FiPS – Physics and Distance Learning

Introduction

Setting up an off campus physics major course is not an obvious task. Some questions arise immediately:

1. How can off campus students be confronted with physical phenomena and experiments?

2. How can one set up an ergonomic and stimulating environment for theoretical discussions that handles the transmission of formulas and sketches on the one hand and allows of structuring complex discussions on the other?

3. How can one evaluate the students' progress and the virtue of the new techniques in this field?

FiPS is the distance learning project at the Physics Department of the University of Kaiserslautern, Germany. In winter term 1998 it supplied 90 students who were mostly bound to military or community service with lectures from first year's physics major studies. The project started in winter term 1997 as a publicity campaign but it fits in perfectly with national and European efforts to catch up in the realm of university teaching via multimedia and telematics (the latter meaning computerised telecommunication). These technologies might have answers to the three questions above and the following paragraphs sketch some of the ideas FiPS is pursuing.

1. Phenomenons and Experiments

Demonstration experiments are typically presented during first year's introductory lectures. Since many universities already use video screens to make them visible to a large audience, it is only a small step to distributing them as elaborate video clips that students can pause and replay at will.

Another issue are laboratory courses. There always will be a practical insight only lab experience can teach. This still demands some weeks of students' presence on campus. But a closer look to the actual learning goals in introductory lab courses reveals new chances if one takes into account the progress of simulation technology. Furthermore, a principal knowledge of these technical means is essential for any didactical consideration after.

a) Some general learning goals of lab courses

- Students shall relate a physical theory to the actual phenomenon and get a notion of orders of magnitude of the involved parameters.
- Students shall learn to record, to interpret and to present physical data in a way that separates the actual phenomenon from errors and interferences.
- Students shall learn to orientate themselves in an experimental set-up of medium complexity. They shall become secure in handling in a creative way complex equipment with frequency abstract controls.

b) Some remarks on educational technology

Former educational simulation programs came along with their specific handling and confronted users with many ways of configuration. The paradoxical result was, that they were quite bulky to integrate into the curricula and still not flexible enough to justify going into their peculiarities in the narrow context they were useful. But times have changed: So-called “hypermedia documents” allow of integrating not only text, graphics, audio and video but also adapted simulations. And this time they display to the student only whatever is needed for the particular animation or the virtual experiment within the physical context. An advantageous approach to the implementation of such lecture-integrated simulations is Java applet technology for three reasons (applet = a computer program that is runable on a web page):

- Java is a most general standard programming language.
- Whenever a physical object is programmed it can be reused in new applets without caring about it’s implementing program code. That means new experiments are produced within only days by programmers.
- Java applets can be made “scriptable”, that means that even non-programmers can reconfigure them in a standard, easy to learn scripting language (Java Script). This is done in a second step when a teacher integrates the applet on a web page and demands basically physical and didactical considerations. Again, this configuration is hidden from the student who is concentrating on the physics of the stimulated objects.

c) Chances of new educational simulation programs in distance learning

The relative simplicity of programming applets enables a teacher to set up individual exercises with virtual objects of investigation on any level of abstraction.

Some examples: Students can displace a photorealistic representation of a lens on an optical bench. They manipulate the trajectory of a chaotic pendulum in its phase space by just the parameters that a teacher decided to be available for them. They compose electronic circuits with a mouse drag from a variety of virtual components. Relativistic gedanken (thought) experiments can be performed according to a tailor-made exercise that refers seamlessly to a pre-existing lecture or textbook. Simulations can include statistical errors or interfering effects to be isolated by the students who work up these data in spread sheets. The teacher can give them gradually more controls for the simulation, so that they can change parameters in order to verify their interpretation. That could be realistic controls like changing temperature or unrealistic ones like changing the gravity constant.

The outcome of such investigations can be discussed just like live experiments. One might compare this with computer experiments in solid state physics or with the data output of remote controlled accelerator experiments. For beginners a simulated Sterling machine with a more or less ideal gas and all sorts of volitional defects could be challenging enough. Clearly simulations will not substitute all real exposure of students to real experiments. But we know from other projects that students can be prepared to laboratory courses in a highly effective way. The training on virtual oscilloscopes for instance saves a lot of time when students ask in the lab “Are we triggering on the right level?” instead of “Why don’t we see anything?”.

2. Communication among students and tutors

The weakest point of distance learning is communication. This holds for socialising as well as for technical collaboration. But even here the telematic approach via the internet paves new ways that go far beyond classical mail-based correspondence courses. Again nobody denies that longish calculations are best performed and corrected on paper and it doesn't really matter whether they are transmitted as letters or electronically scanned through the internet. This is just as long as texts are read best on paper regardless whether they are printed out by the editor or the student's computer. These are matters of costs and convenience. But studying physics is more then reading and calculating. It is to a high extent discussing physics with teachers, tutors and, of course, with fellow students. Our experiences with a classical telephone hotline show that only very few students use this merely auditive medium to talk about physics (though these do it extensively). Again some information on new technical potentialities should precede any considerations about their didactical application.

a) Some general goals of communication in distance courses

- Students must be able to present their individual questions with sketches and formulas to their tutors or to the audience of fellow students.

- Tutors and students must be able to comment on published questions and exercises in a clear arrangement of topics and references.

- Individual real time discussions must be available with transmission of voice, sketches, formulas and possibly of the participants' faces in full-video.

- Some feed back from the students should be collected by automated systems in order to indicate tendencies and the prevailing needs to the tutors.

b) Some remarks on telematics technology

One distinguishes between asynchronous and synchronous communication. Asynchronous media like e-mail, newsgroups, web pages and web forms have feed back delays from some hours to some days. Contributions are posted and answered according to the participants' availability.
Synchronous communication on the other hand is possible via telephone, internet chat or online conferences with application sharing (the latter meaning concerted access to electronic sketch-pads or arbitrary computer programs). In synchronous mode the students have to make an appointment but will get immediate response. There are internet tools which indicate the online presence of other participants allowing of spontaneous calls. Voice transmission via internet is not perfect yet will probably replace conventional telephone in this field.
Sketches and formulas can be drawn with the aid of graph tablets. It is also possible to copy them from other documents and insert them into the electronic sketch-pad on the screen. Another solution for formulas would be an equation editor that provides menus with mathematical symbols (cf. MS Word) but at the same time accepts modifications of a simultaneously generated LaTeX-command (cf. Namo Web Editor 3.0). LaTeX is a

layout language which traditionally many physicists are ready to learn for their further publications.

c) Chances of telematics in distance learning

Asynchronous communication should allow for deeper reflection, elaboration and arrangement of the submitted contributions. They give shy students a chance to ask what they wouldn't have dared in the lecture hall. A lecturer can answer once for all even to particular questions, because all posted articles in a newsgroup are searchable for keywords and are available to future generations of students. Students can answer to questions of their fellows that they wouldn't even have noticed on a normal campus. Such peer tutoring could be honoured with some credit. This mode of communication apparently needs a lot of training for students and tutors before they find a productive style of collaboration.

Synchronous communication seems to be more adequate for students to shape their ideas like in a brainstorming. This mode is much more personal which might be important for socialising but we have still only limited experience with students in this field.

There is a variety of commercial CBT-software (computer based training) that already integrates many of the requested communication features. But they are generally not developed with regard to the special requirements of natural science teaching. The FiPS project aims to define those requirements for physics by testing in practice commercial tools as well as own workarounds for specific tasks. It is obvious that not all kinds of contents and exercises are equally suitable for the mentioned techniques. This again requires a careful reconsideration of the actual learning goals in Physics teaching as a starting point for any technical implementation.

3. Evaluation of the new teaching strategies

In a first step the comparison between on and off campus students will be to let them pass indentical exams. But then: Why are we convinced that classical exams test with validity whatever is needed to become a good physicist? Maybe simulations and newsgroup discussions can promote complex problem solving skills and an intuitive understanding of physical concepts that typical written exams scarcely test. This is at least our hope.

Since we can not wait for the future scientific activities of our students, we try to build up a whole learning environment that comprises lectures, multimedia material, exercises and communication tools. The fact that much of this learning environment is computer based makes it possible to monitor the activities and the progress of our students.

But finally there are professional physicists who inspire multimedia applications according to their learning goals and there are again physicists who tutor the students. And even though most of the exercises will still be calculations on paper, it depends highly upon the subjective impression of those physicists whether we find the students really improving within the described high-tech set-up or not. But this is the same subjectivity that we have in any conventional physics exam.

After all, the ultimate judgement on the new techniques will be pronounced by the community of lecturing physicists: If they finally feel some benefit from adopting e.g. simulation exercises via internet and electronic communication for their on campus students, then we are on the way towards something one could call “mixed mode” with some distance education elements. And then it remains a matter of the circumstances, which compromises and solutions will be found satisfactory. We are still investigating to which extent distance learning in physics could be a serious alternative but we are quite sure that some of its effective means and tools will become standard in physics teaching in the next century.

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