International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 08 Issue 04 Oct 2020
www.ijcsrr.org

Getting College and University Students Excited About Computer Science Through Active Learning

Johanna Pirker
Graz University of Technology Institute for Information Systems andComputer Media
Inffeldgasse 16c, Graz, Austria0043-316-8735625
jpirker@iicm.edu

Maria Riffnaller-Schiefer
Graz University of Technology Institute for Information Systems andComputer Media
8010 Graz
riffnaller@student.tugraz.at

ABSTRACT
Attracting and engaging computer science students to enhance their mathematical and algorithmic thinking skills are challenging tasks. In winter 2013 we introduced a new teaching format for a course, which combines theory in computer science with hands- on algorithmic challenges, mathematical thinking activities, and collaborative problem-solving. Therefore, we introduced the pedagogical model Motivational Active Learning (MAL), which is grounded in MIT‟s successful format for teaching physics, Technology-Enabled Active Learning (TEAL), and combines it with motivational strategies usually used by game designers. Results from the initial setup in class reveals that students indeed assessed the course structure as more interactive and motivating compared to other similar courses. In this paper we discuss the course design, issues, and the impact, and analyze the first results in detail.

Keywords
Active Learning, CS Education, Interactive Learning, Pedagogy, Gamification, Game-based learning, Motivation.

1. INTRODUCTION
In computer science (CS) education an important issue is thesuccessful transfer of not only theoretical concepts, but also teaching skills such as computational and mathematical thinking and creative problem-solving. However, many pedagogical approaches are still auditory, abstract, deductive, passive, and sequential [1] and fail in teaching how to solve problems, and recite the solutions instead [7]. This leads to student frustration,

high drop-out rates, and does not match the objectives of engineering education. In the last decade, especially in STEM fields, there is a growing interest in developing new teaching models based on constructivist models such as interactive engagement, problem-based reasoning, and collaborative problem-solving strategies [9],[12].

One successful implementation of interactive and collaborative learning activities is the way physics is taught at the Massachusetts Institute of Technology (MIT). The format is grounded in interactive engagement strategies and integrates hands-on experiments, collaborative experiences, interactive visualizations and simulations, and mini lectures with conceptquizzes (used with personal response systems). Analyses haveshown that the failure rate has decreased and learning gains have doubled [21]. TEAL achieves student motivation also by integrating collaborative activities, such group discussions. The importance of such motivating and engaging activities in education is well known and many studies promote cooperative learning strategies in order to enhance the students‟ motivation and raise the attendance rate [1],[19]. A rather new approach to engage students to achieve better learning gains and to push their own personal boundaries is the integration of gamification aspectsto create a motivational atmosphere through constant feedback, mini challenges, and positive reinforcement [18]. In this paper, wepresent our pedagogical approach MAL (Motivational Active Learning), which is grounded in TEAL and combines it withmotivational gamification design aspects. We conducted an initial study with one class of 28 students. The aim of this paper is to analyze the study outcomes and discuss the impacts, prospects, and issues of this model and its concepts. The remainder of the paper is organized as follows: we will first present background information and related work in the fields of active learning and gamification in education. After that, we will present the concepts of MAL and will then show a first study setup and its outcomes.

2. THEORETICAL BACKGROUND
Many authors have discussed different learning approaches to make education for students more attractive and help them to"*learn more, learn it earlier and more easily, and […] learn it with a pleasure and commitment*" [4]. In the last decades, especially in the STEM domain physics education, many innovative interactive teaching styles have emerged. Quantitative research promotes the effectiveness of different active learning models using strategies such as collaborative learning methods or computers as auxiliary device for learning. Following we present

and discuss a selection of related important pedagogical approaches with focus on interactive and engaging aspects.

2.1 Active Learning Formats

Interactive Engagement (IE) challenges students in face-to-face lectures to solve problems together. A study with 6000 students shows that IE strategies are superior to support the students‟ problem-solving abilities and their conceptual understanding [9]. Following different formats grounded in IE strategies and active learning are presented.

Peer Instruction (PI) is a teaching model for physics education introduced by Mazur at Harvard. To design a large-scale course to be more interactive and personal, students use personal response systems (PRS) to answer small multiple-choice questions in the lecture. Afterwards they discuss the questions with their peers and can revise their answer [13]. Many authors also report of successful integrations of PI in CS courses. Porter and Simon used a format grounded in PI, media computation (learning computation through digital media manipulation), and pair programming (solving programming exercises in pairs). They report reduced dropout rates, increased student pass rates, and an absolute improvement of more than 30% in programmatic retention among students in a CS1 course [17].

Scale-Up (Student-Centered Activities for Large Enrollment for Undergraduate) is an interactive learning approach, which integrates typical small class elements into large enrollment passive physics courses. Scale-Up combines lecture (discussion), polling questions, laboratory experiments, discussion, and problem solving to create an interactive learning environment. Students work in homogeneous groups of three and each student has a special role. Each group sits on a rounded table togetherwith two other groups (nine students on each table) [8]. Thespecial classroom features whiteboards on the walls, portable whiteboards, a computer/laptop for each group, and a class presentation system. Research has shown that this interactive learning environment has positive effects on the students learning process. As a result, Scale-Up improves problem solving skillsand conceptual understanding of the students. They noted also a positive effect on the grades in follow up classes [2].

Studio-Physics is another example for an active learning approach. Kohl and Kuo transformed the traditional physics course at the Colorado School of Mines into a Studio-Physics course. Modern information technologies were used together with traditional techniques for experiments, hands-on activities, andproblem solving tasks. Some of the activities were done in homogeneous groups so that students could learn from each other.Activities include in-class activities like conceptual questions as well as home assignments. An important element of Studio- Physics is the scaffolding system, which iteratively improves the students‟ problem-solving skills. A study has shown that the students‟ grades have improved. However, they also noted that there is no automatic improvement without also adapting the curriculum to the new learning approach [11].

Technology-Enabled Active Learning (TEAL) is based on the ideas of Studio-Physics and Scale-Up and integrates activities like desktop experiments, reflection/preparing tasks, discussions, and lectures interrupted by conceptual questions. The learning environment of the classroom is similar to Scale-Up. Students are sitting on a round table and work in groups of three to nine.TEAL combines collaborative activities with modern technologies such as networked laptops, whiteboards, and PRSs to foster *visual* skills and conceptual understanding. Researches have shown that TEAL improves conceptual understanding of students and has a long-term learning effect. [5].

It can be emphasized, that a learning approach which combines collaborative working, different kinds of activities, and problem solving tasks with modern information technologies, can lead to positive learning effects. However, Dori et al. found that students show some resistance against new learning approaches which are in contrast to traditional approaches [6]. Therefore, in the next section, we will analyze pedagogical models grounded in gamification and game design to reduce the students‟ resistance and, instead, to motivate the students to actively participate in the course.

2.2 Gamification of Instructions

Motivation is the most important driver for successful learning. Many authors promote the effectiveness of educational computer games as powerful and motivational learning tools. Papasterigou for example describes the successful implementation of a digital game for learning computer memory concepts which not onlyachieved better learning gains, but also enhanced the students‟ engagement (equally for boys and girls) [16].

Recently, also gamification strategies were more and more involved in educational models to engage in particular intrinsic motivation. In comparison to learning games, gamification uses game design elements, such as leaderboards, badges, constant feedback, and points. It is defined as the use of "*game design elements in non-game contexts*" [3]. Quest to Learn (Q2L) is an entire curriculum model in New York City based on gamification strategies. Instead of homework, Q2L promotes mission-and challenge-based units. These quests especially involve game strategies such as collaboration, role-playing, or simulations. The learning experience focuses on hands-on problem-solving approaches [1]. Instead of frustrating and stressing student with failure rates at exams, Q2L uses a point system where students arerewarded for putting extra effort to account for mistakes and not punished for failing one single exam. They can constantly try to level up to master a course and can focus on the course content instead of stressing over their grades [15].

However, competitive gamification strategies do not attract all learning types and can lead to student frustration instead of motivation. Different studies comparing competitive, individual, and cooperative learning strategies report the most successful outcomes by cooperative strategies [10]. Therefore, in theeducational domain it is important to not only integrate competitive game elements such as leaderboard information, but also collaborative elements such as working together as a group towards points and helping each other by achieving common goals.

In the next section we propose a pedagogical model integrating interactive and collaborative aspects from the learning format TEAL and combine it with engaging competitive game mechanics.

3. MOTIVATIONALACTIVELEARNING

Motivated by the positive impacts on students‟ learning outcomes of different innovative learning formats such as TEAL, we designed an initial version of a pedagogical model combining different interactive strategies and concepts with game-design aspects. *Motivational Active Learning (MAL*) aims to help students understanding the concepts in an engaging way.

3.1 Objectives

Hand in hand with designing an actual course in the CS domain, the objectives of the initial pedagogical model were to:

- Design a course combining (1) theoretical background and concepts, (2) algorithmic understanding, and (3)analytical understanding of mathematical models
- Engaging students by interactivities and motivationalactivities
- Increase the students" activities and motivation for hands-on exercises

The single elements and activities of the course format to achieve those goals include a variety of question types and interactive tasks. Based on TEALs example each lecture is organized into mini lectures, each one starting with a concept question and ending with a small concept quiz to be able to observe the learning progress of the students and adapt the speed accordingly.

The course structure is designed to balance hands-on problem- solving activities, necessary abstract theories, and creative tasks and assignments to address the different learning styles of students. Table 1 lists the different activity types. Automatic assessment systems deliver immediate feedback, assignments such as discussion question, however, need a manual grading.

Table 1. Content types and their feedback options

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	More complex 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

Quizzes, assignments, or results of group activities such as discussion or research outcomes are submitted in an accompanying e-learning system (e.g. Moodle) to be able to track the students" progress in-time. This also enables the possibility of giving immediate feedback (by automatic question assessment) on their knowledge and skill improvement by automatically awarding points and giving motivational feedback (by assigning badges and tracking leadership information), which does not affect their grading, but triggers competitive motivation. Most of the assignments are designed to be revisable, so that they can achieve more points by working harder for it.

Summarizing, the main features of MAL include:

- Collaborative Learning: Students solve tasks in small subgroups (2 or 4 depending on the activity)
- Constant interactions: Concept questions, small quizzes and discussion questions are used to stimulate the interactions between instructor and students (see Figure 1, left for exemplary course material)
- Immediate feedback: The majority of the small tasksand quizzes deliver immediate feedback on their task performance
- Motivational feedback: Badges for special activities and leaderboard information deliver motivational feedback, by triggering competitive motivators or positive enforcements
- Errors are allowed: Students are able to revise assignments and repeat quizzes
- Adaptive class design: Learning progress during andafter class allows in-time adaption the individuallearning speed of the class.

The next section describes the first integration of MAL into a CS course with focus on mathematical and algorithmic concepts.

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 08 Issue 04 Oct 2020
www.ijcsrr.org

3.2 The Setting

MAL was first introduced in the course „Information Search and Retrieval (ISR)" in the winter term 2013 at Graz University of Technology. The objective of the course is to build a knowledge base in selected theory and practice in searching and retrieving information with focus on the mathematical and algorithmic concepts. The content includes topics such as indexing and searching models, retrieval algorithm, or query languages. Hence, in each lecture it is necessary to combine theoretical background with algorithmic or mathematical concepts. The course was split into seven lecture blocks. To study the progress of the students and to support activities delivering immediate feedback the course was accompanied by the learning management system Moodle. Hence students had to bring their own technical devices such as laptops or tablets to the course. The course content was presented using power point slides. Figure 1 shows a typical course setup.

Figure 1. Slides of different question types

Special activities were highlighted by different colors andsymbols (see Figure 2). Depending on the content type, students worked individually, in groups of two, or in groups of four. The group formation did not change to ease group assessment. Quizzes were designed as individual tasks, most hands-onexercises were conducted with peers (group size 2). Most assignments were started during class and students had the possibility to finish them as homework. Beside in-class assignments they also had to submit homework assignments, which were to one part compulsory and to another part bonus tasks.

To track in-class activities, an external observer was taking notes and tracking the student activities. Hence, a detailed breakdownof the single lectures into the different content parts was possible. Figure 3 shows exemplary the percentage of different activities in lecture 1. It shows a mixture of different kind of activities such as lecture, questions, discussion, calculation, and programmingtasks. Although the lecture part was predominant, figure 4 shows the special combination of lecture and interactivities for all lectures in more detail.

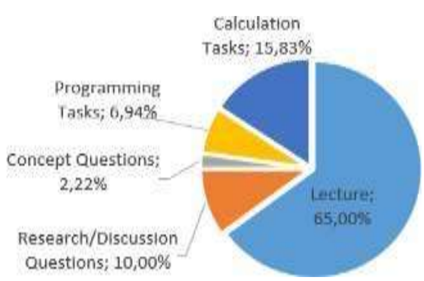

Figure 2. Percentages of activities in lecture 1

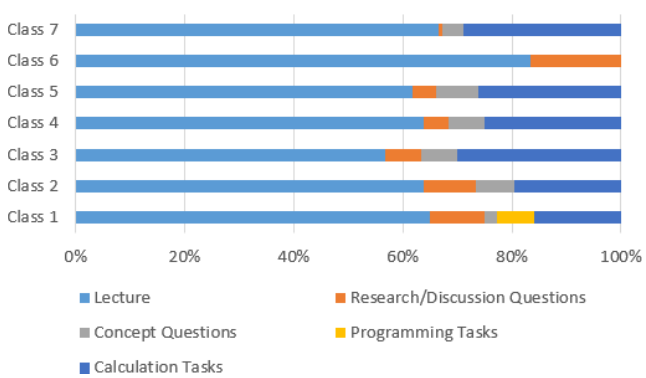

Figure 3. Overview of content distribution in the lectures

3.3 Materials and Methods

To evaluate MAL we conducted an initial study with the ISR course in winter 2013. The research goals were defined as:

- Evaluate the students" understanding of the course content
- Analyze the students" engagement and motivation
- Analyze the students" attitude towards the new model and the used e-learning environment

To evaluate these goals we used qualitative and quantitative methods. Also a field observation during the course was used to analyze the students" behavior and engagement during the course.

Before the start of the course we polled the students of the course via a web-based survey to learn about their expectations towards the course, their usual learning habits and motivation, their previous knowledge about the course content, and experiences with similar learning methods. The survey consisted of Likert- scale (1 strongly disagree, 5 I strongly agree) and open-ended questions. During the course we measured the students" learning progress using small quizzes and concept questions. We collected qualitative data by observing their activity and active participationand taking according field notes. After the course and finishingthe grading, we invited the students to complete a web-basedpost-questionnaire which should shed light on the students" motivation during the courses and their attitude towards the class structure and its content. Therefore the post-questionnaire consisted of reflection about the different content and activity types (see Table 1), their experiences of collaborative assignments, and questions focusing on gamification aspects. Additionally, we added 30 rating questions based on the Advanced Motivation Scale, which is used to measure different types of intrinsic and extrinsic motivation and amotivation [22].

4. FINDINGS

28 students started the ISR course, one student dropped out. The pre-questionnaire was completed by 26 (6 female) of 28 students between the ages of 22 and 31. The post-test was completed by 21(5 female) of 27 students. In this paper we will focus on the outcomes of the post-questionnaire.

Experiencing Cooperative Learning.

The tasks were balanced between assignments to be completed alone, collaborative assignments in pairs, group discussions ingroups of 2, and collaborative assignments in groups of 2-4. We asked the students about their motivation towards these settings. The majority of the students stated to prefer activities in teams and stated to experience advanced learning gains through group assignments. *"The group assignments during classes were thebest concept. It was good to use the concept just learned to remember it better, but also eventual misunderstandings could be discussed"*

Table 2. Survey results of cooperative learning experiences.

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

The results have shown that students prefer tasks in groups of two over individual tasks. (see Table 2) But it was difficult for students to solve tasks in group of four people. In-class we observed, that even for tasks meant to be solved in groups of four, they preferred to work in groups of two and merged their resultsat the end. However, the results show, that the learning styles of the single students differ dramatically. Even though the standard deviation states, that the majority of 21 students prefer assignments in teams of two over teams of two, 5 students would prefer bigger groups.

Experiencing Motivation.

Asking students what they did like in the course, many of them immediately mentioned to receive points instead of grades. *"[I liked] the chance* *to improve already graded work. It was also a motivating thing to immediately see received points"; "[I liked] 2nd chances"; "[I like that it is] hard to fail this course and hard to get lost and procrastinate".* The study results show, that students enjoyed the new grading system (see table 3). They prefer getting points over grades and were motivated to finish further assignments to receive additional points. Another important feature was the grading book. However, the study data show that the students" engagement by the ranking information differed a lot. 5 students agreed to get motivated to conduct further assignments, while 6 students disagreed. This is in linewith our observation of the necessity of attracting different learning styles and integrating both, cooperative and competitive activities. The results also show that earning badges was neither important nor attractive to many students. However, badges canbe used as positive enforcement and to give students an overview of their achieved masteries.

Table 3. Survey results of cooperative learning experiences.

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

Experiencing Interactivities.

Asking students open-ended questions about their attitude towards the course many mentioned the positive impression of the interactive content: "*I liked the interactivity of the course. It was not like in other assignment-based courses, where exercises must be done at home and then presented. There was time for researching or calculations, and then the results were discussed.*"; *"I liked the interactive learning. The structure of the course, some parts lecture, immediately followed by exercises, was nice."* However, many students criticized classes with a large number of exercises. We also found that students get frustrated if they have to solve too many different kind of tasks in one lecture. First, they are stressed because of the short time and cannot finish the task in class. Additionally, if students are interrupted in performing the tasks, they cannot concentrate on new content. They still think about the solution path of the unfinished task. Fortunately, due to the adaptive course design it was possible to revise the course structure accordingly.

Designed for Adaptability.

An important part of the course was the constant attention to the students" feedback during and after lecture. Using the concept questions it was possible to adapt the learning content to their current knowledge base and allowed the instructor to slow down or skip topics accordingly. Also, after each block we asked for feedback about the effort of the past lecture to adapt the lectures to the average class speed. According to the students" feedbackthis was an important step towards interactive, adaptable, andflexible class design: *"It was hard to follow all the stuff showed inthe lecture, but the lecturer obviously read the feedback aftereach block and slowed down a little bit at the end which wasmuch better"*

Assessing Learning Progress.

The learning progress was measured in-class before and after eachmini-lecture. Students had also the possibility to revise the quizzes and assignments. Figure 5 shows the learning progress of the students, comparing the results of the first concept question with their answer after hearing the mini-lecture and their final answer after revising the question at home.

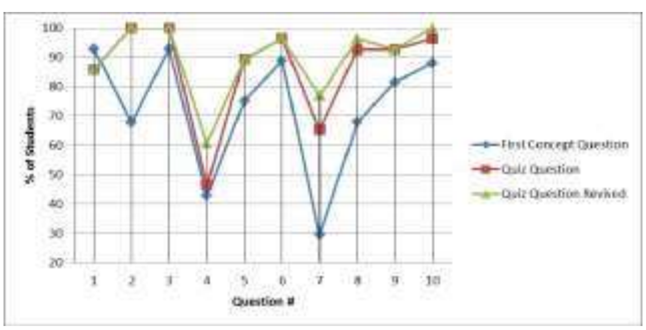

Figure 4. Comparison of learning progress

4.1 Challenges and Solutions

Students had to finish a quiz to recapitulate the content of the previous lecture at the beginning of each lesson. We have found that the communication between instructor and students is lost, if the recap quiz is the first part of the lecture. If the instructor discusses the main elements of last lecture with the students and the recap quiz follows afterwards, the loss of interaction can be prevented.

One of the major challenges is the balance of presenting abstract concepts and interactive assignments. Also, attracting studentswith different learning styles is a challenging task. Having an adaptive teaching model helps in changing teaching speed and style accordingly, but also requires a customizable model for the course content. The studied showed that students preferred small calculation and programming examples over complex ones. For the next phase we will split them down into smaller, but more examples with the focus of having one project that grows with each exercise.

A severe issue in this course was the grading effort of assignments. At this point we only automatized the correction of quizzes and small calculation assignments. In the next phase we will focus on further automatic assessment of programming and calculation assignments.

Learning in groups was analyzed as valuable model for achieving optimized learning gains. However, the attitude of the students towards group sizes varies. For the next course we are planning to use working groups of three students. This has some advantages over groups of two people. For example if one student misses a lecture, no student must work alone and the group is still able to finish the tasks in time. Also the grading time of the class can be decreased. Also, the current course format is especially design for small classes. Constant interactions with the instructor and peers require larger courses (100+) to be split into smaller classes.

5. CONCLUSION

In this paper we have presented the learning format Motivational Active Learning based on interactive and collaborative learning strategies grounded on TEAL combined with engaginggamification mechanics. In an initial study we evaluate the attitude of the students towards MAL and its learning concepts. Stuart and Rutherford have shown that students are able to concentrate for a maximum of 10-15 minutes [20]. In contrast, we found that students are able to follow a more theoretical lecture in combination with some discussion questions for even three hours. One reason for the long lasting concentration could be that in an interactive learning environment, students are more focused because there could be a new activity at any time. This result is important because McConnell has shown that learning content, which is difficult to understand, should be presented in form of a lecture [14]. The teaching format was a good fit for the course content, which integrated theory, mathematical concepts, and algorithms. The combination of interactive and engaging strategies motivated students to finish more assignments on their own accord. Giving students points instead of grading them with traditional grades was an important step towards positive enforcement. To attract different learning types it was importantto integrate both, and collaborative learning activities. The adaptive course content allows instructors to adjust the speed and difficulty to the class‟ learning style and level. Future work includes the adaption of the group size, an elaborate badge design, the reduction of assignments sizes, and the automation of assignment assessment.

6. ACKNOWLEDGMENTS

This work is a work in progress and was first introduced at aposter at SIGCSE14. At this point we want to thank our studentsat TU Graz who have participated in this project.

7. REFERENCES

[1] Augustine, D.K., Gruber, K. D., & Hanson, L. R. 1990. Cooperation works! Educational Leadership, 47

[2] Beichner, R.J. and Saul, J.M. 2003. Introduction to the SCALE-UP(Student-Centered Activities for Large Enrollment Undergraduate Programs) Project. In Proceedings of the International School of Physics “Enrico Fermi”, Varenna, Italy.

[3] Deterding, S. and Khaled, R. 2011. Gamification: Toward aDefinition. In CHI‟11 Gamificatoin Workshop. ACM

[4] DiSessa, A. A. 2000. Changing Minds: Computers, Learning, andLiteracy. MIT Press, Cambridge, MA.

[5] Dori, Y.J. and Belcher, J. 2005. How Does Technology-Enabled Active Learning Affect Undergraduate Students' Understanding of Electromagnetism Concepts? The Journal of the Learning Sciences, Vol. 14(2), 243-279.

[6] Dori, Y.J., Hult. E., Breslow, L., and Belcher, J.W. 2007. Howmuch have they retained? Making Unseen Concepts Seen in a Freshman Electromagnetism Course at MIT. Journal of ScienceEducation and Technology, 16(4), 299 – 323.

[7] Freedman, R. A. 1996. Challenges in Teaching and Learning Introductory Physics. In From High Temperature Superconductivity to Microminiature Refrigeration (pp. 313-322).

[8] Gaffney, J.D.H., Richards, E., Kustusch, M.B., Ding, L., and Beichner, R.J. 2008. Scaling Up Education Reform. Journal ofCollege Science Teaching (Mai/June), 18-23.

[9] Hake, R. 1988. Interactive-engagement versus traditional methods:A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66 (1),64-74.

[10] Johnson, R.T., Johnson, D. W., and Stanne, M. B. 1986. Comparison Of Computer-Assisted Cooperative, Competitive, And Individualistic Learning. In American Education ResearchJournal, Vol. 23, No 3. 382-392.

[11] Kohl, P.B., and Kuo, H.V. 2012. Chronicling successful secondaryimplementation of Studio Physics. American Journal of Physics.

Vol. 80(832), 832-839 http://dx.doi.org/10.1119/1.4712305

[12] MacKay, B., and College, C. 2006. Interactive Engagement.(Science Education Resource Center at Carleton College) Retrieved 9 2012, 1, from http://serc.carleton.edu/introgeo/models/IntEng.html

[13] Mazur, E. 1996. Peer Interaction, A User's Manual. Prentice Hall.

[14] McConnell, J.J. 1996. Active learning and its use in Computer Science. Integrating technology into Computer Science Education,6/96, Barcelona. 52-54.

[15] McGonigal, J. 2011. Reality is broken: Why games make us betterand how they can change the world. Penguin Press.

[16] Papasterigiou, M. 2009. Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation. Computers & Education 52.1-12.

[17] Porter, L. and Simon. B. 2013. Retaining Nearly One-Time moreMajors with a Trio of Instructional Best Practices in CS1. In SIGCSE"13 Proceedings, Denver, Colorado, Usa.

[18] Shantanu S. February 14, 2012. "Motivating Students and theGamification of Learning". Huffington Post.

[19] Slavin, R. E. 1990. Cooperative learning. New Jersey: Prentice-Hall.

[20] Stuart, J. and Rutherford, R. 1978. Medical Student ConcentrationDuring Lectures. The Lancet, Vol. 2, (September), 514-516.

[21] TEAL-Project. 2006. Retrieved 06 2012, fromhttp://icampus.mit.edu/projects/TEAL.shtml

[22] Vallerand, R., Pelletier, L. Blais, M., Briere, N., Senecal, C., and Vallieres, E. 1992. The Academic Motivation Scale: A Measure ofIntrinsic, Extrinsic, and Amotivation in Education. Educational and Psychological Measurement, 52, 1003-1017.