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The Inverted Classroom Model in a Master's Degree Program for Civil Engineers

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This paper should be cited as follows:

Rädel, F., (2018). **"The Inverted Classroom Model in a Master's Degree Program for Civil Engineers",** Athens: ATINER'S Conference Paper Series, No: **ENGEDU2017-2421.**

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URL Conference Papers Series: www.atiner.gr/papers.htm

ISSN: 2241-2891
04/04/2018

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Abstract

The courses of civil engineering in Germany are characterised by a series of lectures, exercises and exams. Several studies show, that a more learner-centered approach has a lot of advantages regarding learner's satisfaction and learning performance. In summer term 2015 elements of the so-called Inverted Classroom Model (ICM) were used in a course of the Master's Degree Program for civil engineers at TU Darmstadt for the first time and with a great success. For summer term 2016 some additional improvements have been included and the complete course has been instructed with the ICM. Different concepts for the use of digital media in higher education are presented in the paper and the ICM is introduced in detail. The reasons for the change to the Inverted-Classroom-Model and the exact sequence of the masters' degree course at TU Darmstadt are presented. In addition a discussion of the results of the evaluation takes place and a perspective on the further application of the ICM in the context of this course is given.

Keywords: Inverted Classroom Modell (ICM), Wiki, Master's Degree, Civil Engineering, learner-centered teaching

Acknowledgments: I want to thank Prof. Dr.-Ing. Jörg Lange, the responsible lecturer for this course, for the possibility to do this research and for important comments on the manuscript.

Introduction

The digitization of teaching is currently a great discussion at many levels. In the year 2000 already, the German Science Council (Wissenschaftsrat, 2000) defined interdisciplinary skills and key qualifications as basic objectives for degree programs. Communication and team skills, presentation and moderation techniques as well as the handling of modern information technologies were identified in the report as important competences for graduates. The extent to which digital media can or should be used in the advancement of the various abovementioned competences within higher education has been controversially discussed for a long time.

Supporters argue that digital teaching and learning scenarios can direct a greater focus on competences. Skeptics consider the tried and tested, classical university scheme to be at risk. Jay Cross, to which the invention of the term "eLearning" is attributed in 1998, is cited as follows: „We thought we could take the instructors out of the learning process an let workers gobble up self-paced (i.e., “don’t expect help from us”) lessons on their own. We were wrong. First-Generation eLearning was a flop.“ (Mason & Rennie, 2006)

Certainly the use of digital media can only be implemented with corresponding didactic concepts. In this article, different approaches of digitization are summarized. The so-called Inverted Classroom Model (ICM) is presented, which is one possibility for the combination of online teaching and presence-based teaching. The use of wikis in higher education is also briefly discussed. A successful example for the application of the ICM within the curriculum of the master's degree in civil engineering at the TU Darmstadt will be explained and discussed in detail.

Concepts for the Use of Digital Media

The term “Digitalized Teaching” is used very widely, similar to the term “E-Learning”. In the absence of a clearly defined definition, there is almost everything possible from the provision of complementary exercise materials in the World Wide Web, through the implementation of electronically supported tests on computers up to the use of MOOCs. Concentrating on specific courses at universities, it is possible to distinguish basically between three different concepts (Bachmann et al., 2002):

- In the **concept of supplement** the traditional teaching is supported by the provision of materials accompanying the course via www.
- The **integrative concept** combines online and presence phases, thus combining the advantages of both event forms.
- In the concept of **virtual teaching** nearly the whole course takes place online.

An essential point of the **concept of supplement** is that the classical form of teaching is largely maintained and could be carried out without digital media. In this case, the digital part assumes a purely supporting function. For example, supplementary material is made available online or a discussion board is offered on an internet platform.

In the **integrative concept**, which is often called blended learning as well, online offers are no longer optional. This is in contrast with the enrichment concept. The online and the presence phases depend on each other, whereby both elements are an integral part of the didactic concept of the course. This is e.g. the case when students are asked to create a wiki page as a course work.

The concept of **virtual teaching**, in which all presence offers are replaced by online offers, is the exception for universities. Here, various scenarios, e.g. Self-learning courses, video lectures or Massive Open Online Courses (MOOC) are possible.

The Inverted Classroom Model

Basics

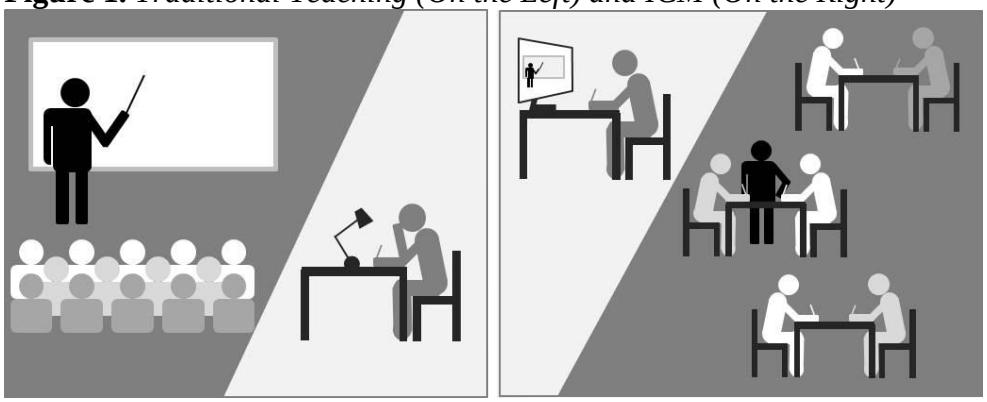
An example of the integrative concept, in which presence phases and online offers are combined, is the so-called Inverted-Classroom-Model (ICM). The basic idea of the ICM, which is also called Flipped-Classroom-Model, is a temporal shift as well as a local reversal of the two main learning phases: The content distribution and the content deepening. In the classical university teaching the content distribution usually takes place in the form of a lecture. The students usually get involved with the learning material for the first time by attending the lecture. They follow the lecturer mainly passively through listening and partly by taking notes. The subsequent phase of content deepening generally takes place at home in form of a post processing or exercise, alternatively in tutorials or exercises at university.

This common sequence of learning phases has several disadvantages. It has already been shown in numerous studies that the attention span during pure listening is much shorter than usual 90-minute lectures. Concerning the university for example, in a study carried out by Margarete Imhof (2004), 75 % of the students stated that it was difficult for them to be attentive throughout the complete lecture. Moreover, due to a heterogeneous composition of students, it is virtually impossible for the lecturer to find a suitable pace for the lecture. There are always students who, because of a greater degree of pre-knowledge, feel low demanded in a lecture. Others cannot follow the lecturer after a short time, are left behind and have difficulties to catch up with the lecture again. In the above-mentioned study, only 39 % of the 465 respondents reported that they rarely lost the thread when listening to lectures. This means, in turn, that more than 60 % of the students are left behind often during lectures. In the case of the individual content deepening at home, there exists

furthermore the problem that the learners are relying on themselves while working on exercises. Misunderstandings can thus often not be solved promptly.

The Inverted Classroom Model counteracts these disadvantages by turning the learning activities. The content distribution happens no longer at the university within the setting of a lecture. In contrast the learners prepare the material beforehand with the help of digital materials provided on the Internet. The subsequent course is used to deepen and practice the learning material in form of discussions, exercises or group work.

Figure 1. *Traditional Teaching (On the Left) and ICM (On the Right)*



Source: Prepared by the author

The individual work with the learning material brings several advantages for the students. Everyone can deal with the documents at any time, at any location at their own pace. For example, content that is already known to a person can be quickly skimmed. More complex contexts, which are not comprehensible during the first perusal, are repeated individually. In addition, it is also possible, to prepare missing basic principles. Besides a higher degree of satisfaction in learning, this also allows a certain balance in heterogeneous prior knowledge.

Various digital media can be used as teaching material. From digital scripts, podcasts and lecture notes to wikis or specially created teaching videos, a wide range of variants is possible. Also interactive graphics and multimedia files are thinkable. In order to be able to check the success of self-controlled learning, e.g. online quizzes or final questions about the edited content are provided. Other advantages include the transparency of the teaching material and the maintaining of the content in spite of illness or holidays. In this type of knowledge acquirement, the students are asked for a much higher degree of self-responsibility.

The subsequent presence time can then be used to discuss and answer specific questions about the online material. Collaborative tasks do not only train professional competencies. The students are more likely to be activated within the setting of such a presence time, which contributes to a higher intensity and thus to a considerably greater depth of knowledge. In addition, the available time provides free spaces for a much stronger interaction between teachers and learners, e.g. in discussions or by providing help in the processing

of exercises. Individual support for individual students with specific problems is possible.

The presence time can thus be significantly more learner-centered than it is conceivable in a monologue during a lecture. For lecturers, however, this also means that their roles are changing decisively. The American pedagogue Alison King phrased this as follows:

"From Sage on the Stage to Guide on the Side." (King, 1993)

History of the ICM

The Greek philosopher Aristotle [384-322 B.C.] once wrote: “What we have to learn to do, we learn by doing.” The Chinese philosopher Confucius [551-479 B.C.] is cited as following "I hear and I forget. I see and I remember. I do and I understand.” More than 2.000 years ago, it was already clear that the most effective form of learning is doing things by itself. Jay Cross, who is credited with the invention of the term "eLearning", added the ancient philosophers "if I hear and see and do and then practice and teach, I understand even better." (Cross, 2004)

Doing by itself, practicing, and mutually explaining are important pillars of the ICM. The following section is a brief history of how the Inverted Classroom Model has evolved. In the engineering sciences, but also in many other academic fields, the traditional approach of the knowledge transfer is that the technical content is presented as part of a lecture, while the content deepening - the own doing and practicing - takes place self-contained or in learning groups.

The basic idea of learners, who are – deviating from this teaching concept - prepared for lectures, is obviously not new. For a very long time, it is quite common in both schools and colleges that pupils or students already deal with course material at home, which is then reviewed or discussed during class. In the past, this mostly happened using available books or using copied scripts. However, the development of various software and, in particular, the World Wide Web resulted in far more possibilities. According to today's conceptual understanding, the ICM, unlike before, includes a "regular and systematic use of interactive technologies" (Strayer, 2012, p. 172) as part of the learning process.

In 1998, Walvoord and Andersen, two US-American female professors, presented a teaching concept with the title "Effective Grading" (Walvoord & Andersen, 1998). The students dealt with a new topic with the help of clearly formulated work assignments. The focus of the in-class time itself was then on the deepening of the learning material, e.g. with the help of feedback and activating forms of learning, such as case studies.

The term “Inverted Classroom” was first used by American economics professors at Miami University in Oxford (Ohio). Maureen Lage and Glenn Platt presented their teaching method, which they had used for the first time in 1996, in 2000 in the Journal of Economic Education. The students had the task

to prepare the respective topic by means of a book chapter and were additionally encouraged to watch appropriate material, which has been made available in very different formats (video, discussed PowerPoint files, pfd files of PowerPoint presentations, etc. (Lage, Platt & Treglia, 2000).

At the beginning of the course, questions concerning the content of the provided learning material were answered by the lecturers. During the remaining period of the in-class time, practical exercises - mostly in small groups - were carried out, in order to give students the opportunity to actively experience economic connections. In addition, there existed worksheets on the respective topics, as well as other online material, e.g. interactive quizzes.

The background of turning their course into this teaching method was the experience of a wide range of types of learners in the course "Introduction to Economics". The two professors had the hope to do justice to all types of learners through the different types of preparatory materials as well as different in-class scenarios without restricting the scope and content of the course.

Under the name "Classroom Flip", J. Wesley Baker presented a similar concept, based on online learning units, at a conference in Florida (Baker, 2000).

In the school sector, the documented history of the Inverted Classroom began in 2007 and quickly became a success story in the USA. The high school teachers Jonathan Bergmann and Aaron Sams at that time came up with the idea of recording PowerPoint presentations with voice and additional commentaries and providing them online for pupils who could not take part in the lessons for various reasons. The two teachers realized soon that the videos provided were not only used by the absent pupils, but also by those who were present to repeat or prepare the exam. This quickly led to the realization that it would be sensible to record all the teaching units and to let the pupils view them as homework beforehand, in order to be able to use the entire period of in-class time to respond to the pupils' individual understanding problems. So, the Flipped Classroom of Sams and Bergmann was born (Bergmann & Sams, 2012).

In 2012, Bergmann and Sams launched a Flipped Classroom Network to inform other interested teachers and to get to know each other (Hamdon, 2013). The great interest in the topic can be seen in a few figures: In January 2012, the network had 2,500 members, in June 2013 it was 10,000 and in May 2014 there were already registered more than 20,000 teachers and lecturers (Yarbo, 2014).

Parallel to the development at US schools, more and more lecturers have introduced the method of the Inverted Classroom at universities. In the first few years, however, only a few documentaries exist. In his dissertation at Ohio State University, J. F. Strayer published in 2007 studies in which he compared the learning activities of mathematics students in traditional classes and the flipped classroom (on the basis of an intelligent online tutorial system) (Strayer, 2007).

Three Miami University researchers in Oxford (Ohio) presented their method of the ICM, based on podcasts, in 2008 at a software engineering conference in Leipzig. They conclude that the ICM combines the advantages of

collaborative learning and self-learning very well, especially in the context of the life environment of today's students (Gannod et al. 2008).

The professors Jörn Loviscach, Jürgen Handke and Christian Spannagel are regarded as pioneers in the German-speaking countries. In 2012 they initiated the first ICM conference in German language, which has since taken place each year with a growing number of participants, and has established itself as a platform for exchanges between teachers at universities as well as schools.

The current distribution of the Inverted Classroom Model is very different around the world. While the teaching method has been used by a large number of teachers in the USA for some time (see Yarbo, 2014 and Bart, 2013), the application in Europe is limited to a very small, albeit increasing, percentage of teachers and lecturers.

The NMC Horizon Report analyzed the Flipped Classroom 2014 for the first time as one of the decisive teaching / learning technology developments in the field of higher education for the following years (Johnson, 2014). In the edition of 2015, this assessment is repeated and reaffirmed (Johnson, 2015). The development and dissemination of the ICM in the school as well as in the sector of Higher Education will certainly continue for several years.

Using Wikis in Higher Education

Definition

The term Wiki is derived from the Hawaiian word WikiWiki, in English "quick". An essential characteristic of a wiki is thus well captured: content can be edited and changed quickly. The first Wiki was developed by the US-American software developer Ward Cunningham already in 1995. Well-known to the large public became Wikis with the success of the Wikipedia projects between 2001 and 2005 (Thillosen, 2008). The world's most widely used Wiki, the free encyclopedia Wikipedia, provides the following definition: “A Wiki is a website that provides collaborative modification of its content and structure directly from the web browser. In a typical wiki, text is written using a simplified markup language and often edited with the help of a rich-text editor.” (Wikipedia)

The characteristic key points of the wiki philosophy are formulated, for example, by Bry and Herwig (2009): simple usability without special programming knowledge, securing all information by version function and uncomplicated linking of the pages among each other as well as the support of all multimedia contents suitable for web browsers.

These functions result in very different application possibilities for Wikis. Relating to the Higher Education these are for example the collaborative text production, project coordination and documentation, or informal communication among students.

Capabilities and Experiences

In the last few years, several authors have dealt with the aspects which are decisive for the success or failure of Wiki projects in teaching. Panke and Thillosen (2008) pointed out that the pure "presence" of a Wiki does not automatically lead to its use and that an unused wiki is more of a demotivating effect. In addition, they point out that "neither collective or public writing, not to mention the disclosure of a" work in progress "" is familiar to the students and these competencies must be established first. Marija Cubric (2007) recognized on the basis of her experience with Wikis in Higher Education that students' engagement is directly dependent on clearly defined learning objectives and the quality and frequency of feedback from the lecturers.

There is agreement among numerous authors that the objectives of the Wiki must be explicitly communicated in order to make the expectations to the students clear (see e.g. Moskaliuk & Kimmerle 2008, Bremer 2008, Cubric, 2007). Bremer points out that, in particular, overloading the learner with different media used in one course must be avoided. This can be prevented by a clear objective in advance (Bremer, 2008).

Moskaliuk and Kimmerle (2008) attribute the importance of the intrinsic motivation to the success of a Wiki. According to Ryan and Deci (2000), the intrinsic motivation, thus the natural tendency to seek challenges and demonstrate the own abilities, is based on three basic psychological needs: the need for competence, the need for autonomy respectively self-determination, and the need for social integration.

According to Moskaliuk and Kimmerle, the participation in developing a wiki can ideally satisfy all three basic needs and thus promote intrinsic motivation. Self-determination is given when the students are free to choose the Wiki areas or topics to which they can write or modify something. It is therefore recommended to involve the students in the selection of the topics or at least to provide options. At the same time, the own competence can be realized by working on Wiki articles, in which a student is well versed.

The feedback of other users and the feeling of working on a common content also satisfy the need for social inclusion (Moskaliuk & Kimmerle, 2008). Conclusively, Moskaliuk and Kimmerle see a great challenge for lecturers to provide sufficient space for voluntary and self-determined learning, despite curricular requirements.

On the basis of the previous information it becomes clear that the success of a Wiki project is not as a matter of course in the context of an educational course. However, many authors conclude that useful Wikis offer a great potential in teaching. According to Flotmann (2014), they enable contemporary learning environments to bridge the gap between active and receptive learning. In her opinion, it is particularly important to follow a successful path between construction and instruction.

Moskaliuk and Kimmerle see Wikis with the background of a constructivist learning understanding as an ideal tool for individual learning and cooperative

knowledge construction, whereby the expectations should not be too high. Ebersbach et al. (2008) summarize this with the following simple sentence:

"Wikis are fascinating tools, but they are not a panacea."

Moreover, the self-understanding of the lecturers and their relationship to the learners is an important point to be considered. When using a Wiki in which students independently create content, which in turn is used and evaluated by other students, the students are clearly more self-initiative and responsibility for the learning process than in a traditional lecture. The lecturer thus becomes a companion of knowledge adoption instead of a broadcaster of knowledge.

Implementation of an ICM-Course with Wiki at the Institute of Steel Structures and Materials Mechanics at TU Darmstadt

Initial Situation

The degree program for civil engineers at the TU Darmstadt is characterized by a series of lectures, exercises and examinations in each course. The problems of this teaching concept have already been explained before. In the following a compulsory-elective course of the Master's degree program for civil engineering will be considered. The course covers 6 CP and is called "Selected Chapters in Composite and Lightweight Construction". The two main topics are steel-concrete composite construction and sandwich construction. These topics have been supplemented in the past by individual lectures on various other areas of lightweight construction, such as, for example, rope and membrane constructions and trapezoidal profiles. A substantial part of the lectures are traditionally held by former scientific staff of the institute, who give an insight into their own research and / or their actual activity in practice. In addition to the topics covered in the course, students in recent years have produced and presented a poster on a self-selected topic from the area of composite and lightweight construction.

In the past, students especially commented the practical relevance of the course, the versatility of the topics and the presentation by several external lecturers. The excessively large amounts of learning material, which resulted from the many different topics, as well as missing exercises on the individual topics were criticized. In addition, the students were often uncertain of the learning target of the individual lectures and the content of the final examination, especially due to the lack of exercises. In the past, this often led to a certain dissatisfaction on the part of the students combined with a reduction in the learning performance.

New Teaching Concept

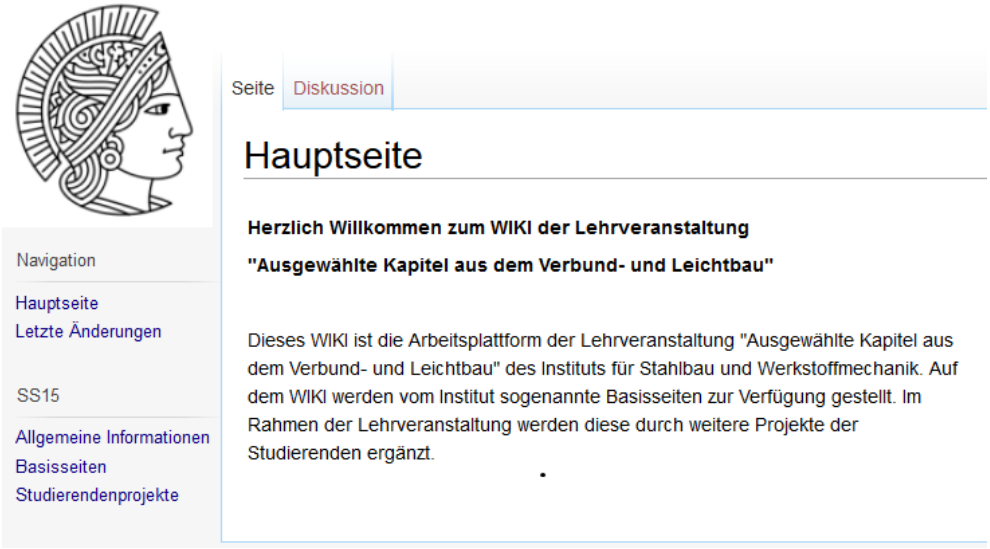
Basics

In the summer term of 2015, the course "Selected Chapters in Composite and Lightweight Construction" was held for the first time with components of the Inverted Classroom Model. In particular, the following two points had to be considered:

- The event with 6 CPs is scheduled on two consecutive days (Tuesday and Wednesday). It was therefore considered as useful to provide online material only once a week, which should be handled by the students in preparation for the in-class time.
- Due to the good experiences with external lecturers, their lectures should be maintained.

The students of the civil engineering department at the TU Darmstadt are already gaining experience with the use of a Wiki in an undergraduate degree course. That was the reason for choosing a course-internal wiki as online platform for this course as well. As can be seen in Figure 2, the wiki was structured very clearly. All important information for the course was compiled under the heading "Allgemeine Informationen (General Information)". The online materials for the ICM course were made available by the teachers under the heading "Basisseiten (Basic pages)". Within the scope of the course work, students were asked to create their own Wiki pages on their own topics together with a partner during the semester.

Figure 2. *Wiki-Homepage*

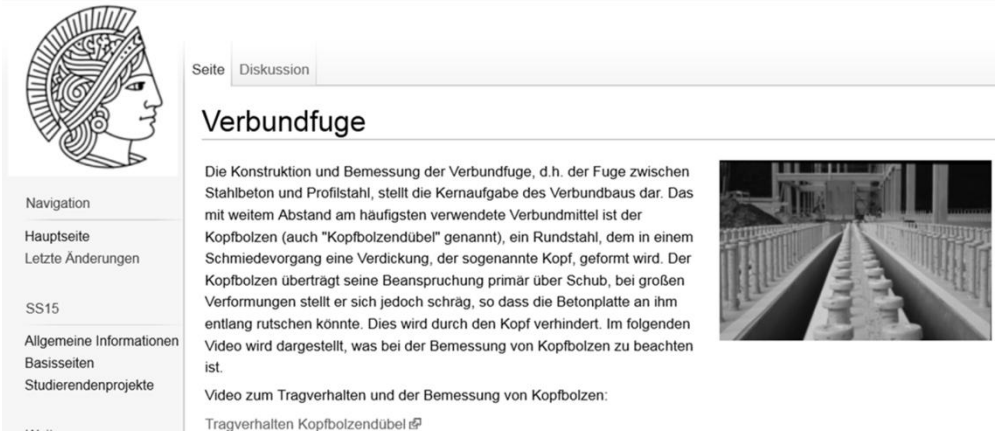


Source: Prepared by the author

Online-Phase

An associated Wiki page has been created for each ICM meeting. All working documents necessary to prepare for the in-class time were made available on this page. Depending on the topic and the material available, the pages consisted of completely new created online content, of individual sections of lecture recordings, of linked professional articles or script excerpts. At the end of each page several questions were asked. These should give the students the opportunity to check their own knowledge. After the in-class time, the page was supplemented sometimes by an exercise including a suggested solution. As an example, in Figure 3 a small section of the Wiki page on the subject of composite joints is shown.

Figure 3. *Chapter of the Wiki-page "Verbundfuge (Composite Joint)"*



Source: Prepared by the author

In-Class Time

During the first run in the summer of 2015, the procedure of the in-class time was approximately the same for the entire semester. The first part was dedicated to clarify open questions and was carried out using the *Think Pair Share Method* (Lyman, 1981). This was described by Frank Lyman in the early 1980s and represents a basic approach for cooperative learning.

In the considered course here, the students first of all noted the decisive points, which they had understood or had not understood when working on the online materials provided (*Think*). Subsequently a discussion occurred in groups of two students, in which the still open questions were discussed among the learners and were clarified in the ideal case (*Pair*).

At the end of this phase all groups wrote down their most important question to be clarified on a record card. The cards were collected by the lecturer and sorted on the board. In the final *share* phase, the questions formulated on the record cards were discussed in plenum or, if necessary, answered by the lecturer. The second part of the in class time was used for practicing and deepening of the learned content. For this purpose, an exercise was mostly

distributed, which was worked out by the students in individual or partner work. The lecturer was available for the students as a contact person for questions.

Course Work

As a semester-accompanying course work the students had the task to create their own Wiki page in groups of two. For this purpose, a list of possible topics was issued, but also freely chosen topics in the field of composite or lightweight construction were possible. The primary target of this task was that the participants independently deal with a special subject and present it understandable for the fellow students within a Wiki.

In addition to the professional development, the development of the course work thus also enhances the competence in the active handling of the online medium Wiki. In addition, the aim of the group work was to support the communication within the group of students. The essential contents of the Wiki page had to be discussed with the partner and a work-sharing had to be defined.

After the completion of the preliminary version of the students' pages they have been evaluated by the fellow students via a peer review procedure. With the help of a predefined evaluation scheme, the content and the layout of the pages had to be commented and improvements had to be suggested. Subsequently, the students had the opportunity to revise their own pages on the basis of the peer reviews, before they had to be presented to all students and the lecturers during a presentation at the end of the semester and assessed by the lecturers.

Evaluation after the First Run

Basics

An obvious way to assess students' success is to compare the examination performances for the traditional course setting and the ICM-setting. However, this comparison has some problems. First of all, there are relatively few student numbers, which make a comparison of the examination results very difficult. In addition to this, only technical knowledge is assessed during the examination and the additional learning effects (e.g. creating online content, research on unknown topics, collaboration with fellow students, peer review of student work, etc.) can only be assessed very limited or not at all. For that reason, in the following only the results of questionnaires are discussed.

All ICM units have been evaluated using questionnaires answered by students anonymously, which has always been distributed at the beginning of the subsequent in-class time. Each questionnaire was almost identical. The students' work behavior (for example the period of working on the wiki pages), their opinions about the online material as well as the procedure and content of the in-class time have been determined.

In addition, there was always the possibility to name suggestions for improvements, comments or wishes. On average, the questionnaires have been completed by 19 students, which was roughly equivalent to the average

attendance. In the last week of the semester, a questionnaire on the general experiences with the new teaching method was distributed. In the following chapters the main results of these student surveys are presented.

Attendance

28 students were enrolled in the course and all of them participated in the examination at the end of the semester. The attendance averaged 20 persons. No difference could be found between the ICM units and the traditional teaching units.

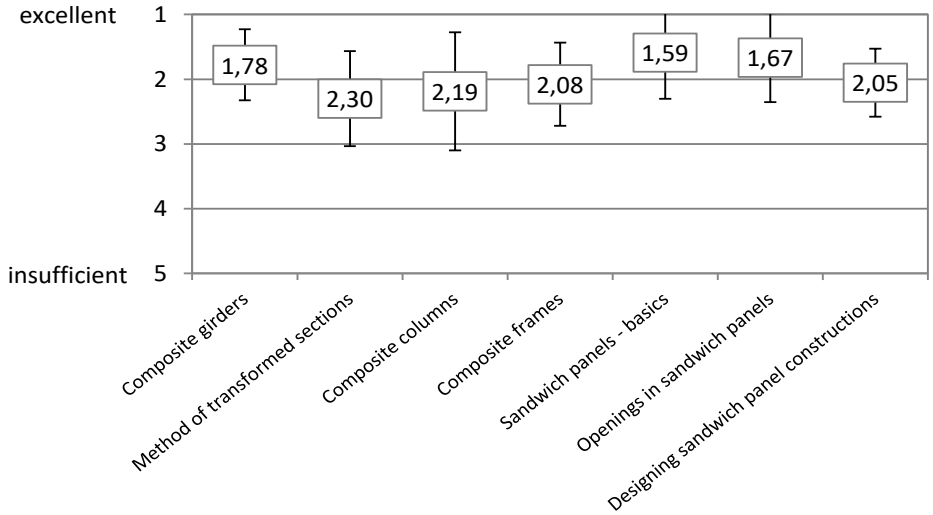
Assessment by the Students

On average, 89 % stated that they prepared themselves for the in–class time with the online material. The average processing time for the preparation was 46 min. According to the answers of the students, an average of 74 minutes would have been necessary to fully understand the online material. This means, the students came into the class knowingly with knowledge gaps.

However, the discrepancy between actual and necessary preparation time decreased significantly during the semester. This can be explained by the fact that the wiki pages have been designed shorter by the lecturers. However, it may also be the case that the students have understood during the semester that an attendance of the in-class time is only useful for them if they have sufficiently prepared themselves.

The learning material provided on the wiki pages was rated on a scale from 1 (excellent) to 5 (insufficient) on average with a grade of 1.95. In addition to the mean values which result from the individual responses to each topic, the corresponding standard deviations are also shown in Figure 4.

Figure 4. *Students' Assessment of the Wiki Pages in Summer 2015*

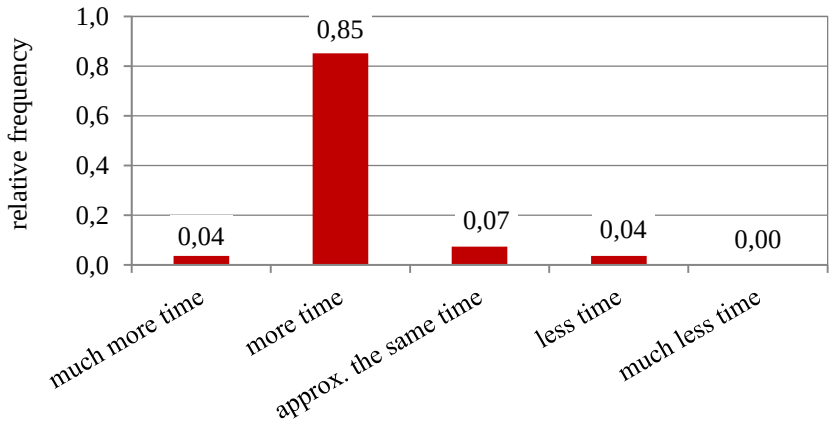


Source: Prepared by the author

The in-class time was positively evaluated by the attendant students without exception. The question, if the procedure of the in-class time was helpful led to a mean value between 1 and 2 on a scale from 1 (applies) to 5 (does not apply) for all ICM units. Also the question if all own professional problems could be solved in the in class time, has been answered on the same scale always with an average value better than 2.

During the last week of the semester, the students were asked about their basic experiences with the Inverted-Classroom Model. Firstly, the students' learning behavior and learning success was requested. The majority of the respondents stated that during semester they spent more time in the ICM-course than in a traditional course (see Figure 5a). In this context it has to be added, that the same students confirmed after the exam that they spent much less time on preparation for the exams.

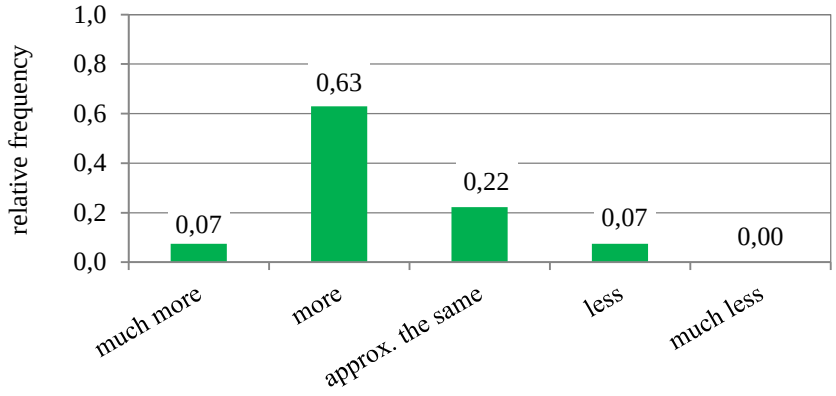
Figure 5a. *"Compared To A Traditional Course I Spent…" (Database: Summer Term 2015, [N=27])*



Source: Prepared by the author

As can be seen in Figure 5b, a majority of the participants also estimated their own learning success increasing as a result of the Inverted Classroom Model. When asked about the preferred teaching method for a masters' degree course, two-thirds of the 27 students answered to prefer the ICM. A quarter stated to prefer a traditional course. The remaining 2 participants answered they would approve a mixture of both methods.

Figure 5b. "*Compared to a traditional course I learned…" (Database: summer term 2015, [n=27])*



Source: Prepared by the author

Advancements after the First Run

As shown in the previous chapter, the first-time application of elements of the Inverted Classroom Model in the summer term 2015 could be evaluated as successful. The teaching concept has worked well within the setting of the rather small course at the master's program. However, the own experiences of the lecturers and the results of the evaluations have shown possibilities for improvements in various areas. For the summer term 2016 the following points have been advanced:

- The complete course was even better structured to give students more security with the new teaching concept. Due to the good experiences, the number of ICM units was also increased. This resulted in 13 ICM units, of which a total of 5 were conducted by students. Table 1 shows the basic development of the semester structure.
- By reducing the amount of topics, more space was created for exercises. The primary objective was to provide a deeper understanding of the topics to be dealt with by the learners.
- The wiki pages have been revised. The contents of the wiki pages have been shortened for some topics. Particularly at the start of the semester, it has been payed attention to a manageable amount of online material to prevent students from being demotivated and to ensure that the students had enough time to prepare the contents completely and thus did not come to the in-class time unprepared.
- The Wiki pages which had to be created by the students were better integrated into the course. In addition, the transparency of the assessment was significantly improved by providing a learning target matrix and a rating matrix.
- During the in class time other methods were used in addition to the *Think Pair Share*-method. This should, on one hand, prevent "routine"

among the students and also oblige the students who had difficulties with the method used so far.

Table 1. *Comparison of the Semester Structure 2015 and 2016*

		Sommer term 2015	Sommer term 2016
1	Tue	-	Introduction and repetition
2	We	Introduction and repetition	Introduction in Wiki, lecture
3	Tue	**ICM: in class-time**	**ICM: in class-time**
4	We	Traditional lecture	Corresponding tutorial
5	Tue	**ICM: in class-time**	**ICM: in class-time**
6	We	Introduction in Wiki	Corresponding tutorial
7	Tue	**ICM: in class-time**	**ICM: in class-time**
8	We	External speaker	Corresponding tutorial
9	Tue	**ICM: in class-time**	-
10	We	-	**ICM: in-class time with exercise**
11	Tue	-	**ICM: in class-time**
12	We	External speaker	Traditional lecture
13	Tue	**ICM: in class-time**	External speaker
14	We	**ICM: in class-time**	**ICM: in-class time with exercise**
15	Tue	Traditional lecture	**ICM: in-class time with exercise**
16	We	External speaker	External speaker
17	Tue	External speaker	**ICM – Students**
18	We	External speaker	External speaker
19	Tue	**ICM: in class-time**	**ICM – Students**
20	We	External speaker	External speaker
21	Tue	External speaker	**ICM: in-class time with exercise**
22	We	External speaker	Visiting laboratory
23	Tue	Visiting laboratory	**ICM – Students**
24	We	Students' presentations	External speaker
25	Tue	Students' presentations	**ICM – Students**
26	We	Students' presentations	**ICM – Students**

Source: prepared by the author

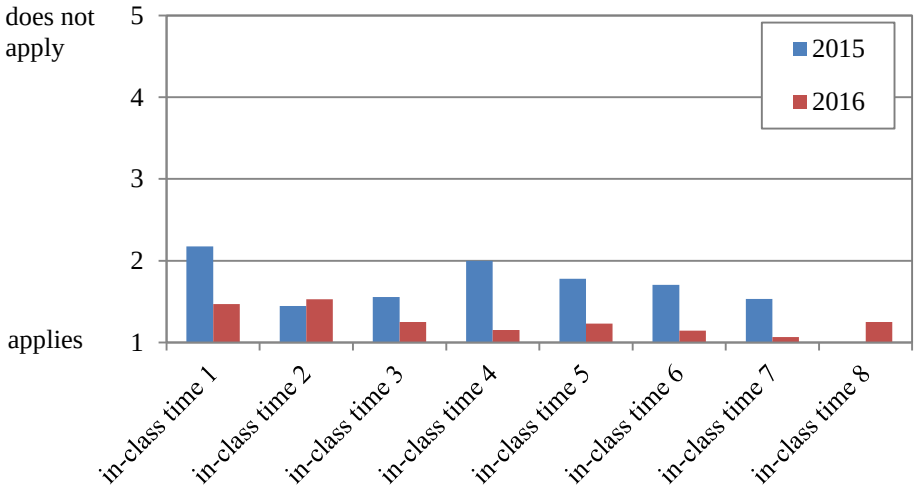
Discussion and Conclusions

The student surveys in the summer of 2016 confirmed the positive effects of the new teaching method. The revised and online provided material was even better accepted than in the previous year. According to the surveys, an average of 54 minutes was spent on working on a wiki page (46 minutes in 2015). The quality of the online material was rated similar to 2015.

The in-class time was even more positively rated by the attendees than the year before. In order to determine whether the procedure of the in-class time was helpful, a mean value of 1.27 (2015: 1.56) was obtained for all events on a scale of 1 (excellent) to 5 (insufficient). For this good result, certainly the change of methods within the in-class time is responsible. The question if all own professional problems could be solved within the in-class time, has been answered on the same scale with a mean value of 1.24 (2015: 1.47).

Particularly pleasant are the answers to the question "I have dared to ask my questions". The outcome of this question was an average value of 1.26 (2015: 1.74, see Figure 6). A major target of the new teaching method was thus achieved very well: students honestly ask their questions within the setting of the in class time and then receive directly a corresponding answer.

Figure 6. *"I have dared to ask my questions" (Database: Students' evaluation in summer term 2015 and 2016)*



Source: Prepared by the author

In the question regarding the learning effect of the in-class time a mean value of 1.20 (2015: 1.67) resulted. This quite significant improvement can be explained, among other things, by the restructuring of the overall course. In addition, significantly more exercises have been performed during the in- class time, which certainly positively influences the evaluation of the learning effect.

In the free text answers of the student surveys the ICM itself, the independent learning, the interactive design of the in-class time, the detailed discussion of

students' questions as well as the competent external speakers have been positively highlighted. Suggestions for improvements were largely confined to implementation details. In sum, the course was rated with the grade 1.33. By comparison, the first-time use of the Inverted Classroom Model in the summer semester 2015 resulted in a grade of 1.60 and in the summer semester 2012 by a traditional concept in a grade of 1.93. So a steady improvement is in evidence. The course will therefore continue to be offered as an ICM course. In addition, further courses of the department are being converted to this teaching method.

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