# Motivational Active Learning for Computer Science Education


## Johanna Pirker, Christian Gütl

**Institute for Information Systems and Computer Media - Graz University of Technology**

Graz University of Technology



## Abstract

Motivational Active Learning (MAL) is an innovative pedagogical approach based on MIT's teaching format TEAL (Technology-Enabled Active Learning) combined with advanced motivational strategies based on gamification design aspects. The main idea of MAL is to enhance learning outcomes using motivational and social learning experiences. The lecture format is designed for courses, which combine theory in computer science with hands-on programming challenges and collaborative in-course problem solving. The main features of MAL include collaborative learning, constant activities to stimulate interactions between instructor and students, immediate feedback for self-assessment, and motivational feedback such as badges or leaderboard information. The course is structured in the form of mini lectures with constant interactive challenges and interactions such as small arithmetic problems, programming challenges, or research and discussion assignments, which are available using a learning management system as supportive in-course technology to provide the interactive course content and according immediate feedback. First outcomes show positive impact on student motivation and attention during the lessons. Also, more students are willing to complete bonus tasks voluntarily to gain extra points.


## Introduction and Background

*„I hear and I forget. I see and I remember. I do and I understand"*

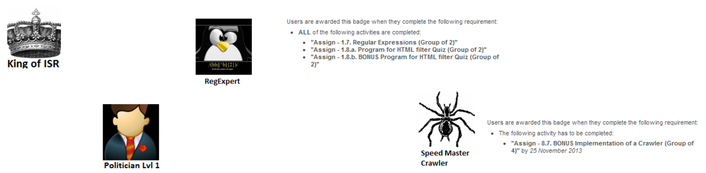
- Active Learning formats successfully raise the conceptual understanding [1,2,3]
- Cooperative learning strategies deliver the best learning outcomes (compared to competitive and individual) [4] and enhance student engagement [5]
- Motivation is one of the most important driver for successful learning [7]
- Gamified classroom scenarios can enforce intrinsic motivators [6][7]

## Objectives

- Design a course combining (1) theoretical background and concepts, (2) algorithmic understanding, and (3) analytical understanding of mathematical models
- Engaging students by interactive and motivational activities
- Increase the students' motivation with hands-on exercises and collaborative tasks

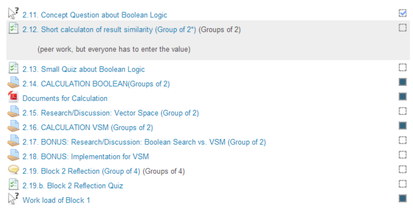
## Course Design

- *Collaborative Learning*: Students solve tasks in small subgroups of 2 or 4.
- *Constant interactions*: Concept questions, small quizzes, and discussion questions are used to stimulate the interactions between instructor and students.
- *Immediate feedback*: The majority of the tasks and quizzes deliver immediate feedback.
- *Motivational feedback:* Badges for special activities and leaderboard information deliver motivational feedback.
- *Errors are allowed*: Students are able to revise assignments and repeat quizzes.
- *Positive reinforcement*: Additional effort should be rewarded and students should not be punished for failing single exercises.
- *Adaptive class design*: Measuring the learning progress during and after class allows in-time adaption the individual learning speed of the class.

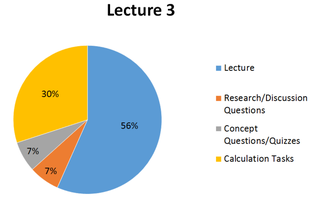



Unexpected and expected badges as additional motivational feedback

## Motivational Active Learning in Action



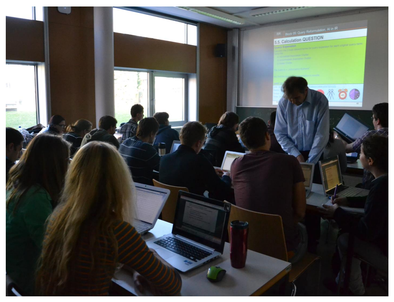

Moodle is used in and outside class to provide interactive exercises with immediate feedback



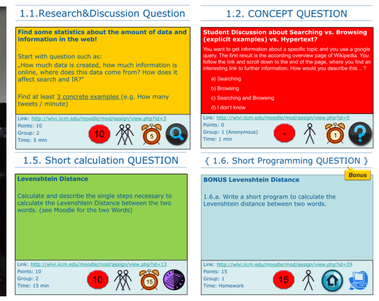

Example class structure

| Content Type | Feedback | Definition |
|---|---|---|
| Lecture Block | - | The lecture is divided into different blocks. Learning content and concepts are presented on power point slides. |
| Recap Quiz | Immediate | A small quiz at the beginning of each lecture about last lectures content |
| Concept Question | Overview statistic | Ungraded question about a new concept. |
| Concept Quiz | Immediate | Questions based on previous concept question. |
| Discussion Questions | Deferred | Peer / group discussions about new concepts / ideas / issues |
| Research Questions | Deferred | Internet Research assignments for peers / small groups |
| Programming Exercises | Deferred | Programming exercises to practice learned concepts |
| Small Calculation Tasks | Immediate | Very small calculation tasks to practice learned concepts |
| Advanced Calculation Task | Deferred | Advanced calculation tasks to practice learned concepts |
| Reflection Quiz | Immediate | A small quiz after each lecture to revise the content |
| Reflection Forum | Deferred | In an online forum groups should discuss last lectures' content and issues |

Overview of the different course elements



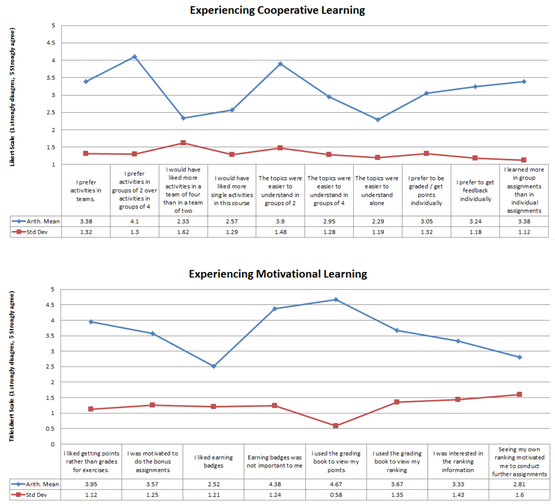
Students use their laptops to solve the exercises and use the e-learning system in-class




In-class and online presentation of slides signalizing the different question types

## Results and Observations

The approach was evaluated in a first test series with a class of 28 students (course: Information Search and Retrieval).




| | I prefer activities in teams. | I prefer activities in groups of 2 over activities in groups of 4 | I would have liked more activities in a team of four than in a team of two | I would have liked more single activities in this course | The topics were easier to understand in groups of 2 | The topics were easier to understand in groups of 4 | The topics were easier to understand alone | I prefer to be graded / get points individually | I prefer to get feedback individually | I learned more in group assignments than in individual assignments |
|---|---|---|---|---|---|---|---|---|---|---|
| Arith. Mean | 3.38 | 4.1 | 2.33 | 2.57 | 3.9 | 2.95 | 2.29 | 3.05 | 3.24 | 3.38 |
| Std Dev | 1.32 | 1.3 | 1.62 | 1.29 | 1.48 | 1.28 | 1.19 | 1.32 | 1.18 | 1.12 |

| | I liked getting points rather than grades for exercises. | I was motivated to do the bonus assignments | I liked earning badges | Earning badges was not important to me | I used the grading book to view my points | I used the grading book to view my ranking | I was interested in the ranking information | Seeing my own ranking motivated me to conduct further assignments |
|---|---|---|---|---|---|---|---|---|
| Arith. Mean | 3.95 | 3.57 | 2.52 | 4.38 | 4.67 | 3.67 | 3.33 | 2.81 |
| Std Dev | 1.12 | 1.25 | 1.21 | 1.24 | 0.58 | 1.35 | 1.43 | 1.6 |

## Future Work

- Course 2015 : Change group size to 3 students
- Advanced balancing of instructions and assignments
- Smaller but more calculations and programming examples
- Advanced automated assessment and integration into Moodle


## Acknowledgements

This work is a work in progress. An extended version is submitted at ITICSE 2014. At this point we want to thank our students at Graz University of Technology who have participated in this study and the team of CECI at MIT who inspired us with their active teaching format TEAL.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## Contact Information


Web: www.iicm.edu
Email: jpirker@iicm.edu
Email: cguetl@iicm.edu