Enhancing physics laboratory work with online video instruction

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INTRODUCTION

This paper describes the idea, setup and the results of video instruction in engineering physics laboratory delivered in a modern way using smart phones, YouTube, Moodle and PlayPosit. The main goals of the method are to achieve better student preparedness for laboratory work, to save valuable laboratory time for active working and to improve learning outcomes. This approach also enhances student-centeredness by giving the students more autonomy and responsibility in learning.

1 GENERAL

1.1 Educational videos

Short, individually streamable video clips have dramatically increased versatility and possibilities in teaching and studying over the last ten years. They can be delivered via YouTube, for example. Moreover, it is possible to build multiple-choice and open-ended questions on top of YouTube videos using PlayPosit (former EduCannon), which demands the students to interact with the video instead of just watching it. Educational videos have also enabled new teaching methods like flipped classroom, just in time teaching and peer Instruction [1 - 3] and videos have been used as tutorials [4]. The main idea is to use videos for one directional sharing of information and free valuable face-to-face time for active learning, which is demonstrated to increase learning outcomes [5]. A learning method combining these good practices in theory courses, both in face-to-face and online implementations, have been introduced in SEFI conferences earlier [6,7].

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In this study, similar methods are used in larger-scale introductory physics laboratory courses. This idea itself is not new, it was presented already in 70’s [8] and was used in 90’s [9] with specific video tape players. However, the development and current prevalence of powerful mobile devices and fast 4G connections have made videos a powerful learning tool, available 24/7, practically everywhere.

1.2 Physics laboratory courses in Tampere University of Applied Sciences

Physics laboratory courses have been included in the curricula of engineering degree programs more or less always. The implementation methods may vary according to the University. In Tampere University of Applied Sciences they traditionally have been organized as follows:

- There are four similar equipment setups for each laboratory work. Students work in pairs and so there are eight students (4 pairs) carrying out similar measurements. One teacher instructs two different works and has therefore 16 students to instruct.
- Measurements start with a short briefing to the work, 7-15 min normally. More instructions are given during the measurements. Time period of three hours is reserved for the measurements. Each measurement session usually ends with 10 – 15 minutes short explanation of what students are expected to present at their written reports.
- The reporting takes place at home, either individually or in pairs.

Traditionally students have been rather poorly prepared to the laboratory work. Even when they have studied the theory background and have a general idea of the coming measurements, they haven’t been able to see the equipment in use. Therefore, some time is needed to instruct the students, at least about the proper usage of the laboratory equipment. In many cases a review of the underlying theory is also given - and necessary.

Due to the fact that two types of measurements need to be instructed, half of the students need to wait until the teacher has time for them. This inevitably delays the start. Once accustomed to be instructed on site, the students wait the teacher to advice next step in the measurements. The whole learning and measurement session is then orchestrated by the teacher, who is busy circulating between the two laboratory works.

1.3 Instructional videos in physics laboratories in Tampere University of Applied Sciences

To free teacher’s time and, above all, to change the students’ position from “outside instructed absorber” to active doer, the instructional part of the laboratory course was changed. All one directional information sharing was recorded to videos. The students need to watch them beforehand prior to coming to the laboratory and accomplish pre-laboratory assignments. The laboratory course’s teacher made the video clips with the help of a cameraman (another teacher). In brief, the teacher showed how to use the equipment and simultaneously explained the methods and principles of operation, supplemented by theoretical points of view. A snapshot of such a video is presented in *Fig.* 1. All videos were uploaded to YouTube as “unlisted” and links to videos were provided in the course’s learning management system (LMS), Moodle.

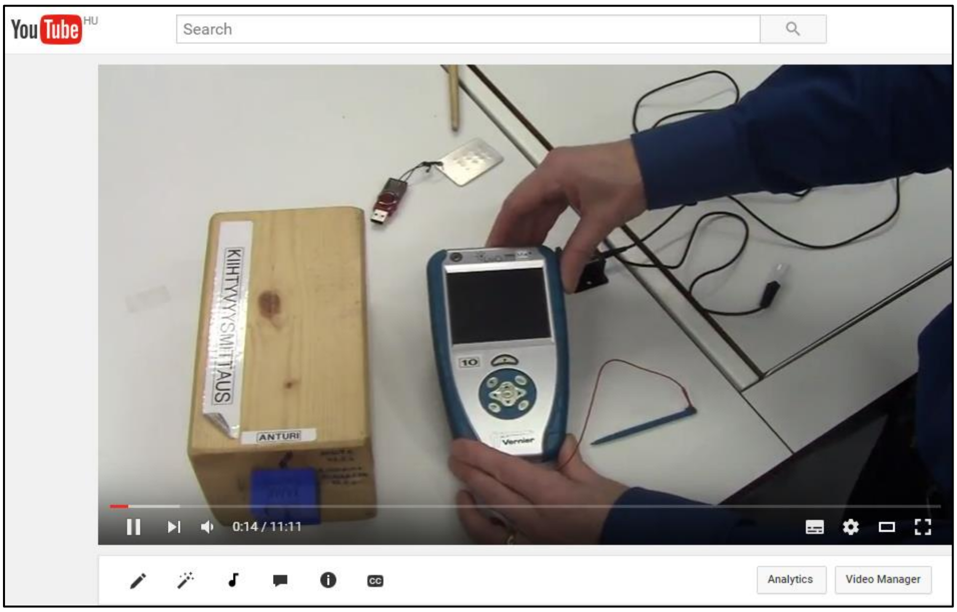

Fig. 1. A snapshot of instructional video for acceleration measurements.

Two different ways of delivering the assignments were used:

1) The video link and the assignment questions were provided separately. In this case students watched the video in YouTube and answered the questions in Moodle.
2) The questions were built on top of the YouTube video using PlayPosit (*Fig. 2*). It is an online learning environment to create interaction to videos. These interactive videos are called "bulbs" and they can be shared among teachers and can be assigned to student groups. Teachers begin with any online video (screencasts, Khan Academy, YouTube, etc.) and build multiple-choice or open questions on top of it. The video stops automatically for presenting the questions at the chosen time instants. Teachers access the answers via web interface.

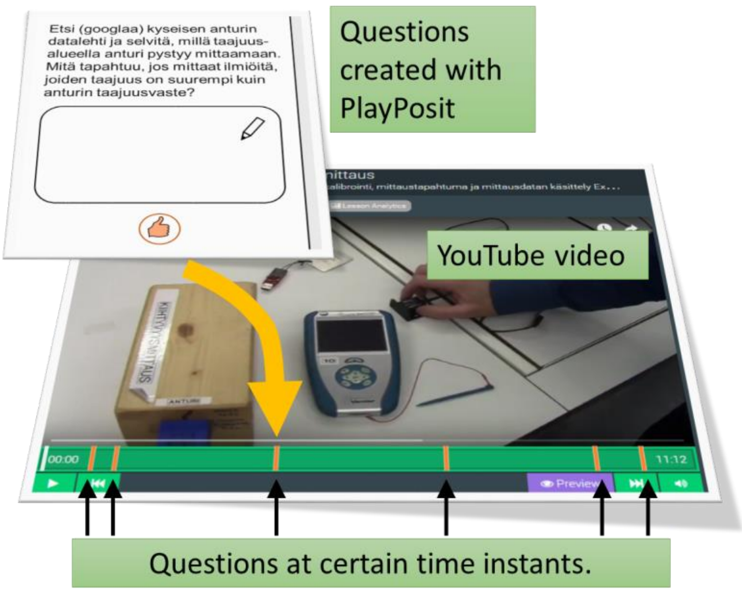

Fig. 2. Principle of PlayPosit.

Each of the four different laboratory works had two instructional videos: one about the equipment and carrying out the actual measurement and another of the measurement data analysis and reporting. In addition to the videos, also traditional written instructions were available online in Moodle.

2 STUDY AND METHODS

In this study, the effects of video instruction on the teacher's and students' time usage in the laboratory is studied. Also, the way of using the videos was studied by examining the times of video openings in the Moodle log file. Student experiences about the video instruction was surveyed with online questionnaires after the course.

From each laboratory work a couple of certain, easily recognizable, specific events were selected to work as a time stamps. In that way, the times of different student groups, different teachers and different ways to give the instruction could be compared. For example, in measurement of thermal radiation they were: 1) turning on the 1st heating source (Leslie's cube), 2) turning on 2nd heating source (light bulb) and 3) handing out the measurement log book to teacher for inspection. Similarly, in other measurements certain events were chosen.

The time stamps of five student groups, five teachers and three different laboratory measurements were recorded. Three of the student groups had video instruction and one had the traditional written material only. The log files of one video instructed student group was examined. All three video instructed student groups were asked to give feedback about the video instruction. Based on their previous laboratory course, they have experiences also about traditional instruction. The contribution of each group is presented in Table 1.

Table 1. The student groups, their instruction types and contribution to the data.

Group	No of Students	Instruction type	Time-stamp data	Feedback	Log file data
A	25	Traditional	Yes	No	No
B	32	Traditional	Yes	No	No
C	28	Video	Yes	Yes	No
D	35	Video	Yes	Yes	Yes
E	26	Video	Yes	Yes	No

3 RESULTS

3.1 Video views

The laboratory time for one group was Thursdays at 14:15-17:00. The time instants of measurement video openings for this group is presented in *Fig. 3*. The total number of video views in is 441, of which 30 took place during the weekend (Saturday and Sunday are left out from the figure for clarity). By far the most common time is Thursdays at 14-16, with 110 views (25%). Not surprisingly, the videos are watched during the laboratory work for help and guidance. This was also recognisable in the laboratory: videos were running on different hand-held devices, tablets and smart phones as well as on laptops. In the beginning it was a bit chaotic and confusing to hear the teachers' voices coming asynchronously from many different spots. However, students rapidly learned to bring headsets to the laboratory. In addition to the laboratory time peak in the data, also laboratory day's morning and the previous day have significant activity. This is likely related to accomplishing the pre-lab assignments.

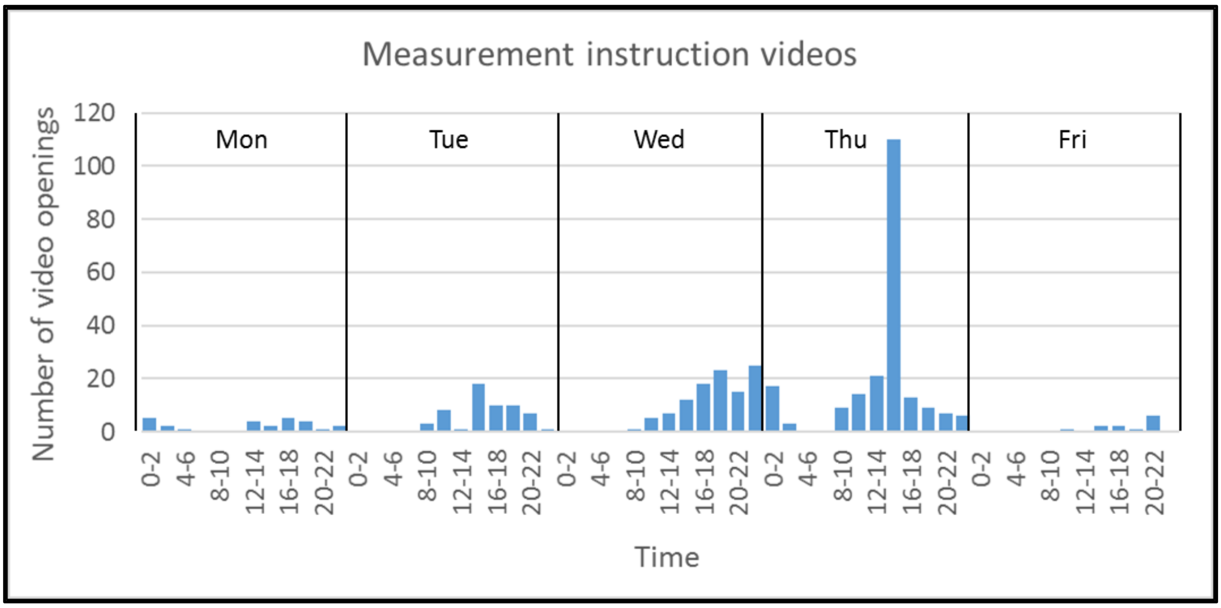

Fig. 3. Temporal distribution of instructional video views. The weekend is omitted due to its low log event counts.

The video usage during the laboratory time revealed a problem: presenting the questions with PlayPosit makes the questions to appear every time the video is watched. During laboratory usage this is unnecessary. The problem was solved by giving up the use of PlayPosit and assigning the pre-laboratory tasks in Moodle. Nevertheless, Playposit is a nice way to present the questions and next time the video links to PlayPosit pre-assignments and to "bare" YouTube videos need to be offered separately to the students. The watching times for reporting instruction videos and the usage of written material has very similar temporal distribution as the watching times of measurement instruction videos and are not presented here.

In *Fig.4* the distribution of video views per student is presented. in this group there were 35 students, of which 6 didn't watch any measurement instruction videos at all and 8 not a single reporting video. The average number of views per student in measurement videos was 1,9 times and that of reporting videos was 1,5. One student has watched the all the videos five times.

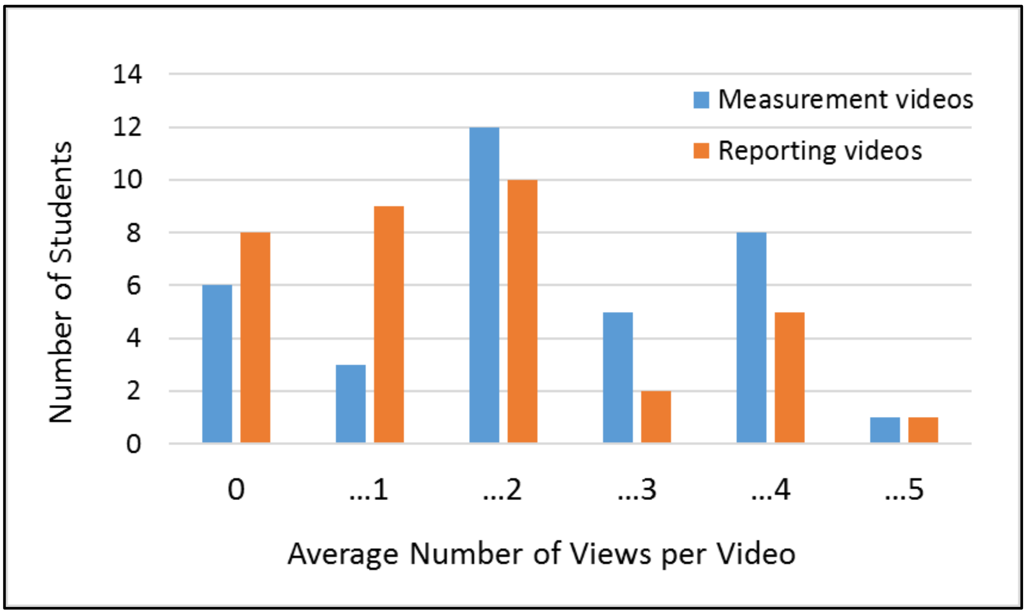

Fig. 4. The number of views.

3.2 Laboratory time usage

The time reserved for measurements in the laboratory is 3 h (3 x 45 min). based on time-stamp data, the starting times and finishing times (min – average – max) of two laboratory works is presented in *Fig. 5*. The video instructed groups started the actual measurement earlier in both works compared to the traditionally instructed groups. However, the γ-radiation laboratory work has safety issues which have to be made clear to the students. Therefore, work 1 shows only little difference in starting time. Both laboratory works show earlier finishing time for video instructed groups.

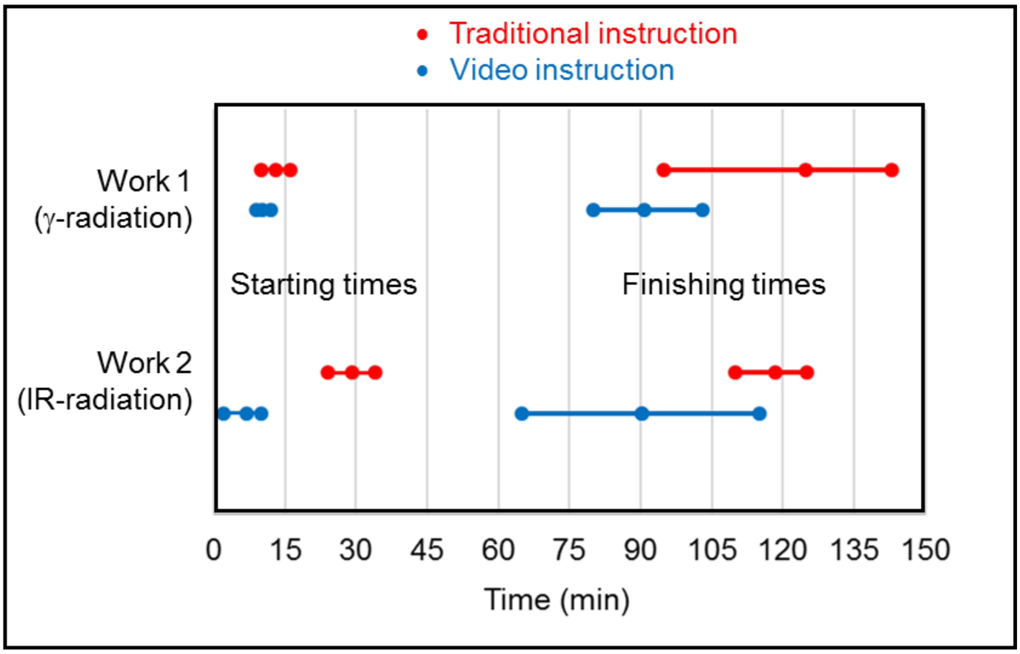

Fig. 5. Student groups' starting and finishing times for two laboratory works.

According to all time-stamp data, students with traditional instruction finished their work after 122 min on average variation being from 95 to 143 min (average of all groups, all teachers, all works) whereas students with video instruction finished in 91 min on average (65…115 min). This is significant reduction of laboratory time. In traditional instruction, students started the measurements on average 20 min (10…34 min) after entering the laboratory, whereas in video instructed laboratories students started on average at 8 min (2…12 min).

3.3 Student feedback

The feedback was collected using Google Forms survey. The form was sent when the laboratory course was already finished and hence the number of answers remained low. Altogether 41 students (83 % male, 17 % female) answered the survey. All of the answered students had watched the instructional videos.

First, the students were asked, if they agreed/disagreed the following statements about the videos:

1) The videos quickened starting of the laboratory work.
2) The videos made the measurements easier to accomplish.
3) Watching video instructions took more time than written instructions.
4) Watching videos is better way to prepare for the laboratory work than written instructions.

In the survey, 5-point Likert scale was used. The results are presented in Fig. 8. According to the results, the students like the video instruction very much – majority (78 %) prefers watching videos over written instructions.

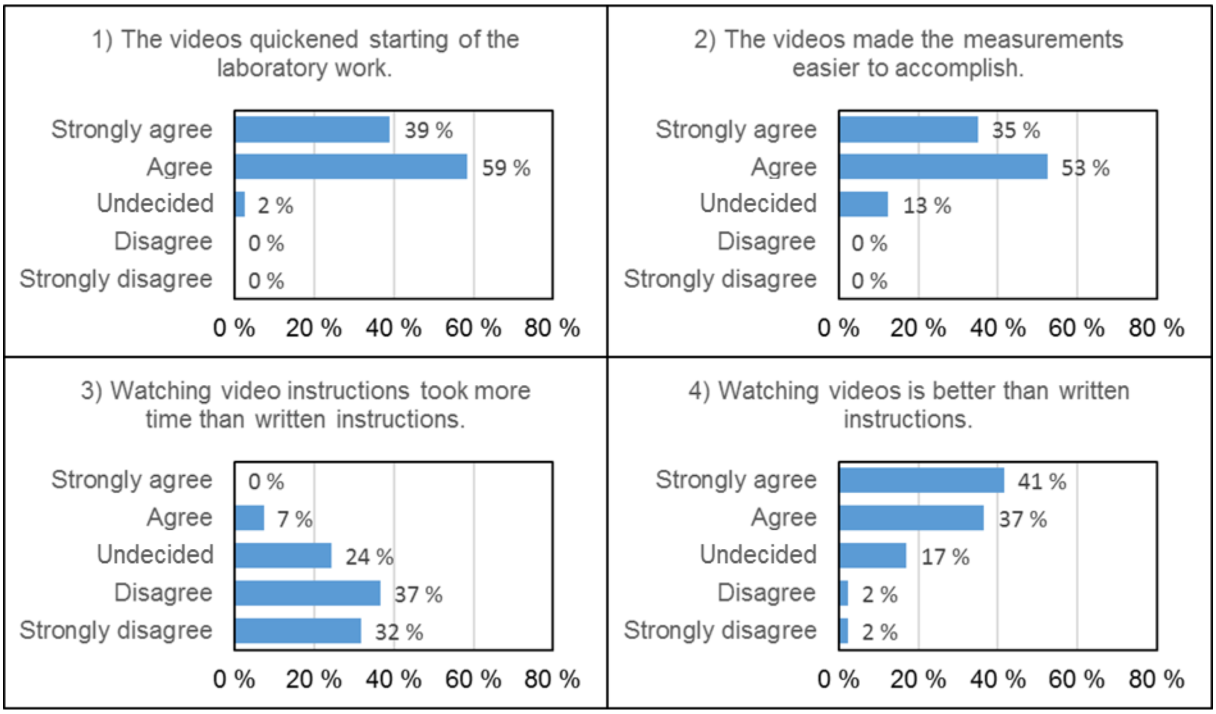

Fig. 8. Survey results

The same result is clearly visible in the question, where students were asked to choose their preference of the three options. The percentages represent students' answers.

1) Teacher explains the measurement in the beginning of laboratory work. Teacher answers questions during laboratory work. (2 %)

2) The instructions can be watched on videos before laboratory work. Teacher answers questions during laboratory work. (95 %)
3) Written instructions can be read both before and during the laboratory work. Teacher ansers questions during laboratory work. (2 %)

4 CONCLUSIONS

A significant reduction in laboratory time was achieved and more importantly, the students didn’t need to wait anymore before starting and between measurements. Teacher was freed to really observe the progress and instruct when needed and those who needed. The students were more responsible for their own learning than in traditional instruction. Students considered the video instruction to be much better compared to written instructions and to teacher’s presentation of the work.

For future development, this study suggests the possibility to reduce laboratory time slot from 3 to 2 hours by carefully planning the measurements and producing relevant, thorough and interactive video instructions. Moreover, a comprehensive laboratory video material enables more flexible arrangements in laboratory work.

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