Combining good practices in fully online learning environment – introductory physics course

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Conference Topic: Active Learning

INTRODUCTION

Based on a selection of good educational practices reported in the literature, a new method to study introductory engineering physics at Tampere University of Applied Sciences was introduced. This method was presented in SEFI 2013 conference [1] for the first time and it mostly relies on classroom teaching with some online content provided via Moodle. The results have been promising as reported elsewhere [2-3].

Now the aim is to implement the same good practices in a fully online learning environment successfully. The challenges are: How to achieve interactivity while presenting demonstrations on video? How to carry out measurements individually at home, but still work on the assignment as a team? And all this with only the equipment a normal student has easily available.

1 BACKGROUND

1.1 Some aspects of online learning in higher education

The amount and availability of online learning has increased over the decades dramatically. In some cases the driving force has been the assumed cost-effectiveness, in other cases the intention has been to offer time and place independent studying opportunities. In addition to online implementations, also traditional face-to-face course implementations have developed towards active engagement of the students, which is reported to significantly enhance learning outcomes [4]. In some cases, hasty online implementation can turn out to be a material bank, which students go rapidly through just before final exam. Or, the instructor's attitude to online learning and its benefits can for a barrier to innovative online pedagogy [5]. However, the aim is to create truly inspiring and activating online environment. Based on recent studies, online learning gains can be as good as face-to-face learning gains [6]. Hybrid implementations (blended learning) benefit the social and activating aspects of face-to-face learning and simultaneously offer material and assignments in online environment, delivered for example using flipped classroom methodology [7]. Peer work is reported to dramatically improve learning outcomes and motivation [8]. However, it can be difficult to implement a peer instruction successfully in a fully online environment. Encouragingly, there are examples of successfully virtual team work and even PBL-implementations online [9]

The development of smart phones has made decent quality sensors and data logging available to anybody, not to mention the opportunity to easily record HD video. By downloading free software, it is possible to convert the phone to a handy data logger to measure position or acceleration, for instance [10]. Nowadays, most of the engineering students seem to have smart phone suitable for small measurement assignments.

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1.2 Challenges in online implementation

The introductory engineering physics course “Mechanics, 3 ects” is offered to students as a fully online course implementation autumn 2014. Based on the good experiences, feedback and results obtained previously with the new blended teaching method in classroom implementation [3], the same elements are included in the online version. The key aspects are:

1. Active engagement
2. Peer instruction
3. Interactive lecture demonstrations
4. Pre-lecture assignments,
5. Small scale measurement tasks
6. Video-content
7. Continuous assessment.

Some of the aspects listed are easy to convert to online implementation: video content is already being shared using university’s YouTube channels. Moreover, technology for video conferencing has been available for years. Pre-lecture assignments are a natural part of online implementation: students can be asked to do the studying or they can be given any other type of assignment prior to a video lecture. Even active engagement is built in to online participation – without lecturer and fellow students present it is only you yourself who is responsible for studying and fulfilling accomplishments.

However, there are key aspects, which are not so easily converted or achieved in online learning. For example, lecture demonstrations are easily showed using YouTube, but how to achieve at least some level of interaction? Or, how to encourage peer working between individuals, who haven’t seen each other and never will see? Even harder, how to arrange meaningful measurement assignments with only equipment an average student has easily available?

2 “MECHANICS” – COURSE: FULLY ONLINE IMPLEMENTATION

2.1 Schedule and structure of the online course

In Tampere University of Applied Sciences, a semester consists of two 8-week periods. From experience it is known that students tend to intensify studying prior exams, which have traditionally been at the end of a period. For this online course implementation an approach was chosen, in which this intensifying would hopefully happen more often. Therefore, the major entities and activities are strictly scheduled, whereas the time table for minor parts and at detailed-level are left free.

Fig. 1 summarizes the schedule for the course entities. At the beginning, one week is reserved for the students to get to know each other and for the teams to be formed. The aim is to achieve such teams and team dynamics that they are able to carry out measurement assignments together - even though not physically working together. Also some of the algebra-based tasks are group assignments.

The students are asked to plan their working hours both for individual work as well as for the group work. The planned time for the course is 81 hours (27 hours/ects) of students’ time. Participants also need to upload their plans to Moodle. In this way it is hopefully possible to get the students to realize how much time they need for studying the course material and also reserve that time for themselves.

Week exams and measurement assignments are arranged every two weeks. The total length of the online course is adapted to follow the rhythm of academic year in general, and therefore the course is planned to last eight weeks (one period). Content packages are:

- Kinematics of Linear Motion
- Dynamics of Linear Motion, Newton’s laws
- Energy, Energy Conservation
- Linear Momentum and Impulse Law
- Circular Motion and Kinematics of Rotational Motion
- Dynamics of Rotational Motion

The strict deadlines apply to week exams and measurement assignments. Therefore, a student should study one content package per week. The week exam questions are related to week’s content and they are available for one day and their answer folder is open for two hours after a student has opened the questions. During the two hour period the students have to solve the problems stated and hand out their scanned solutions to Moodle. The time window for questions is the same for all students, but within that window, students can choose individually when to carry out the assignment. In some cases automated, multiple choice questions are used to collect the answers. Measurement assignments are opened at least one week before the deadline.

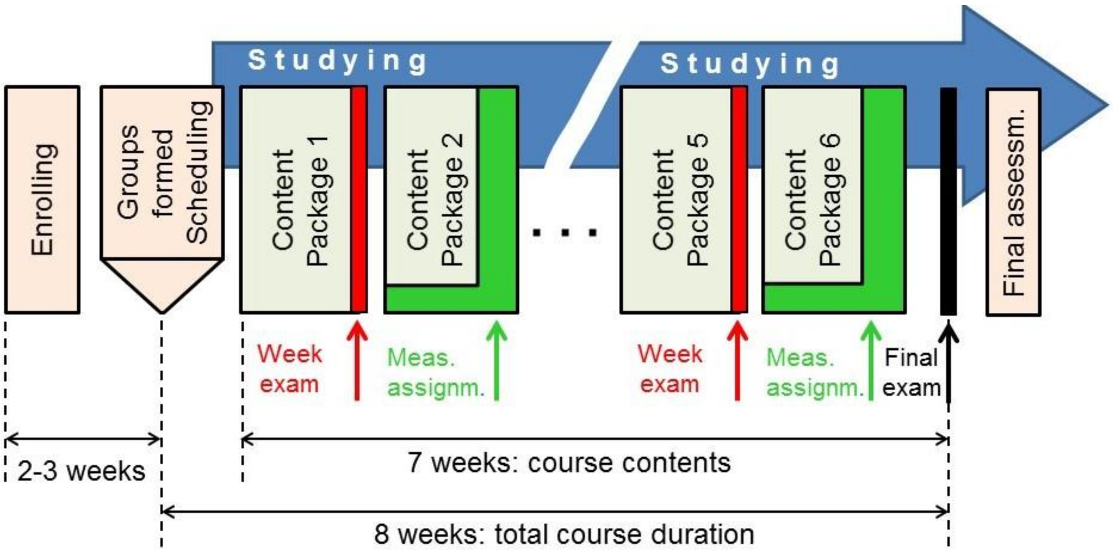

Fig. 1. Schedule for course entities.

The structure of a content package is shown in *Fig. 2*. Any new topic starts with a set of conceptual multiple choice questions aimed for student groups. The key idea is to encourage the students to discuss the topic with peers, rationalize their reasoning and come to a joint conclusion of the questions and problems stated. The students can freely choose which platform ever to use for their mutual communication – Facebook, Moodle, Skype, WhatsApp etc. Only the synthesis of their reasoning is then uploaded to Moodle. The participants of a student group are also asked to evaluate each other's contribution to the discussion and problem-solving. At this time, there is no need carry out any calculations, but rather make the reasoning and possible presumptions and misbeliefs visible to the teacher and the students themselves.

Feedback to the answers of conceptual questions is given neither individually nor group-wise, but rather at general level. The typical misbeliefs are discussed and right answers with argumentation is presented as a video clip. The students then continue individual studies of the package contents with the aid of books and tutorial video clips. To enhance learning, introductory lectures are given at a few topics using Adobe Connect video conferencing software. If a student is not present at the time of the lecture, he or she can watch its recording later. Instructor also has a weekly reception time when he/she is available online to answer questions. For this purpose, Moodle's chat area is used.

Homework exercises are available at the beginning of each the week. Homework doesn't contribute to sum of points a student gathers during the course. Therefore, the solutions to homework problems are available all the time as unlisted YouTube videos. Previous studies [3] have shown that most students find the video format very helpful to the understanding of the solution compared to a mere written solution.

Algebra-based group assignments are traditional exercises, in which students practice their problem solving and mathematical skills. These assignments are given to student groups. Why to separate these from homework assignments, which they already have? The purpose is to encourage – or even force - the students to discuss the problems together and to help each other in problem-solving, which is reported to enhance learning [8].

Every other week there is a week exam or a measurement assignment. Week exams are individual, whereas measurement assignments will have parts containing both an individual and group work. Examples of measurement assignments are given in chapter 3.

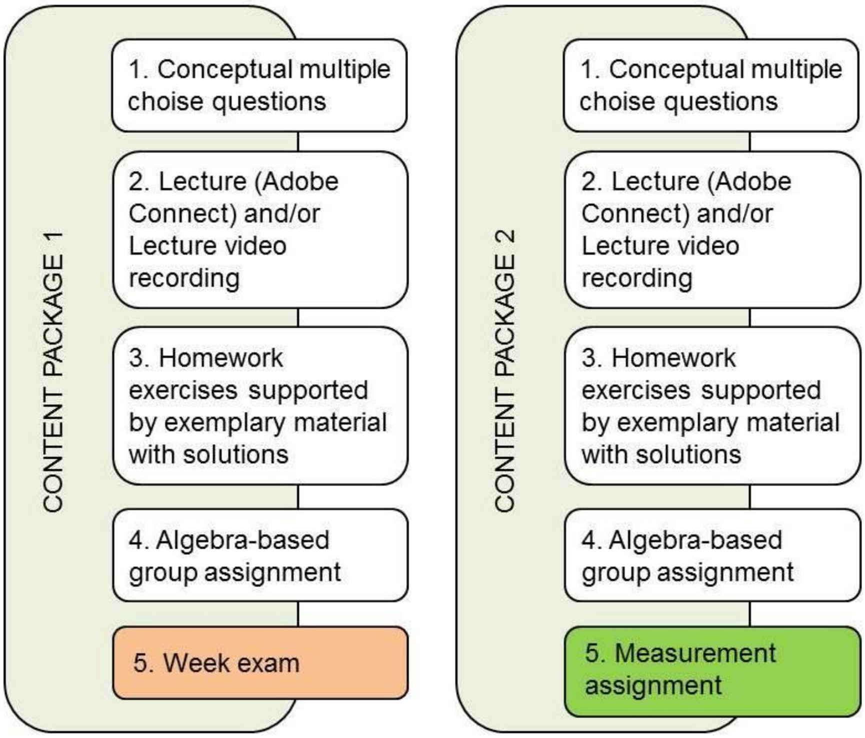

Fig 2. Content package structure.

2.2 Assessment

To encourage continuous studying and to spread the workload evenly throughout the course, continuous assessment will be used instead of a mere summative final examination. The final grade is based on week exams (weight 30 %), measurement assignments (20 %) and final exam (50 %), as shown in *Table 1.*

Table 1. Assessment

Week	Task	Weight	Assessed
1.	Measurement	5 %	Group
2.	Week exam	10 %	Individual
3.	Measurement	5 %	Group
4.	Week exam	10 %	Individual
5.	Measurement	10 %	Group
6.	Week exam	10 %	Individual
7.	Final Examination	50 %	Individual
	Total:	100 %	

The assessment is mostly individual (80 %). Points given in measurement assignments are based on the result itself and in principle all participants in a group will be given the same amount of points. Since the individual parts form majority of the assessment, there is no inherent need to take the possibly uneven distribution of workload in measurement assignments into consideration. However, to encourage peer work and to enhance students' mutual communication, in some measurements assignments the students are asked to evaluate each other's' contribution and the division of workload. Then, there is an option to share the points according to their comments.

3 EXAMPLES OF MEASUREMENT ASSIGNMENTS

3.1 General aspects

Small measurement assignments were an important activating part of the classroom implementation as presented earlier [1-3]. This aspect needed to be taken care of also in online implementation. Since almost every student has a smartphone, they were chosen to be used as tools in most of the measurement tasks. The main features used are acceleration sensors and video camera.

3.2 Motion with constant acceleration

In this assignment students are asked to record a video of a dropped object, for example a ball, with any cell phone. *Fig. 3* shows a combined picture of 12 consecutive video frames as an example. It was recorded using Samsung Galaxy S4 Zoom and had a frame rate of 28 fps. A classroom ruler is shown behind the object. For students, a large scale tape measure is provided as a pdf file, which can be printed and attached to wall, for example. The recorded video is then watched frame by frame for example using Windows Live Movie Maker and the position of the object is determined visually using the tape measure on the background.

Fig. 3. Twelve consecutive video frames of a falling ball.

Exemplary data determined the way described above is presented in Table 2. Figure 4 presents this data as graphs: the position as a function of time t (left graph) and as a function of t^2 (right graph). It can be seen that the position can be determined with sufficient accuracy. The students are asked to calculate the acceleration and velocity of the object. In this example, the obtained acceleration due gravity was 9.6 m/s^2.

Table 2. Exemplary position data of a falling ball determined visually frame by frame from a video clip.

Position on ruler / cm	Position *y* / cm	Time *t* / s	Position on ruler / cm	Position *y* / cm	Time *t* / s
100	0	0	77	23	0,214
99	1	0,036	70	30	0,250
97	3	0,071	62	38	0,286
94	6	0,107	50	50	0,321
90	10	0,143	38	62	0,357
85	15	0,179			

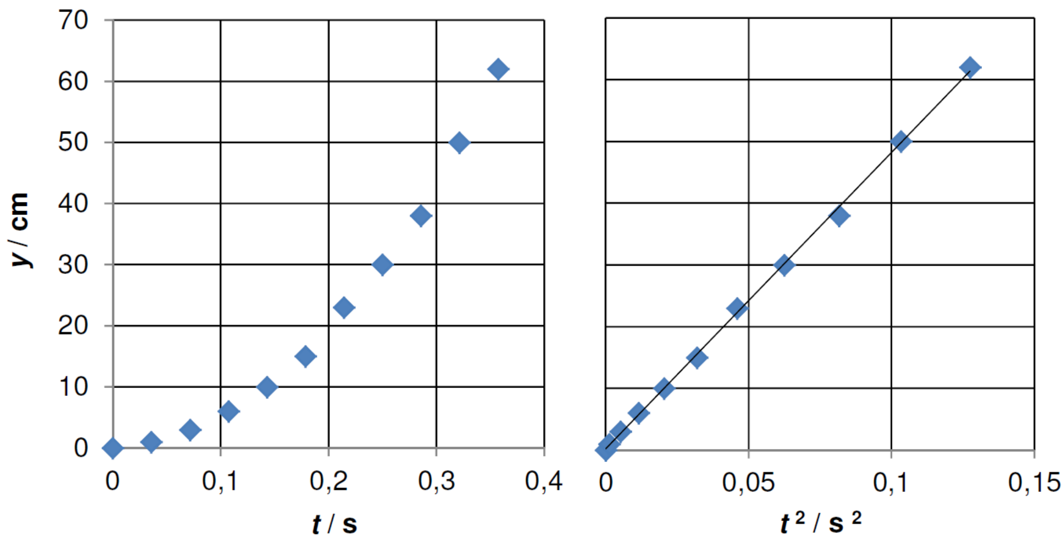

Fig. 4. Position of a falling ball as a function of time (left) and time squared (right) determined from video clip frame by frame.

3.3 Coefficients of static and kinetic friction

The same video clip based method as presented above, can be used to determine coefficient of kinetic friction by sliding an object on the floor. Static friction is asked to be measured by tilting a surface, for example a large hard cover book or a board of a self and by measuring the angle when objects starts to glide. For this assignment, students are advised to download an angle measure applet to their smart phones, for example “Angle Meter” for Android phones. To encourage peer work, all members of a student group are asked to measure coefficients of kinetic and static friction between different surfaces. All the results are then collected together and presented as a table. The points of this assignment will be divided among the members of the student group based on their contribution to the final output.

3.4 Motion with varying acceleration

Students are asked to download “Accelerometer Monitor” applet to their smart phones. With this applet they are then asked to measure the acceleration of a lift, a bus between two stops or any other similar rather linearly moving object. *Fig. 5* shows an exemplary acceleration measurement of a lift and its analysis measured with Samsung Galaxy S4 Zoom. Again, to encourage peer work, one member of the student group carries out the measurement, second member calculates velocity and third the position of the object. If there are more than three people in the group, two students work on the same sub-assignment individually. After finishing the work, the results are collected together and presented as a whole.

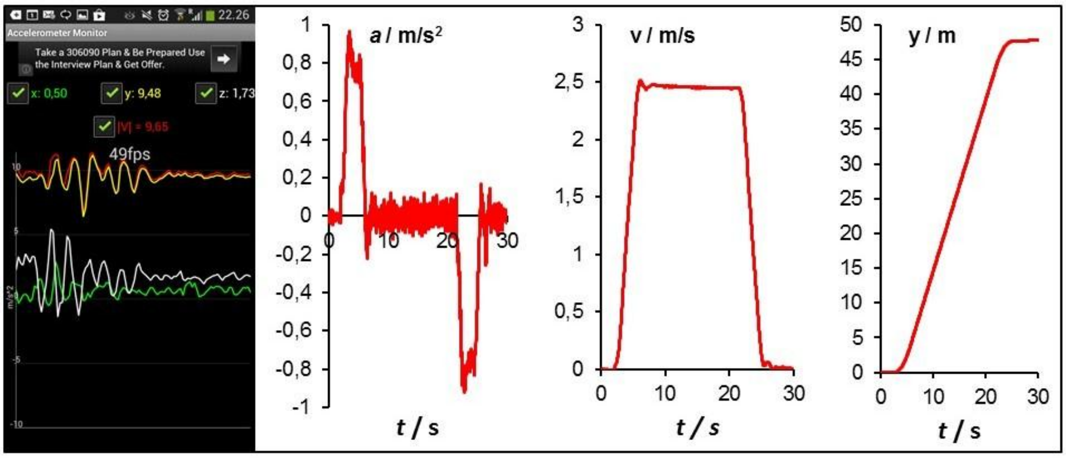

Fig. 5. An exemplary acceleration measurement of a lift and its analysis. Measured with Samsung Galaxy S4 Zoom and “Accelerometer Monitor” applet.

3.5 Torque and equilibrium

In this assignment, the students are presented a video clip of a rod kept in equilibrium with a spring scale as shown in *Fig. 6* (left). In the video, the position and the angle of the force exerted by the spring scale are varied and the students are asked to draw a graph of the forces to a template (fig 7, right) as well as to find the relevant equations and explanations. The students then hand out the filled in template with their texts.

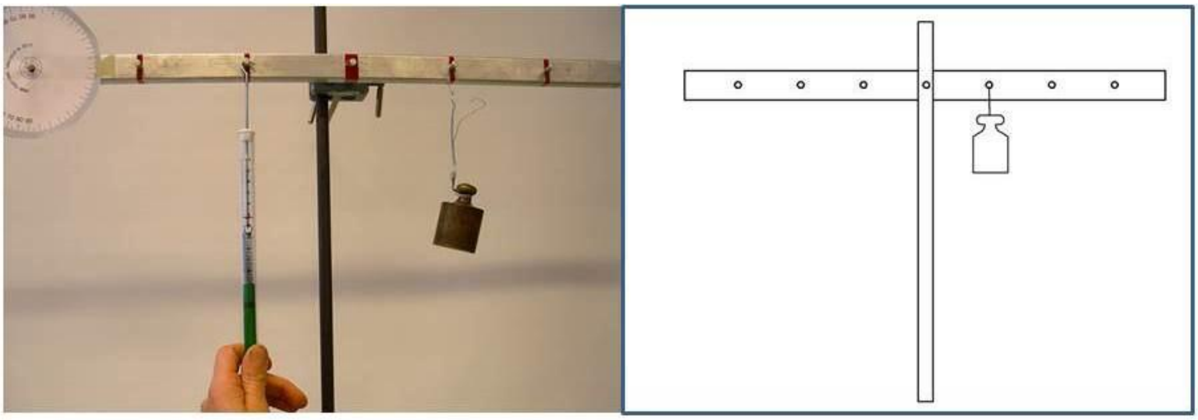

Fig. 6. Measurement of forces presented as a video clip (snapshot on the left) and the template to draw the force vectors (right).

4 SUMMARY

In this paper, a method to implement an elementary engineering mechanics course fully online is presented. In the planned implementation, major entities and activities are strictly scheduled, whereas the time table for minor parts and at detailed-level are left free. Total length of the 3 ects course is eight weeks. Small-scale measurement assignments are included to course contents, in which the students are asked to download software to their smartphones and use that to carry out measurements. In some cases, a video clip is asked to be recorded which is then analysed frame by frame to find out the relevant physical quantities. To enhance peer work, many of the tasks are group assignments, in which the members of a student group need to cooperate to get good results. Assessment is mostly individual, based on online week exams and final exam, but in measurement assignments the students are assessed as groups.

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