Augmented Reality used in physics experiments – Increase pupils interest and reduce the cognitive load?

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Abstract. The subject of electricity offers many experiments to use an augmented learning environment. The Application *PUMA: Magnetlabor* developed in the PUMA project is mainly intended for visualizing the models of the magnetic field and provide an insight into matter. A comparative study examines the influence of augmented reality on cognitive load and situational interest. The focus is pupils' individual perspective. This is assessed by intermediate tests after each of three presentation options. Experiments supported by a simulation application, experiments enriched with an AR application and classical settings are compared.

Introduction

We live in a complex, high-tech world that forces each of us to deal with technology in everyday life, which generates and exacerbates major global challenges such as global warming. The natural sciences with their experiments and theoretical models, contribute greatly to both predicting and processing global challenges areas as well as qualifying people for a well-thought-out use of new technologies. It is also important to excite learners about these topics at a young age and to introduce them to scientific ways of thinking and working with an intrinsically motivated approach. In particular, dealing with and communicating scientific models poses a number of major cognitive, affective, and interpersonal challenges. We present our study which aims to manage these challenges using augmented reality (AR).

Theoretical framework

AR three-dimensionally overlays virtual elements with the real world and allows user to interact with digital content in real time. Using AR applications in an educational context can lead to an increased motivation, improvements in interaction and collaboration, and gaining experience with the direct application of learning contents [1]. An intriguing feature of AR is that virtual elements can be manipulated using a tangible user interface that connects digital information with real world objects. This approach renders an AR system very intuitive and especially suits the visualization of scientific models. Furthermore there are still only a few quantitative contributions on the subject of AR in the context of learning environments [5]. Dealing with scientific models such as the model of magnetic field lines, requires a high degree of complexity for the learner. According to the Cognitive Load Theory [4], three types of cognitive load in learning processes can be differentiated: Intrinsic load is constant for a learning object and results from its complexity. Extrinsic load depends on the presentation of the learning content and is generally not beneficial to learning. The aim must therefore be to reduce this type of stress. Learning-related load arise from gathering and storing of the input in long-term memory and is therefore conducive to learning [4].

Methods and findings

In a comparative study, the influence of the type of presentation on the constructs of cognitive load and situational interest [2] is analyzed. The physical self-concept, the expectation of self-efficacy, the interest in the subject as well as the subject matter expertise, serve as control variables raised in the pretest. There are three different blocks in total, in which the students carry out the block with the corresponding representation. The two constructs mentioned above are then queried in an intermediate test after each block. The time frame, including a break after each block, is four hours. At the beginning, the class will be divided into three groups. In each group, the representation method is rotated in order to minimize the temporal effects (see Fig. 1).

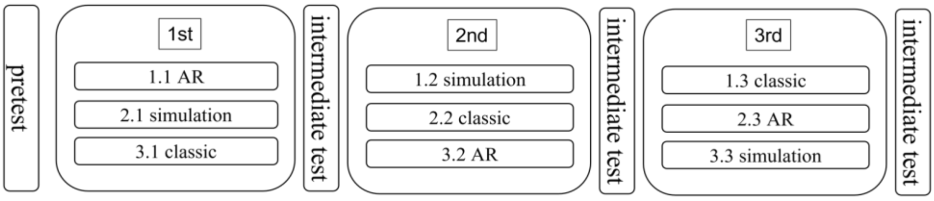

Figure 1: Time course of the survey

For this study, both the AR application and the simulation app were developed as part of the PUMA project (physics lessons with augmentation). Each student carries out the experiment of a block either with an additional AR application or with a simulation that is locally separated from the experiment or with a classical 2D printout of the physics model. The aim is to investigate if the extrinsic load is the lowest, when performing the AR application according to the principles of spatial and temporal contiguity of the Cognitive Load Theory of Multimedia Learning [3] (RQ1). In addition, an relationship of AR with situational interest [2] and its components of emotional valence and activity-related intrinsic motivation will be examined (RQ2). The study with 400 participants ended in February 2024 and will now be evaluated. First results show an impact on the extraneous load (ANOVA). Further results will be presented in this talk on 4th WCPE 2024.

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