Learning in Collaborative and Motivational Virtual Environments

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ABSTRACT

In particular in STEM education, disciplines, which require students to understand difficult conceptual concepts such as physical phenomena, different learning strategies have evolved to enhance the students' learning success and engagement. Many of these strategies include interactive activities such as hands-on experiences, game-based learning, or cooperative assignments. It is challenging to include these methods in an online and virtual environment. My research aims to design, implement, discuss, and compare different forms of motivational and interactive virtual learning environments with focus on game-based and collaborative approaches. This includes virtual learning tools such as multi-user virtual worlds, gamified interactivities, and learning games to teach physics and software engineering

Categories and Subject Descriptors

H.5.3 [**Group and Organization Interfaces**]: Computer-supported cooperative work.

General Terms

Virtual environments, motivation, collaboration, virtual worlds, gamification

Keywords

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1. INTRODUCTION

Teaching conceptual concept of STEM fields such as mathematics, physics, or software engineering, requires the lecturers not only to present solutions, but also to teach skills how to solve the problems. In recent years, more and more pedagogical methods have evolved, which integrate hands-on experiences, live experiments, simulations and visualizations, learning games, or collaborative assignments into the class. One example of a successful pedagogical method is TEAL (Technology-Enhanced Active Learning), which is used to teach freshmen physics at MIT. TEAL produces about twice the average normalized learning gains compared to traditional instructions[2, 3]. One key element to achieve such learning gains is to focus on the students' motivation. *"In the context of academic achievement, motivational concerns would be addressed if we were to ask, for example, why some students complete tasks despite enormous difficulty, while others give up at the slightest provocation, or why some students set such unrealistically high goals for themselves that failure is bound to occur."*[4]. TEAL uses interactive engagement strategies and cooperative tasks to motivate the students. This includes small assignments and tasks with interactive and immediate feedback, collaborative group assignments with focus on discussions, and hands-on experiments.

Many traditional e-learning formats and technologies and also innovative MOOC systems try to simulate such engaging in-class experiences by adding cooperative assignments in forums or interactive applications such as visualizations or games as learning content. However, many aspects of interactive engaging pedagogical models are hard to implement in a static, asynchronous e-learning environment. Often they do not or not sufficiently support the integration of cooperative and interactive scenarios, such as hands-on experiments, or engaging discussions with peers. The lack of engagement through interactive and collaborative assignments and missing social interactions results in issues such as motivational throwbacks. Multi-user three-dimensional virtual worlds support social activities, the integration of different tools, such as simulations and visualizations, the use of different communication channels, and collaborative learning and working activities. In a first research project in cooperation with MIT, we developed the Virtual TEAL World (see Figure 1 and Figure 2), a multi-user collaborative virtual world to learn basic physical concepts.

In this world the pedagogical model TEAL is simulated and its main components, such as three-dimensional simulations and experiments, are integrated to provide users an interactive learning situation. This makes the virtual learning experience similar to the in-class experience. Users can learn together by working with three-dimensional simulations and visualizations of concepts such as Faraday's Law and can discuss the topics in real-time. First results indicate that the collaborative assignments are an engaging and interactive experience[6, 5]. However, the results also indicate, that the environment should be designed in a more engaging way, so

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Figure 1: Students learning in the environment.

Figure 2: Physical visualizations in the virtual world.

that users would also use the environment on their own and not only with peers.

Another teaching method to engage students, which became more popular in recent years is the use of games or game design elements (gamification)[1] in the classroom. These engaging and playful experiences support students to learn and understand concepts by experiencing and solving problems either in a group or on their own[9]. Also combining immersive environments such as the Virtual TEAL World with game design elements can add engaging aspects to the learning experience and can make such worlds to promising tools for student groups, but also for learners, who would prefer to learn on their own.

2. RESEARCH FOCUS AND VISION

The main of my research is to explore and combine different pedagogical strategies such as game-based learning, gamification, and cooperative learning in different environments and technologies, including multi-user virtual learning environments. Future steps concentrate on the integration and exploration of further pedagogical motivators in such environments. This includes game design elements, cooperative assignments, and other forms of interactive engagement. The main research goal can be described as the implementation and comparison of different motivators in both, multi-user, but also single-user environments.

The overall vision of this project is to study the learning behavior and motivators in different virtual learning scenarios in STEM education and to model an immersive and motivational framework for e-learning scenarios, which is applicable for pedagogical objectives of different STEM fields. The results of this project will increase our understanding of the integrability of pedagogical motivational factors in interactive e-learning environments including MOOCs, of the generalizability and interoperability of the according tools, and the effectiveness of virtual motivational immersive environments in STEM fields.

The main idea is to design, implement, and compare similar teaching concepts of different STEM fields (e.g. physics simulations or programming exercises) in (1) gamified scenarios, (2) game-based scenarios, and (3) collaborative scenarios.

To integrate other pedagogical models into our motivational immersive environments it is important to research further pedagogical motivators in the context of immersive environments and online environments such as MOOCs. The main research tasks after the first experiments can be summarized as follows:

1. To study further the motivational aspects of immersive environments (collaboration, game-based/gamified scenarios, interactivity) and the impact of the different learning strategies
2. To define what and how we can measure motivation in virtual environments
3. To extend the experiment setup to other STEM fields
4. To broaden the principles on a high level to make them applicable across different virtual and online environments

Summarizing, the main research hypothesis of the project can be stated as the following: *"Motivation in virtual and online environments can be achieved by adding game-based, gamified, interactive, or collaborative elements. A motivational, immersive environment for teaching STEM fields can achieve equally well learning out-comes as in-class courses. It is more appropriate to integrate different pedagogical models than traditional e-learning environments.*

3. WORK IN PROGRESS AND NEXT STEPS

An important step is to find and define measures to compare the developed environments. The results are evaluated focusing on (1) motivation, (2) immersion, (3) learning progress, and (4) conceptual understanding. A mixture of qualitative and quantitative evaluation methods to measure these factors is used. In the first phase we have already identified and evolved pre-questionnaires and post-questionnaires out of different standardized questionnaires to test learning progress, motivation, and motivation types in science education (with focus on physics education). Based on these findings we developed the Computer Science Motivation Questionnaire[8] to be able to compare the results of different STEM fields and to compare also results in traditional classroom settings with results in virtual environments. Additionally, we combined eye-tracking studies with think-aloud protocols to gain additional understanding of

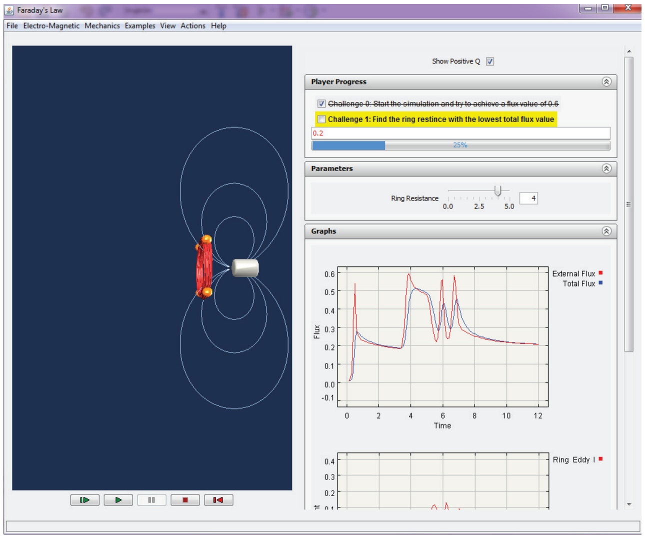

Figure 3: Physics simulations with flexible interactive game design elements in the form of interaction/feedback loops.

the users' behaviour and their engagement while they are learning with the different technologies.

In a first step a gamification model was developed, which is used to build educational science simulations with integrated tasks and feedback systems based on gamification strategies. The model uses an interaction/feedback loop with focus on interactive simulation elements, the integration of different feedback types, and flexible challenge design to engage the users[7].

In the current research phase I am working on the implementation of different versions of a virtual environment, which integrates a physics simulation to teach a single concept of electromagnetism. The different versions represent different pedagogical approaches: different forms of game design aspects and collaborative activities. In this case we want to find out how students perform using a simple simulation compared to a simulation that integrates game design elements designed with the gamification model for educational science simulations[7]. First, both versions will be tested by individual learners, after that in peer-learning scenarios.

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