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# The Inverted Classroom Model in Technology and Engineering Education: Teaching "real-world" Skills to solve "real-world" Problems

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***Abstract***

An ambition for the Technology and Engineering Pedagogy is to teach skills, which are really needed in specific jobs. But as in all educational programs, the theoretical content is huge and often has to be preferred instead of practical experiences. Several studies show that the inverted classroom model (ICM) can link theory with praxis. Educators offer in this innovative concept learning videos combined with quizzes or lecture notes to their students and make sure that they attend prepared to class. As a result the in-class time changes: A diversity of teaching methods can be used to instruct the students in so called "real-world" skills such as problem-solving, working in teams, interacting with experts, planning, designing, programming, analyzing, testing and of course organizing projects with real clients. The results of the studies show that the students perform better and prefer this way of teaching. ICM also holds positive effects for educators: the diversity of teaching methods keeps their interest in the topic high even if repeating it semester after semester and various methods enforce the cooperation between educator and class.

| *Keywords:* | *Schlüsselwörter:* |
|---|---|
| Inverted Classroom Model | Umgedrehter Unterricht |
| Innovative teaching concepts | Innovative Unterrichtsmethoden |
| Active learning | Aktives Lernen |

## 1 Introduction

In all subjects teaching and learning changes. Learning is no longer passiv and one-sided but active and a process of construction. Teaching is now preparing the circumstances for the students to facilitate their learning. This shift from behaviorism to constructivism is a chance for the Technology and Engineering Education. A lot of methods are discussed and a lot of research is done how to teach technology and engineering. The aim of all studies is to find a way real-world skills can be trained. Therefore problem-solving and practical tasks in class are necessary. On the other hand there are standards every student has to know to pass a final exam. The solution can be to link theory with practice. One pedagogical concept that allows this link is the inverted or flipped classroom model. What this model looks like and how it can be implemented in a classroom is described in Chapter 2. The benefits of inverted classroom for Technology and Engineering Education are discussed in Chapter 3 by presenting results from several research studies. Chapter 4 summarizes the findings of this article.

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## 2 The Inverted Classroom Model

In the traditional lecture or lesson the students visit the class, sit on their chairs and listen to the instructor. They are in a passiv role, no individualised learning is offered and the duration of the theoretical input is longer as the attention span. The teacher or lecturer is active, spreading all the knowledge to the audience. At the end the students get some home tasks which they have to solve without the expertise of the specialist.
The inverted classroom model turns this traditionell concept upside down by using digital possibilities. Now the theoretical input is outside the classroom. Students watch videos, read texts or listen do podcasts before class and attend prepared to the lecture. To ensure the preliminary provide some extra material to the students while watching the videos, listening to the podcasts or reading the texts. This can be a quiz with questions belonging to the video, a script with gaps which have to be filled or just a hint to think about questions that will be asked in class. The role of the teacher or instructor changes from *„sage on the stage to a guide on the side"* (Lage et al., 2000). The new role allows the lecturer to prepare a learning environment where the students are active and the teacher acts like a coach. The students work on assignments like problem-solving, planing and organizing own projects, work together in groups or discussing questions of the lesson-topic.
Essential advantages of this model are:

- Individual learning: Videos allow the learner to pause, rewind or go ahead with the content and to watch them wherever and whenever they want
- The use of videos belongs to the environment of 21 century students
- Active learning instead of passive consume
- Instructors act like coaches and help students with their problems
- Time for variety of hand-on activities

## 3 Benefits for Technology and Engineering Edcuation

The main challenge for technology and engineering education is teaching real world skills. These skills are needed to solve real world problems and of course to create real world software. For that a hand-on pedagogy during class time is necessary.
Inverted Classroom is one didactic opportunity to ensure such an lesson-format.

### 3.1 Research Studies

Choi (2013) implemented inverted classroom to a software engineering in computer engineering lecture and started a second lecture with the same title at the same time. The second group was teached in a traditional format. The ICM group watched video lectures and a lot of different in-class activities were offered. Especially cooperative learning was promoted because working in IT sector is very complex and needs a lot of collaboration.
38 students were part of the inverted lecture group, 35 in the traditional lecture group. After 16 weeks satisfaction, grades and understanding was surveyed.
No significant differences were found by comparing the grades of written exams and project work between the two groups.
Satisfaction was higher in the ICM group, especially because of the immediate feedback the students get from the professor. Also team- and projectwork had positive influence to lecture satisfaction.
Deeper unterstanding was a little bit higher within the ICM group compared to traditional teaching method.
Reza & Ijaz Baig (2015) inverted the course Data Structures which is part of the Bachelor of Science in Computer Science program. The researchers used a pre-test and post-test design model for their investigation.
42 students in the control group were taught traditionally, 23 in the experimental group under inverted classroom model conditions.
In this case the educators used text material for the students preparation. Before class they posted the material on a webpage and the students read it. Class-time started with a short quiz and the results showed

the individual preparation of each learner. Next an assignment appropriate to the topic of the lecture was given to the students. To manage the assignment problem-solving competencies were required. The teacher acted like a coach and helped the students when they were not able to solve it on their own.
The authors explored three categories of learning:

- Programming Ability
- Problem Solving Skills
- Theoretical Knowledge

The students completed the pre-test at the beginning of the semester. The results showed that both groups had similiar knowings and skills in the three categories.
After the semester the post-test was issued to both groups. No significant difference was found for the category "Theoretical Knowledge".
Differences were found for programming ability and problem-solving skills. The ICM group achieved a higher score and significant better performance than the control group in both categories.
Further Reza & Ijaz Baig (2015) also explored the attendance in the lectures. They found that the ICM group appeared more frequently to class than the control group.
An over-all questionnaire about the concept indicates that the students like the ICM format.
Sureka et al. (2013) combined the inverted classroom model with large-group, real-client and studio-based instruction model. They tought a Software Engineering course with 89 students at the State University New Delhi and tried to change the traditional pedagogical circumstance. The motivation was to activate the learners and giving them the chance to work in large groups and on real-world problems like they need to do after their studies.
The students worked in teams with 8-9 members and used a Wiki to collect their documents. The challenge was to manage all the problems large groups come up with. For nearly all students this was the first time working in such big groups and two third confirmed that several problems have to be discussed and solved.
To create a real-client based learning environment the student-groups worked on problems proposed by the members of administrative departments of the institute such as academic, financial or facility management. For more than 80% of the students this was the first time they experienced hands-on tasks and 70% reported working on real problems increased their motivation.
Studio-based learning was arranged by changing the seating plan. Every group got their own table with chairs and if needed an extra working space for more collaboration.
For all students this was the first time they learned in a studio-based environment. More than 70% agreed that studio-based learning helped them to understand the concepts and for 60% the model increased the motivation and engagement level.
For the inverted part videos and reading-material were offered to the students. A lot of Videos from Youtube or other internet-sites were used so the authors did not create this content on their own. For 95% it was the firt time they experienced the inverted classroom model. The main benefit for the students was the one-on-one interaction with the instructor during class time.
Mason & Cook (2013) flipped a Control Systems course at Seattle University. They created their own content by producing 45 videos. Compared to a traditional classroom setting a year ago they found that the inverted class group performed better. A difference in this study is that the students did not reported about extra time to watch the videos. They thought that they spend less time on studying than in other courses. The researchers think that this is because watching videos is not per se perceived as studying. Another result of this study is greater satisfaction within the inverted classroom group.

## 4 Conclusion

The reviewed articles and studies have one claim in common: Technology and Engineering Education has to teach real world skills. For the researchers it is not enough just to increase the knowledge. Problem-solving, working in groups, planning and organizing own projects are competencies that are needed to work on real world problems. The inverted classroom model is one concept that allows teachers and educators to link the

theory with the practice. The students watch videos or read texts before class and the in-class time changes. Active learning is provided, working in teams and on specific problems is possible. Research results show that inverted classroom model can increase performance and of course engagement and motivation. Also the learners satisfaction can be influenced in a positive way through this concept especially because of immediate feedback provided.

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