course *Databases and Multimedia Information Retrieval* is based on this basic idea. Figure 1 shows the Model of Model-Based Instruction adapted for the course. The figure shows the reversal of the self-study and attendance phases. It also shows the introduction of further reflection and exercise phases at different levels of complexity.

This extension is significant for the flipped classroom concept presented in this work and allows the application of Bloom's taxonomy (Anderson & Krathwohl, 2001) at different levels by gradually building students' skills. The integration of the different cognitive processes and types of knowledge is referred to during the description of the respective event types.

Figure 1: Flipped classroom concept based on the Model of Model-Based Instruction: Areas marked in orange take place in presence, areas marked in blue take place in self-study (based on (Hanke, 2021))



The various levels of complexity are based on the model of constructive alignment, which describes the alignment of teaching methods and examination performance based on the defined learning objectives (Biggs, 1996). The learning objectives of the course focus on the practical application of the content taught in the courses, as the following excerpt from the list of skills to be taught shows:

- Students acquire theoretical and practical knowledge to be able to apply the content taught in the course in their everyday professional life and to be able to justify later actions in this context.
- Through discussions in (small) groups, students practice formulating and communicating their own solutions to problems.
- Looking at different interest groups promotes cooperation with specialist representatives and people from outside the field and offers insights into different perspectives.

In the spirit of constructive alignment (Biggs, 1996), in a previous iteration of the course, the written exam previously conducted in the lecture hall was replaced by a written exam on the PC with a practical focus.

The gradual teaching of content that builds on each other and the outsourcing of the theoretical foundations to self-study create sufficient time for interaction with the students in the face-to-face courses and thus enable the students to develop their own skills. The associated focus focus on the practical application of theoretical principles and working with real examples, methodically supports the achievement of learning objectives and optimally prepares students for future practical projects in the context of their studies and professional life.

The phases of the Model of Model-Based Instruction are divided into seminar (self-study), lecture (Reflection & Exercise II) and practical course (Reflection & Exercise III) as described in detail below.

### **2.1.1 Seminar with selected teaching video materials**

The seminar is available to students as self-study time, during which they should develop the theoretical foundations. Students are given one or more tasks to complete. The context associated with the tasks serves to motivate the students and creates a certain obligation to complete the self-study. The information required to solve the tasks is made available to the students; for this purpose, the information is prepared as instructional videos.

The instructional videos themselves each deal with a subtopic; the length of the videos is no more than 15 minutes. On the one hand, this supports flexible self-study times, and on the other hand, shorter videos are easier to process in terms of attention span. Slides are used in the instructional videos to illustrate the content; they are made available to the students as handouts. The slides contain little text and instead give students the opportunity to make individual notes on the spoken content of the video. Students have various options for individual adapting the instructional videos. They can adjust the speed of the video, skip forwards and backwards in the video as required and repeat specific sections using chapter markers.

To test the knowledge acquired through the videos, students are provided with quiz questions that give them direct feedback. Activating exercises are also incorporated into the videos where appropriate. These exercises are designed to activate prior knowledge or encourage students to engage with the content they have heard so far. For example, as part of an instructional video, students are asked to think independently about the everyday situations in which they might encounter databases and the advantages of using databases over using files. In the instructional videos themselves, the exercises are then evaluated so that the students can compare their own considerations with the solutions presented in the video. Additionally, there will be an opportunity to ask questions and discuss them during the classroom lectures.

The seminar covers three taxonomy levels according to Bloom: Remembering (factual knowledge is conveyed through videos), Understanding (explanatory examples, making your own notes and quiz evaluations) and Applying (activating exercises in the teaching videos). Regarding the knowledge dimensions, factual knowledge (terms and definitions), conceptual knowledge (connections, e.g. advantages and application scenarios of databases) and metacognitive knowledge (self-reflection in the learning process) are conveyed.

### **2.1.2 Classroom lectures**

The lecture, which is held as a classroom course, is based directly on the content developed in self-study. At the beginning of each lecture, students are given a few minutes to briefly review their self-study work. Questions that arose during the self-study are then collected in the plenary session. Depending on how well the questions fit into the topic of the lecture, the questions are either integrated into the lecture or answered directly by other

students or the lecturer. After the questions have been collected and, if appropriate, answered, the actual lecture begins. Depending on the lecture, further content is developed in short presentations and plenary discussions and/or theory from the seminar is applied in more advanced concepts. In addition to short presentations and plenary discussions, various methods such as buzz groups (Sonntag et al., 2018) are used.

During the lecture, the taxonomy levels Understanding (by repeating and discussing questions), Applying (by transferring theory to examples), Analyzing (by discussing and breaking down concepts) and Evaluating (by presenting own results on an argumentative level) are illustrated. This promotes both conceptual knowledge (interplay of terms in concepts) and metacognitive knowledge (formulating own questions and plenary discussions).

### **2.1.3 Practical courses with real examples**

As part of the practical courses, the theoretical foundations and concepts developed are transferred into further practical examples. While the lecture embeds the theory at concept level in practice, the practical course goes one step further and applies the concepts to real examples, for example by formulating SQL statements for existing databases or developing database models based on real data.

The taxonomy levels Apply (implementation of concepts in concrete application examples), Analyze (requirements analysis), Evaluate (by presenting own results on an argumentative level) and Create (development of models, implementation of database structures) are applied during the internship. The courses teach factual knowledge (syntax of the SQL scripting language), conceptual knowledge (understanding and applying database concepts) and procedural knowledge (developing SQL commands, designing your own database models).

## **2.2 Evaluation of the flipped classroom approach**

The evaluation of the flipped classroom approach includes an interim evaluation, a survey at the end of the semester in the form of a target evaluation (Düwel et al., 2024), an evaluation of the learning success as well as an analysis of access to the platform on which the course materials were made available. These methods are described in more detail below.

### **2.2.1 Interim evaluation**

The method used for the interim evaluation is the Teaching Analysis Poll (TAP) (Kordts et al., 2025; Schmidt, 2024), which is based on the following questions:

- What do you learn most from in this course?
- What makes your learning more difficult?
- What suggestions do you have for improving the obstacles?

The survey is carried out by a person not involved in the course to allow students to give open feedback. The evaluation is carried out as part of a lecture, whereby the teacher is not present. The students are asked to answer the three questions in writing on notepads; these are then collected on the blackboard. The person leading the evaluation then responds to the written answers by discussing them with the students, gathering opinions and asking questions. The results of the evaluation are then made available to the teacher and discussed with them. (Schmidt, 2024)

### **2.2.2 Target evaluation**

A target evaluation (Düwel et al., 2024) was carried out at the end of the semester, in which the students were asked to indicate how much they agreed with five statements (1 - I disagree to 5 - I fully agree, 0 - no response). The students' answers are then visualized using a target, whereby full agreement is visualized by a dot in the center of the target, whereas no agreement is represented by a dot in the outer ring. The choice of method is based on flexibility regarding the number and content of the questions in combination with the visual representation of the results. The latter forms the basis for further discussions with the students. The following statements were part of the evaluation:

- The videos provided were understandable and supported my learning process.
- The scope of the self-study units was appropriate and easy to manage.
- The attendance sessions were well coordinated with the self-study units.
- The attendance sessions helped me to consolidate what I had learned.
- Overall, I am satisfied with the flipped classroom concept.

### **2.2.3 Learning success**

For the evaluation of learning success, the examination results using the flipped classroom were compared with the results of the previous year, in which no flipped classroom was used. In addition to the overall average, the focus was particularly on the proportion of top grades given and the proportion of students who were unable to successfully complete the module.

### **2.2.4 Access numbers**

The access numbers were evaluated using the integrated functionality of the learning management system used. This collects the number of accesses to the individual course components or the course itself for each day. The latter was analyzed as part of the evaluation.

## **3 Results**

The results of the various evaluation priorities are described below.

### **3.1 Interim evaluation**

As part of the interim evaluation, students praised the flipped classroom concept. In particular, the short and concise videos in combination with the independent knowledge assessment during the seminar were very well received. The interlinking of the various course formats and the module's practical relevance were highly rated as well. No aspects of the method that hindered learning were identified.

### **3.2 Target evaluation**

17 students took part in the final evaluation; the results are shown in Figure 2. Overall, the method was well received by the students, but individual students were less satisfied with the flipped classroom concept. When asked, it was stated that the students themselves did not favor the method. Again, no points of criticism were expressed related to the flipped classroom approach developed specifically for the course.

### **3.3 Learning success**

In addition to the evaluations, the examination results were also evaluated in comparison to the previous year. In the previous iteration of the course, a written exam was conducted for the first time on a PC, in which the students worked exclusively on practical tasks. Figure 3

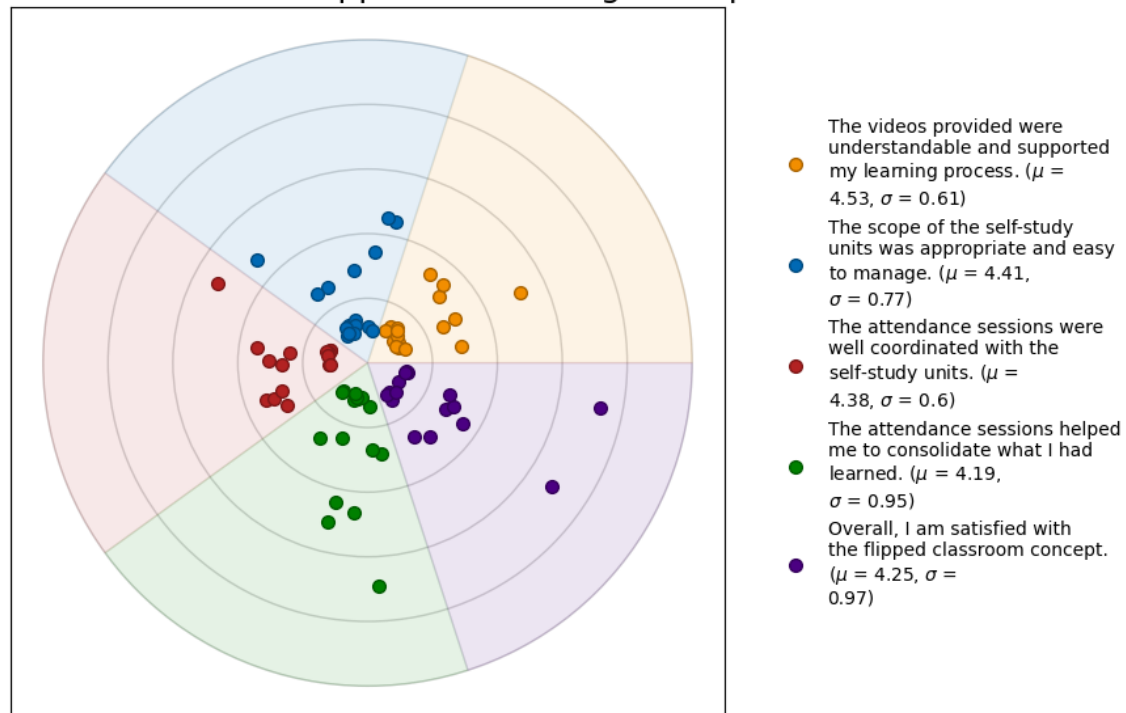
shows the grade distribution of the examination without the use of a flipped classroom and the grade distribution after the flipped classroom approach was applied. The proportion of students who failed the course (grade 5.0) fell from 12.90% to 6.98%, while the proportion of students who achieved the top grade (grade 1.0) increased from 12.90% to 16.28%. The improvement in examination performance is also reflected in the average grade. Compared to the previous year, the average grade was reduced from 2.67 to 2.50.

### 3.4 Access numbers

The survey and analysis of access numbers shown in Figure 4 revealed increased course access at the beginning of the semester and shortly before the final exam. During the semester, constant but relatively low access numbers were observed (approx. 10-20 accesses vs. 53 course registrations). These observations are consistent with the number of participants in the face-to-face courses.

Figure 2: Results of the target evaluation: The target visualizes the agreement with the statements listed. The further inwards the dot is, the higher the level of agreement. 17 students took part in the evaluation, abstentions were possible for individual statements.

#### Evaluation of the FlippedDB teaching concept



## 4 Discussion

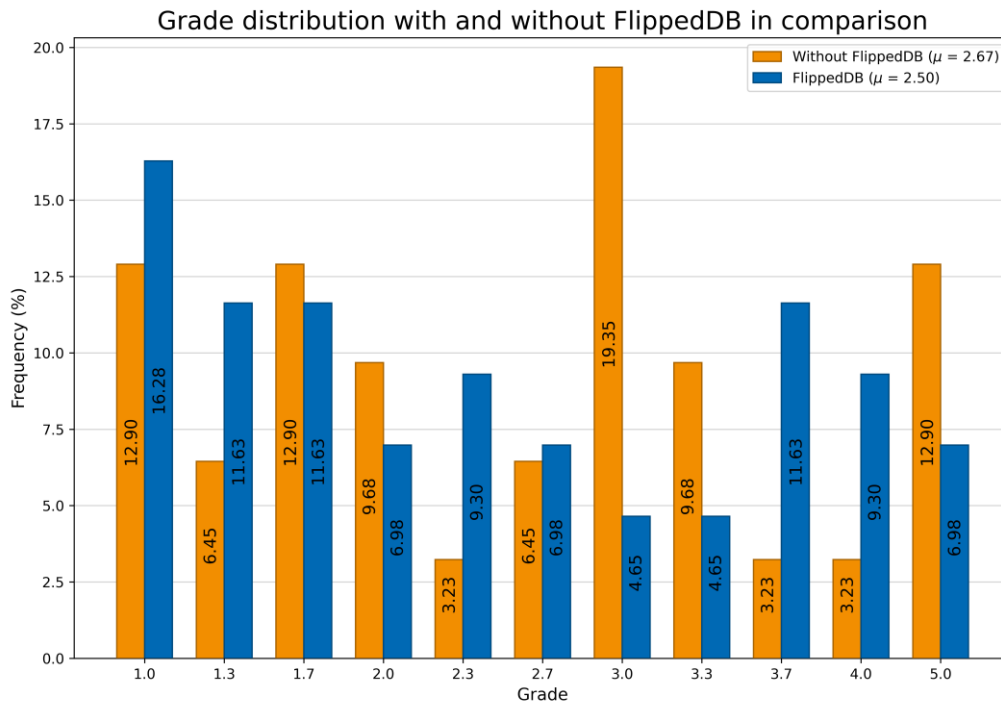
The results of the evaluation are discussed below. In addition to the evaluations and test results, the user statistics and possible extensions are also discussed. In addition, general design principles for the practical application of the flipped classroom concept are derived.

### 4.1 Discussion of the evaluations and examination results

The results of the evaluations suggest that the flipped classroom concept was well received by the students and creates an environment conducive to learning. In addition, a minimal improvement in examination results was observed, which could indicate a positive effect of the flipped classroom. However, it should be noted that the improvement in the average grade awarded and the proportion of top grades and students who did not pass the examination are not necessarily due to the flipped classroom. The improvement could also be due to a higher-

performing group of students taking part in the course using the flipped classroom approach. Furthermore, there is no statistical significance due to the small sample size. To confirm the positive influence of the flipped classroom on examination performance, the results of the next examination should also be evaluated to rule out a one-off fluctuation.

Figure 3: Comparison of grade distributions without and with the use of a flipped classroom



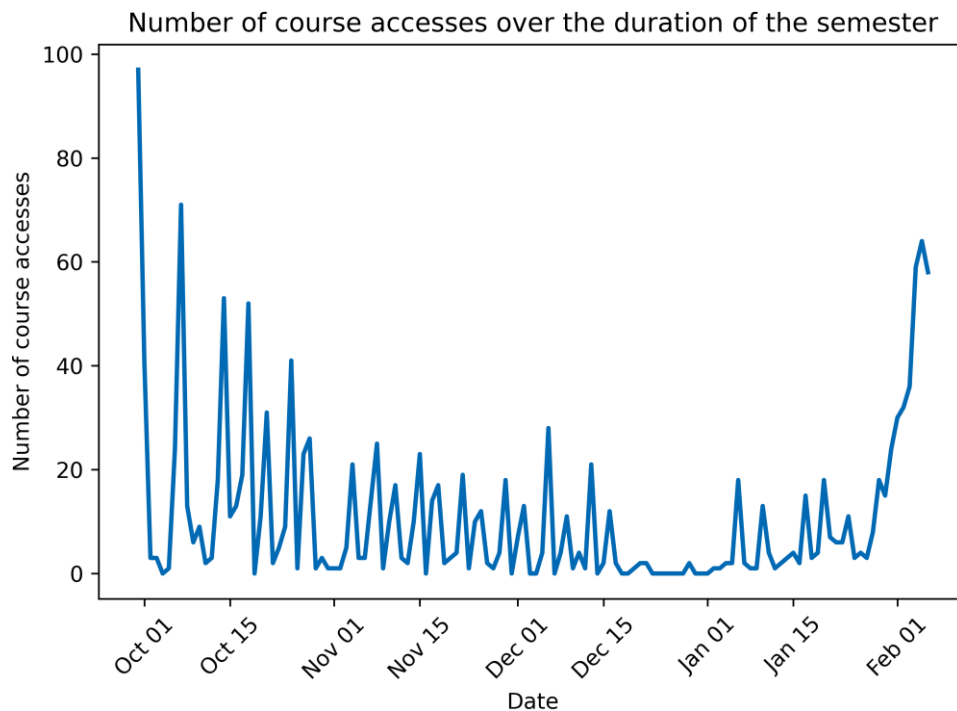
## 4.2 Discussion of the usage statistics and observations during the semester

Although the students praised the flipped classroom model in both the interim and final evaluations, only a small proportion of the students registered for the module took part in the face-to-face sessions. The usage statistics also showed that most students only accessed the materials in the last few days before the exam. Access during the semester, on the other hand, was relatively low and can be attributed to the students who took part in the face-to-face courses. To better understand why students decide not to take part in lectures and practical courses, a survey is planned for the next iteration of the course. In addition, the self-study materials will be supplemented with further interactive elements to increase motivation to promote a continuous way of working. Irrespective of the relatively low number of participants in the face-to-face courses, however, it was possible to ascertain increased collaboration as well as regular participation.

## 4.3 Possibilities for expanding the flipped classroom concept

In addition to analyzing why few students take part in the face-to-face courses, there are also plans to expand the self-study materials. In the evaluation, students asked for more exercise materials for independent reflection and consolidation of the content conveyed in the teaching videos. In addition, the phases of provocation and prior knowledge activation should be further expanded. Although these were fundamentally considered in the implementation of the flipped classroom concept, increased use and a comprehensive design can continue to contribute to the motivation of students and their practical understanding of the topics.

Figure 4: Number of course accesses over the duration of the semester, beginning with the first lecture on September 29, 2024, and ending with the exam on February 6, 2025; lecture-free period between December 23, 2024, and January 3, 2025.



#### 4.4 Evaluation of the objectives

Three primary objectives and two secondary objectives were defined as part of the work. The primary objectives were the promotion of participation in classroom teaching, regular engagement with the module content and the improvement of examination performance. Secondary objectives were also defined as the feasibility in terms of time and the coherent anchoring of the individual course formats. The extent to which the respective objectives were achieved is explained below.

**Promotion of participation** Increased participation was observed in the face-to-face courses compared to other courses, especially compared to other lectures. In addition to participating in the interactive exercises, this also manifested itself in the discussion and answering of questions. This objective can therefore be considered achieved.

**Regular engagement** With regard to regular engagement with the course content, based on the access numbers analyzed, it can be determined that only a fraction of the students registered for the course regularly interacted with the documents. In addition to the high access numbers at the beginning of the semester, a sharp increase was also observed shortly before the exam. This observation is consistent with the proportionally low number of participants in the face-to-face courses. Accordingly, the goal of regular engagement with the course content was only partially achieved. Regular interaction with the course materials was observed, which can probably be traced back to the students participating in the face-to-face events. At the same time, however, the number of course access remained below the theoretically possible number of accesses based on the course enrolments.

**Improvement of examination results** As described, improvements were achieved regarding the examination results in terms of the general grade average as well as the percentage of top grades and the failure rate. However, due to the small number of people in the comparison groups (31 participants without FlippedDB vs. 43 participants with

FlippedDB), the results should be interpreted with caution, as they are not statistically significant ( $p > .05$ ) and the determination of Cohen's  $d$  showed a very small effect (Cohen's  $d < 0.2$ ). The objective is therefore only fulfilled to a limited extent, as the improvements appear promising in terms of content, but are not statistically verified and their reproducibility remains unclear.

**Feasibility in terms of time and anchoring of the individual course formats** Using the target evaluation, the students' opinion of the implemented flipped classroom concept was determined. The results show that the students were largely satisfied with the concept. Very good results were achieved regarding the amount of time spent on self-study and the linking of the individual course formats, as shown in Figure 2. The preparation of the teaching videos was also rated very highly. It was therefore possible to implement a flipped classroom, the preparation of which was profitable and feasible in terms of time for the students, while at the same time creating added value in attending the face-to-face events, the content of which is well coordinated with the preparatory materials. This objective can therefore be considered achieved.

#### **4.5 Derivation of general design suggestions for setting up a flipped classroom**

Based on the flipped classroom concept presented in this paper, some design decisions can be derived that enable the concept to be used in different modules.

First, the interlocking of the course formats to map Bloom's taxonomy (Anderson & Krathwohl, 2001) should be mentioned. The gradual increase in taxonomy levels depending on the course format enables students to repeat and work on deficits and to prepare for further courses in the same subject area in a targeted manner. At the same time, the interlinking creates a binding nature for the implementation of self-study, compliance with which was recognizable among the regularly participating students.

The preparation of content in the form of instructional videos should also be mentioned. The design of these promotes individualized teaching by using short videos with individually adaptable speed and the possibility of targeted repetition through chapter markers. The slide sets used as the basis for the videos are made available as handouts for individual notes, which demand the students' attention but also provide guidance when taking notes.

The introduction of knowledge tests makes it possible to check the knowledge acquired and, building on this, to encourage the targeted repetition of content or the asking of questions in the classroom sessions. As part of this, care must be taken to actively involve students in the course content and methods and thus promote the acquisition of the skills required for the examination.

Finally, it is important to align the examination performance with the learning objectives in terms of constructive alignment (Biggs, 1996). This ensures that students who have actively participated in the methodology are rewarded with correspondingly good examination results and, in the best case, can use the skills they have learned in future projects.

## **5 Conclusion**

The work presents a flipped classroom concept that focuses on teaching students the necessary skills in the practical use of databases. Using instructional videos and quizzes for self-assessment, students work on the theoretical basics in self-study, which are deepened in the lecture and in the practical course at various levels of complexity. The course concludes with a practical examination. The two evaluations and the examination results suggest that the use of the flipped classroom has created an environment conducive to learning. Due to the

small number of participants, however, these results should be viewed with caution and re-evaluated. Based on the generally valid recommendations for the implementation of a flipped classroom, which have also resulted from the implemented methodology, it is possible to implement the concept presented in this paper in other disciplines apart from the database course presented in this paper. The prerequisite for this is a similar basic structure that enables the multi-level application of Bloom's taxonomy and the MOMBI model adapted and described during conceptualization. In addition to re-evaluating the results, there are also plans to expand the teaching materials to include further (interactive) exercises and to extend the phases of provocation and prior knowledge activation. A student survey will clarify why only a fraction of students attend classroom lectures and practical courses.

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