MOBILE PHONE PHYSICS LABORATORY

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ABSTRACT

In an attempt to increase the part of practical work in a first year physics course at the Faculty of Business ICT and Chemical Engineering we have introduced mobile phone laboratories for one group of students. Mobile phones have a large number of sensors to measure changes in the orientation of the device, acceleration, light conditions, sound levels etc. These sensors can also be used for measuring physical phenomena. This paper reports a short study of the feasibility of open, less guided, experiments in the field of mechanics. The study was done during a part of the Engineering Physics course given to our international information technology students. At the same time we studied the effect of activity based assessment and compared it with the results from an exam like exercise. As a result from this study we can conclude that introducing mobile phone laboratories made the course more attractive. But, the activity based assessment is in need of an update.

KEYWORDS

Physics Education, Laboratory, Active learning, Assessment, Standards: 5, 7, 8, 11

INTRODUCTION

Changes in the university funding drives the development of the education towards larger student groups and less contact hours in an attempt to cut costs. This makes it more and more difficult to give all students enough time for practical laboratory exercises. At the Degree Programme for Information Technology the amount of credits in physics have been cut from 15 ECTS credits down to 10 ECTS credits when the curriculum changed 2014 (Turku University of Applied Sciences). At the same time the resources given to the teachers for development of courses and lecturing were decreased.

The current set of physics courses at the degree programme consists of two separate courses, Engineering Physics and Measurements in Physics, worth 5 cr each. Both courses are given during one semester. The first course covers the theoretical part including mechanics, electricity and optics. The second course is as the name indicates focused on measurements and presentation of measurement data. From the student perspective the first course has been considered theoretical in the sense that the part where students actively participate has been limited to traditional problem solving. On the other hand, the second course is mainly based on student activating practical work. Due to the restrictions in the laboratory, regarding space and equipment, not all students can do the same laboratory work at the same time. This makes it difficult to connect the laboratory works in the Measurements in Physics course with the theory in the Engineering Physics course. Students may be forced to do an experiment before they have the corresponding theory.

To solve these problems we have tried to introduce experiments as home work for the students in within the Engineering Physics course. As almost all of our students have smart phones, we decided to use mobile phones and the sensors in the phones as measurement tools. In this way no extra resources was needed to build the mobile phone physics laboratory.

DEVICES AND SOFTWARE

Most smartphones are equipped with motion sensors such as accelerometers and gyroscopes. The main purpose for these sensors is to sense changes in the spatial orientation of the device. But they can also be used as sensing elements for mechanics measurements (Kuhn et al., 2013). In this test our students used their own phones. As a consequence different brands, models and operating systems were used.

To be able to read the sensors and get the data in a form that allows us to analyze it a dedicated software is needed. There are several different possibilities available on the market. However, few of them are available for all operating systems. In this study the students were recommended to use the Physics Toolbox (Physics Toolbox) if they use an Android is IOS device. For Windows phones the Sensor Emitter (Sensor Emitter) is one option. The drawback with the latter software is the data transferring that requires an in situ contact with a computer.

THE ENGINEERING PHYSICS COURSE

The Engineering Physics Course is a 5 ECTS credit course. The course was given to our first year international students at the Information Technology programme during their first semester. The early intake for the programme is 40 students and this year 42 students registered for the course. The content was divided into 12 weekly topics and two week time for an individual final project. The weekly topics were:

Week 37: Introduction, fundamental laws of motion and the SI system
Week 38: Independent exercises
Week 39: Force and motion, Newton's laws of motion
Week 40: Independent exercises
Week 41: Application on Newton's laws of motion
Week 42: Independent exercises
Week 43: Work, power and energy
Week 44: Electric fields
Week 45: Magnetic fields
Week 46: Electric circuits
Week 47: Optics
Week 49: Temperature and heat transfer
Week 50 - 51: Independent final project

The students had 3 contact hours every week of which two were dedicated for theory and one for exercises. As an addition to normal physics exercises the phone physics laboratory was introduced week 41 and 43. The students formed groups of 3 to 5 persons for the laboratory exercises. The course was assed based on the student activity and returned exercises and reports. The reports exercises were marked with scores on a scale from 0 to 2, 0 = no report or not acceptable, 1 = acceptable or late report and 2 = good report. The impact of the individual final project was larger than the impact of the other exercises and reports. It was

graded on a scale from 0 to 6. The last traditional exercise was held in the same way as a final exam but with the difference that the impact on the final grade was as small as for an ordinary exercise. However, it was also graded as a traditional exam to enable a comparison of the activity based assessment and a traditional exam. Feedback was collected after the course to evaluate the effect of introducing experimental work to the theoretical class.

Mobile Phone Physics Laboratory Exercises

The main idea with the Mobile Phone Physics Laboratory Exercise was to introduce more hands on experiences of physical phenomena for the students. They should also get a feeling of how to design an experiment and analyze collected data. To facilitate the learning of the latter two themes the given tasks were open in the sense that the students could decide within the groups how to measure the phenomena and how to analyze the data. However, some leading questions were given. Students were also supposed to build their own measurement setup using items that they find "at home". All groups should report their work with a video recording and a theoretical calculation of a similar simplified problem. As an example a problem could be;
"Study a pendulum using you your mobile phone. What useful data can be measured? What happens if you change the pivot point, i.e. the length if the suspension? What happens if you increase or decrease the deviation from the position where the pendulum is at rest? Make a video showing your experiment and give a theoretical explanation of your findings."

RESULTS

The overall student activity during the course was higher than during earlier versions of the same course. One reason is clearly the assessment system that was based on continuous assessment and student activity.

The idea that the students should do the experiments on their own time outside the school did not work as planned. Is seem that it was too demanding to ask them to design their experiments without help. To overcome this problem we used some of the lecture time to do the experiments.

Another problem was the data analysis part. Not all groups were able to analyze the data in a way that connected it to theory. This was to some extent a problem that we expected to have, the students are first year students and they haven't had courses in data analysis. However, some of the problems arise from using the software in the phone, saving data and transferring it to a computer. This was a thing that we expected them to learn easily as they are information technology students.

Looking at the outcomes from the experiments we found that the students did participate actively in this part of the course. Almost all participated in the experiments and all groups returned a report. Doing the work in groups is of course one to activate individuals as the group members push each other. However, it can also be a way to enable free riders. But comparing the in class activity in the course Measurements in Physics, were the same group did traditional guided physics experiments, with the in class activity during the more open experiments in the Engineering Physics course the activity was much higher in the latter. In the best cases the groups developed their experiment setups during the process to get better data e.g. one group started to use two strings as suspension to eliminate rotation of mobile phone that was used as the bob.

In a comparison with previous years the overall through put of the course was better than before. The reason for this may be that the dropout rate during the course was lower. A comparison between the grades from the activity based assessment and the last exercise shows that the grades in many cases are close to each other when the grades are low or on an average level but there are huge differences when the activity assessed grades are high. In some cases an exam would have given a better grade, see Table 1.

Table 1. Differences between activity based and exam based assessment

Stud. ID	Activity based	Exam based	Stud. ID	Activity based	Exam based	Stud. ID	Activity based	Exam based
ID 10	5	1	ID 35	4	0	ID 17	2	0
ID 16	5	0	ID 39	4	1	ID 24	2	2
ID 18	5	1	ID 40	4	1	ID 5	1	3
ID 22	5	2	ID 1	3	3	ID 14	1	2
ID 26	5	1	ID 2	3	2	ID 19	1	0
ID 33	5	2	ID 6	3	2	ID 38	1	0
ID 36	5	3	ID 7	3	5	ID 4	0	0
ID 41	5	1	ID 15	3	4	ID 8	0	0
ID 21	4	1	ID 25	3	2	ID 12	0	0
ID 23	4	0	ID 27	3	3	ID 13	0	0
ID 29	4	2	ID 31	3	1	ID 20	0	0
ID 30	4	2	ID 3	2	2	ID 28	0	0
ID 32	4	3	ID 9	2	1	ID 37	0	0
ID 34	4	2	ID 11	2	1			

Most of the students that got a good grade form the activity based assessment did put down a lot of work on the course but were not able to write a good exam. It could be that that the activity based assessment leads students to learn to find solutions to problems but not to solve problems by them self. It is worth thinking on what we want to assess.

The collected feedback was overall good. Open comments about the mobile phone physics laboratory experiments were encouraging. The students liked the experiment as they shed light on the theory. The most negative comments were given on the amount of feedback given on returned exercises. The quick grading on the scale 0 – 2 did not give enough feedback and the evaluation was late. The quick evaluation was introduced to speed up the evaluation process to enable fast feedback. This did not work, the process required still too much work and was too slow. Some students would have liked more traditional teaching with more guided examples solved in class.

CONCLUSION AND FUTHER RESEARCH

The attempt to introduce mobile phone physics laboratories in a first year engineering physics course to increase the active learning and hands on experiences was partly successful. Most of the students enjoyed the experimental part and participated more actively in the learning process. However, the learning out comes were not as good as we expected. There was clearly

a need of more support in the experiment design and data analysis part. This problem could be overcome by a deeper integration of the two courses Measurements in Physics and Engineering Physics.

The increased student activity during the course and the activity based assessment gave a higher trough put. However, the assessment based on activity and returned reports in need of an update. It is of great importance that the assessment leads the students to gain the skills that we want them to have. The activity based assessment lead students to seek solution to problems but not learn how to solve them independently.

There is clearly a need of further research concerning the learning outcomes. Another interesting topic would be to study the effect of usage of the accelerometers in mobile phones for visualizing coordinate transformations.

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BIOGRAPHICAL INFORMATION

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