The educational value of ”Interactive Screen Experiments” - a new representation of experiments with multimedia technology

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Abstract

In most physics courses using multimedia, real experiments are represented as digital video demonstrations. The disadvantage of these time based media is that students are in the state of passive learner, avoiding the individual activity which an experiment requires. Traditional multimedia learning environments only allow the selection of different media, but the learning process is not supported by interactions within these media. More suitable representations of real experiments force students to manipulate the experimental set-up directly and authentically within a digital photo. The new type of representation, developed at the TU Berlin, is called an "Interactive Screen Experiment" (ISE). This paper will briefly review our research and development on ISEs since 1996. It will also discuss the lessons learned about media design and new instructional approaches in physics education.

Background, Aims and Framework

In traditional multimedia based physics courses, real experiments are represented as digital videos. With this time based type of media students can only learn from given demonstrations. User control is limited to turning the demonstration on or off. Once turned on, the flow of information is controlled by the medium and not by the user – i.e. the student who is trying to learn, or the teacher who is trying to respond appropriately to the needs of the students.

We are interested in new types of interactive representations of real experiments which allow an active participation of the user, and an individual control of the experiment with an immediate and authentic feedback. Rather then merely integrate the various media (text, picture, audio and video), we utilize the potential of multimedia technology to enhance the engagement of the learner in learning processes with experiments.

The central aim of our research is to develop and evaluate interactive media which represent experiments in physics within multimedia learning environments. This allow the interactive representation of experimental physics in great variety, independent from place and time. To attract and hold the student's attention in the learning process requires also an element of "reality based activities". Interactive Screen Experiments (ISE), help students to understand physics and its technical applications by exploring complex systems. This approach can also bring students into a more intimate relationship with the basic principles of physics.

- Within the ISE approach, multimedia is used to create a realistic image from a real experiment in which the student is able to make his own findings. User actions within the ISE should be designed to simulate real user actions.
- Students can use ISEs to prepare, repeat or extend real experiments for individual learning purposes. ISEs should not and can not replace real experiments and personal lab experiences.

Based on this approach we have defined core projects to investigate the educational value of ISEs:

- *ISE enhanced lecture:* In the heavily populated (up to 800 students) physics lecture "Physics for engineers" at the TU Berlin, only a very limited number of real

experiments is demonstrable (because of technical problems). Since there is no required laboratory instruction in this course, the ISE enhanced lecture demonstrations offer the only opportunity for most students to observe the experimental fundamentals of physics within own activities.

- *Interactive Experiment Instruction Manual:* In the first year laboratory in physics, students often have to experiment with various instruments. To use the lab time effectively, students need to know these complex instruments and how to handle them. Our "Interactive Experiment Instruction Manual" has the purpose of preparing students to conduct the various experiments with this instruments.
- *ISE based learning modules:* Together with the German publishing house Klett we develop and evaluate ISE based learning modules for individual learning activities. Students and pupils are often in the state of passive learners, escaping from the interactions with a demonstration experiment. They also have no opportunity to repeat an experiment at home. The CD-ROMs are designed to support individual learning exercises based on experiments (also at home), and to bring students into an intimate relationship with phenomena in physics in all of its diversity.
- *Experiments in distance education:* One of the major problems in distance education in physics is the absence of possibilities for the students to conduct experiments. Since experimentation is traditionally considered to be a vital part of the education in these sciences, a way has to be found to make them available in correspondence courses.

Mode of inquiry

One of the first steps was to investigate standard interactive media formats (e.g. Virtual Reality) to develop some prototypes of ISEs for testing new interactive representations of experiments in various learning situations (lecture, small learning groups, individual learning, distance education). First we evaluated the acceptance and effectiveness of these prototypes. Additional assessments, including participant observations, category based video analysis, questionnaires and interviews, are providing a more detailed picture of student learning with ISEs. Also, the design principles of ISE type user interfaces and the appropriate behaviour of screen objects (cognitive interactions) are part of these investigations.

Outcomes

First ISE prototypes are developed with QuickTime VR (Apple Computer, Inc.). They are not time based media objects, like digitised video. The recording process is based on the idea of single frame animation of stationary experiment states instead of continuos video recording. After this step a multidimensional matrix is built from the recorded pictures, in which the user selects images by moving the mouse. This produces the illusion of directly manipulating experimental devices represented in ISE.

A serious disadvantage of the QTVR format is the simple user interface. The ISE can be controlled only by moving the mouse in two dimensions, and the reactions of the image are independent from the pointer location. This may confuse the user, as we have observed in several investigations with students in individual learning situations. As a second step in our research guided development of ISEs we now use multimedia authoring tools, like Macromedia Director, to construct object-oriented ISEs, which enable the author to design more realistic user interfaces.

The more than 300 ISEs we have developed up to now include qualitative experiments which illuminate phenomena in physics, as well as quantitative ones in which the measured values of recorded variables are of significance in the learning process.

- ISEs have continuously been used in our lecture ”Physics for Engineers” for more then three years. The acceptance by lecturers and students is significantly high. Efforts are under way to extend these methods to other lectures, and later to the whole university.
- As a result of our collaboration with Klett we have developed the first CD-ROM: "IBE Optik", which is used in many German schools now. The next CD-ROM ”Electricity” will come out soon.
- From the project ”Interactive Experiment Instruction Manual” we have learned, that lab preparation with ISEs can make lab time more effective for students.
- We have now several collaborative projects with other universities (FU Berlin Kaiserslautern, Düsseldorf, Davidson College) to develop and evaluate ISEs in learning environments (e.g. using ISEs in the distance education project ”FiPS”).
- For our innovative approach using multimedia in physics education we have received the European Academic Software Award 2000 (www.easa-award.net).

Conclusions and Implications

With ISEs we have found an new educational tool beyond traditional multimedia learning environments. Further development and research are necessary to create useful multimedia learning aids based on ISEs which could effectively solve specific problems in physics education (learning from experiments within individual learning situations, group work and even life-long learning). We assume it is a didactic advantage if students are exposed to ISE as a basis for the theoretical understanding of concepts in physics.

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More information and examples on ISE projects: www.ifpl.tu-berlin.de