VIDEO INSTRUCTIONS FOR UNDERGRADUATE LAB EXPERIMENTS: A STUDENT-TO-STUDENT APPROACH

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ABSTRACT

Lab experiments are an important part in teaching undergraduate physics at universities, in particular in subsidiary courses for engineering students. A lack of preparation time and/or motivation of students affect the ability to successfully perform a given experiment. Our attempt of improvement is providing video tutorials that explain the lab experiments in addition to usual text instructions while giving experimental details to large groups. This adds an interdisciplinary aspect, and the advanced students serve as role models for other students.

INTRODUCTION

Physics remains the fundament of all modern sciences and engineering disciplines. In universities, it is nowadays often absorbed in special courses designed to meet the purposes of the actual major subject; nevertheless, most non-physics science and engineering programs include a first-year module concerned with teaching the fundamentals of physics.

Since the advent of affordable video equipment, attempts were made to implement this new tool for teaching physics [1]. With the rapid development of internet availability and video-sharing platforms during the last years, educational footage has become a widely used source of information. Mobile information technology enables users to quickly find answers to questions of different levels of detail.

In this paper, benefits and difficulties in first year physics courses at universities are discussed and analysed. As a possible attempt to overcome the difficulties, we present our experiences with student-made introductory videos to lab experiments. Instead of presenting the whole experiment in a recorded video, only the introduction to conducting the real experiment is shown [2]. We discuss the additional learning outcome and motivation boost associated with the preparation of such videos and suggest strategies for a proper integration into existing courses.

PHYSICS LABS: BENEFITS AND DIFFICULTIES

All science and engineering courses at Rhein-Waal University include at least a one-semester course on elementary physics. The degrees include mechanical engineering, electrical engineering, materials science and science communication among others. Students enrolling in these courses have often a very different expectation and also a varying skill set with respect to physics.

A typical physics course taught as a minor subject consists of a lecture with e.g. two hours per week presence time, accompanied by a one-hour problem solving unit and a two hour lab course. The latter usually requires students to understand the theory of the experiments, conduct the actual experiment in the lab and present the results in the form of a written lab report.

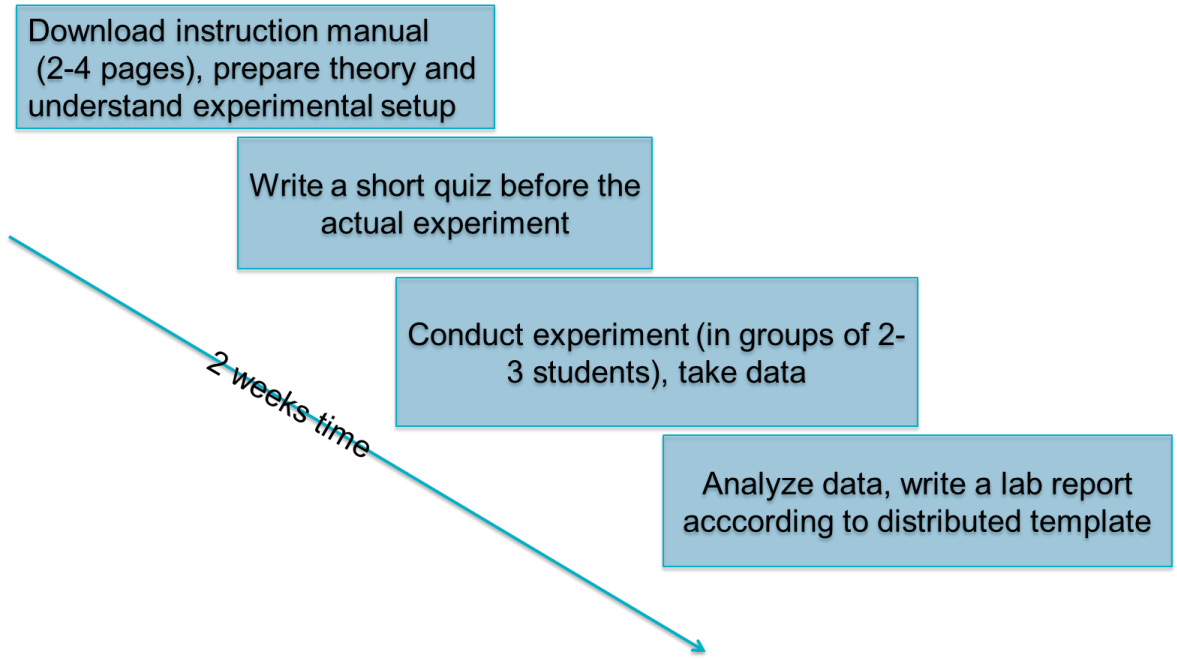

Fig.1. Workload cycle for first-year students in the physics lab courses. Engineering students have to complete five experiments in the first semester.

The physics labs (Fig.1.) play an important role in transferring methodical competence. Students are not only introduced to scientific methods, the art of measurement, data analysis and error treatment, but are also confronted with teamwork, often for the first time.

In many reported cases, the exact sciences like mathematics and physics turn out to be very difficult for students who have to take these subjects only as minors as illustrated in Fig.2. The reason for this is often a lack of motivation, because the students cannot see yet how these subjects are related to their majors. Moreover, even introductory courses often need to rely on the fundamental ability to think scientifically. In fact, even simple approximations require a certain level in mathematical education that cannot always be met by first-year students; important concepts like error propagation and other statistical tools for quantitative measurement analysis are even more out of reach for scientific beginners.

VIDEO TUTORIALS AS SUPPORT FOR LAB INSTRUCTION DOCUMENTS

The expected benefits of video tutorial can be grouped into a technical, a sociological and a pedagogical aspect.

1. Technical aspect

Even simple experiments can have a complex setup that is sometimes hard to describe by a written introduction. In a typical arrangement, various devices are connected in different ways that are visually perceived easily while evading a short description in words. A technical drawing can perhaps visualize the setup but often fails to illustrate the dynamics of the measurement. Very fast or slow events can be presented in different replay modes. Additionally, a video can transport real acoustical features of the experiment, e.g. in collisions

of object, friction sounds or humming of transformers. This makes students feel more familiar with the experiment when actually being in the lab. Moreover, artificial sounds can be included to emphasize certain details, e.g. the sound of accelerating cars. This is intended to help students relate to the subject by making connection to everyday experiences. Small details of instruments, fittings and other parts can be filmed in close-up mode and thus can be shared with a large audience. It is also assured that different groups performing the same experiment get identical instructions. Especially in international classes taught in English, the visual outreach of the video can help overcome language difficulties by directly linking pictures of objects with technical terms. Difficult experimental situations can be scrutinized by the audience by individually pausing or rewinding the film. Sharing the footage well before the experiment enables the students to get familiar with the actual equipment even before entering the lab. This saves time for students and instructors and allows for more time to actually do the experiment. The video can be maintained over different courses, improvement and reaction to student feedback can be consistently offered over a long period of time.

2. Sociological aspect

Video instructions designed and filmed by students who have already taken the labs help to establish them as role models for the next generation. Unlike more senior lecturers, they can better relate to new students facing the experiments for the first time. Furthermore, a certain enthusiasm can be stimulated easier from student to student.

Since video clips are part of the students' everyday life, the students can easily be addressed by this communication channel.

3. Pedagogical aspect

Our science communication students have to complete the same physics labs in the first semester as all the other, mostly engineering students. While producing the clips, they can directly apply their recently acquired proficiencies in film making. In addition, they intensify their knowledge about physics and their experimental skills.

There is also a fruitful feedback from students to the lecturers; by actively accompanying the production process, they obtain incentives for improving physics teaching.

MAKING VIDEO INSTRUCTIONS

The videos of five physics lab experiments (Kinematics, Pendulum, Energy and Momentum, Moment of Inertia, and Resonance) and a tutorial on data analysis software were produced by four students studying in the Rhein-Waal bachelor degree course "Science Communication and Bionics", from April to May 2015. The production of the video was completed by June 2015. The aim of the videos was to instruct students how to work with the equipment and what exactly they were supposed to do as part of the experiment. Each video took approximately 2 hours to prepare a script, 2-3 hours to film, and 7-9 hours to cut clips and produce the whole video. The script was based on the written lab guidance to the experiment, on the lab reports written earlier by the team, and on the test-videos developed by the instructors preliminary to the more detailed production completed by the students. Professional equipment, such as TV cameras and video post-processing software, were used for filming and cutting. The length of the videos depended on the content and the amount of tasks which had been completed in the experiment:

- Kinematics (4:50 minutes);
- Pendulum (5:09 minutes); this clip can be seen at [3]

- Energy and Momentum (5:37 minutes);
- Moment of Inertia (4:42 minutes);
- Resonance (6:08 minutes);
- Tutorial on data analysis software (10:49 minutes).

Each video ends with a small, somewhat ironic or funny scene involving presenters and part of the equipment. This entertaining part was created as a 10-30 second closing, in order to encourage students to work hard and to show them that physics can be fun and, more importantly, is closely related to everyday life.

Fig.2. Video production of the experiment on moment of inertia.

CONCLUSIONS

With the help of students from our science communication course a set of video tutorials for physics lab experiments have been created. This tool offers several benefits in teaching first semester students innovatively, although further statistical and pedagogical investigations are required to quantitatively judge the impact of this teaching method. We have already received an overwhelming positive qualitative feedback from a number of students who were using the video tutorials in September 2015. In particular those students, who did not pass the labs during the previous year without video tutorials, were able to judge the new teaching using videos in comparison. We are aware of possible drawbacks of our approach, like a reduced imagination of real setups and processes based on written descriptions. The development of such skills have to be addressed within the curriculum, but not necessarily during the physics labs, so that introduction videos can become a helpful tool for teaching.

ACKNOWLEDGMENTS

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3. The videos are available on the YouTube channel of Rhein-Waal University: https://www.youtube.com/user/HSRheinWaal