USING SMART PHONES TO ENHANCE UNDERGRADUATE LEARNING IN LABORATORY CLASSES

1. ABSTRACT IN ENGLISH

We explore how mobile technology can improve undergraduate students' learning experiences. Introductory Physics courses are often challenging for undergraduate students enrolled in Engineering. We propose a classroom activity that combines active learning of the principles of physics with communication skills, team work capability and enhanced active learning. Students use their cell phones to record and send short digital video clips. The goal was to record a short video (2-3 minutes long) with the aim that anyone will know how to perform the lab experience just by watching it. We discuss its results and potential for other teachers who consider using cell phones as powerful learning tools.

2. **KEYWORDS:** active learning, smart phones, physics lab
3. **FIELD OF KNOWLEDGE:** Engineering and Architecture
4. **SUBJECT AREA:** Autonomous Student Learning
5. **PRESENTATION CATEGORY**: Oral Presentation
6. **DEVELOPMENT:** 25.000 characters (with spaces)

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a) Objectives

Success in learning substantially depends on generic skills and qualities that can be transferred across time and place. Students at the University of Girona at the end of their training must show proficiency on a set of core skills. Students must be able to work effectively in teams, as well as to effectively communicate, both abilities being of particularly relevance for engineers. Specifically, the capacity to work in teams (including multidisciplinary groups) to autonomously evaluate the processes and the roles developed, to exercise them (including leadership), and to incorporate changes as a result of shared discussion from reflexion must be stimulated though proper activities.

Consider the following sequence of actions: to communicate orally in an auditorium or a known target, (by following a script of our own), any information, idea, problem or solution; to evaluate the results; and to come up with proposals for improvement. Oral communication requires flexibility, by adapting to the audience or recipients (experts versus non-expert audiences) and by using the media and resources that are most effective in oral contexts.

Lack of mathematical background, widely spread misconceptions, lack of self-awareness about their own learning skills and capacities all combine to make it hard for undergraduate students enrolled in Engineering to properly learn new concepts in Physics.

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Today's students tend to carry their smart phone with them everywhere. We have many examples of how the smart phone technology can be used in class [1-3]. Availability of embedded cameras and apps allows for a number of interesting applications [4]. In addition to specific applications for Physics [5-6], many smart phone apps are generally useful in the classroom [7]. Additionally, educators are developing activities for learning that may not necessarily use a particular app program [8-9]. Students are autonomously harnessing smartphone technology to support their learning [10].

We explore how mobile technology can improve undergraduate students' learning experiences. The goal of the activity was to work collaboratively on a physics lab experience with emphasis on group work, collaboration, communication, sharing activities, and critical reflection. Students use their cell phones to record and send short digital video clips. The video must explain how the experience was conducted and should give information in enough detail for the viewer to repeat the experience.

This type of learning contexts move from teacher centred activities with the free and formal context to fully learner centred activities in the informal context [11-12].

b) Description of your work

The experience followed a semester of four lab classes (of about 16 students each) of undergrad engineering students taking Physics 101. Students were given a five pages hand-out with all necessary information to accomplish their task. Hand-outs are graphically illustrated with pictures of each experience. The hand-out comprises an introduction, where the physical principia involved on the experience are explained, and required equations are presented, a section devoted to detail the experimental methodology, an a final section of results to be filled by the students. Each experiment has to be accomplished within two hours.

The first experiment demonstrated heat transport mechanisms in a model of a house, modelled as a cube. Each wall of the house was made out of wood, glass or Styrofoam. Thermocouples placed inside and outside each side of the cube recorded temperature. The thermal conductivity k for wood was found and compared to the actual value from one or more references (Fig. 1).

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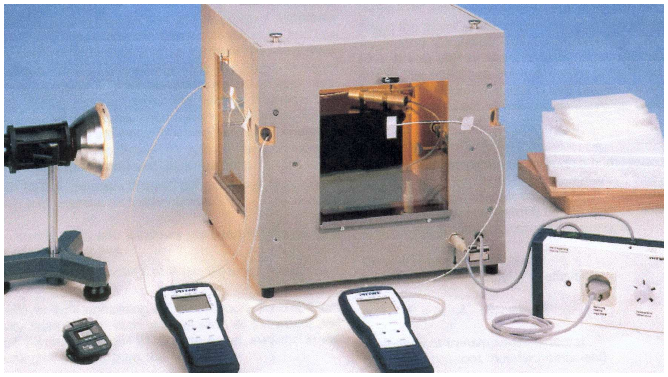
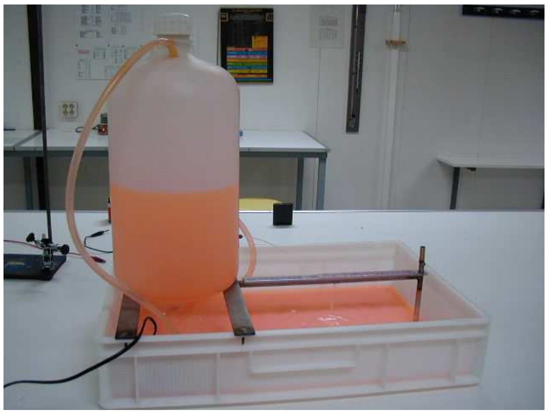


Figure 1: model of the house in the lab experience

The purpose of the second laboratory experience was to study some aspects of ideal fluid flow and to see demonstrations of fluid flow and statics, which can be interpreted by the Bernoulli equation. Measures of volume, time, and pressure were taken and computed to give values of speed at a Venturi apparatus, and flow of a container full of water discharging through a hole (Fig. 2).



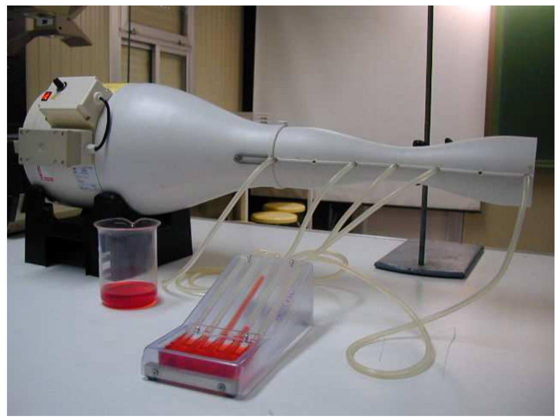


Figure 2: pictures of the container (left) and Venturi apparatus (right)

The experience started with the instructor explaining the goal of the lab experience, the goal of the activity, and the functions of each role. Students were divided into teams, with defined roles: director, introducer, script writer and cameramen. Cameramen had to decide what to shoot, the framing and timing. Some indications of proper use of camera were given, along with basic notions of framing and the kinematic nature of the narrative of images. Clear guidelines were provided to script writers on how to organize information, how to create script books, and being synthetic in their way of thinking. Creativity, freedom and imagination were emphasized. The director should provide guidance and vision to the team. Presenters were given instructions on how to clearly vocalize. Tips against common mistakes before the camera were advised. Use of any mean to convey information (poster, fix images, blackboards) was encouraged. Before the experience, a brief personal interview allowed the instructor to assess the personality of each student. Questions about their skills, and previous experience were asked. Roles were assigned in reverse correspondence with the perceived personalities of the students (i.e. the passive personalities were given the director's role and the timid ones, the presenter role).

Time was limited, which meant that teams need to work fast and cooperatively, developing a set of communication skills and the capacity of synthesis. The teams had about 15 minutes to engage into creative brainstorming, deciding what to say, how to shot the video, and whether any visual method to convey information was needed. After a short time for rehearsal, the video was shot. The overall process must be completed within 30 minutes. Each team worked on a different lab experience, making it possible to work with several teams at the same time.

c) Results and/or conclusions

At the end of the lab session, each video was seen in the lab and critically analyzed in an open discussion between the instructor and the students. The team performance was self-evaluated by each group. The instructor asked some questions about the individual performance of each team member. They were asked and answered on the spot, providing a first evaluation of the performance. After seeing all the videos, a comparison was established, criticising the weakness and highlighting the strong points of each video. Solutions and ideas to address the perceived weaknesses were also exposed and debated. The open discussion lasted twenty minutes approximately. We also evaluated this innovative experience by means of a survey. As the survey was anonymous, answers given reflected a more accurate account of the experience. Questions asked tried to capture a better picture of the processes and perceptions taking place. Some questions were grading others required some writing. Albeit a bit crude, a five points scale permits a quantitative assessment of the dimensions. Quantitative analysis can detect areas for future improvement. Table 1 summarizes the results.

Students have a positive view of the experience. None of the dimensions measured were given a negative grade. The first two questions were aimed to know if the students had understood the goal of the lab experience (Q1), namely thermal house and fluid mechanics lab experiences, and the goal of the activity (Q2). Students understood the goal of each lab experience (100%) and the goal of the activity (80%).

Next, the qualities of the video clip and the performances of each team member were evaluated. Whereas the question if the goal was attained (Q3) was graded positively (3.6), a more accurate analysis of the video reveals some variability. While there is a positive perception of time management (Q4; 3.7), accuracy of the vocabulary (Q5; 3.6) and the perception of the how the lab experience is explained (Q6) is placed above the mean evaluation (3.9) students have found harder to explain the physical concepts Q7 (3.3) and the data processing of the lab experience Q8 (3.3),

An open question of how their work could be improved was asked (Q10). Surprisingly, students were harsh critics of their own work. 80 % of answers agreed upon that physical concepts could have been explained more clearly. A better presentation of how to make the lab experience and an accurate explanation of how data had to be processed were all pointed as areas with great potential of improvement. This result arguably confronts the student with the need for a better understanding of the physical concepts and procedures introduced by the lab experience. Another frequent complaint found was that more time was needed, meaning that students need to learn how to improve their time management and coordination skills. A more detailed briefing was also demanded.

Students valued positively working as a team Q11 (3.8), and as an overall, were quite satisfied with their work (Q12; 3.8). Following questions (Q14-Q17) gauged the perceived performances of each role. Self-evaluation of the director and script performances (4.1 and 3.8) are higher than the group perception (3.6 and 3.5). Camera's own performance perception ranks the lowest (3.5), while the presenter's self perception performance nearly matches the group perception (3.9 and 4.0 respectively), with the highest grade.

Students praised the experience as a tool of self awareness of their own limitations and skills Q18 (3.8), and a leaning tool of physical concepts Q19 (3.6). Not surprisingly, less comfort is shown with the role assigned Q20 (3.4), as their roles were assigned against their perceived personalities (i.e. shy persons were given the role of anchors, passive personalities were assigned to be directors and so on). In that fashion, students were pushed outside their comfort levels, forcing them to explore sides of their core skills being untouched in their daily life experiences. Although it can be argued that assigning roles opposite to their perceived personalities could be stressful for the students, we believe that it gives an extra value to the experience, regardless their condition of freshmen students. Indeed, it is by exploring their boundaries how can assess their own weakness and strengths.

The learning experience was further explored by means of two more open questions, specifically asking what characteristics their role must have (Q21) and what had the student learned out of the experience (Q22). Answers are highly revealing. Team work it is perceived as a key factor to accomplish a complex task. Students found that leading was more difficult than expected. Answers given fall into two broad categories of leadership; the predominant one sees the director as a conflict solver, a facilitator, whereas a minority perceives its role in a more classical way of command and control. Vision, taking the initiative and management skills were frequently named as qualities of a good leader. Leading a team required skills, combined with strength and determination. Listening and conflict dealing were also perceived as desirable characteristics. Some students pleasantly confessed that they had discovered leadership skills on them, prompting to think about a new career path.

Charisma and sympathy were the qualities more named for a good introducer. Students found hard speaking in public, being shy as one of the limiting factors of their performance. They also acknowledge their lack of vocabulary and vocalization as a handicap.

Script writers must be creative and synthetic, according to the most popular quality cited by the students. Delivering a precise description of the activity using appropriate images and metaphors, with proper language was highlighted as a desirable characteristic of a good script writer. Organizing ideas and presenting them in a coherent way was particularly daunting. This role was praised in high regard by all participants.

Properly framing the scene and taking into consideration light conditions were the most valuable qualities of a good camera. Taking into account the lighting conditions, as well as capturing the flow of the scene were among the most cited concepts among cameramen.

Although it is very tempting devote some time before to prepare some details, we believe that there are substantial advantages in the proposed structure, in which fast thinking, creativity and the ability to make decisions on the spot are emphasised. Plus, students are exposed to their limits as in real life situations. As an ending conclusion, the proposed experience is a good tool to identify and correct learning problems. One area in which students need improvement is the proper understanding of the physical concepts; this weakness was detected on the survey ranking below average. Another is time managing, a point students emphasize. Taking advantage of this unprecedented capability of smart phones has very positive learning implications. The possibilities are endless. And this advancement in tools puts no costs on the University.

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	Camera	Director	Script	Presenter	Mean
Q1. What was the purpose of the lab experience?					
Q2. What was the purpose of recording a video?					
VIDEO ANALYSIS					
Q3. If a person sees your video. Could he/she repeat the lab experience?	3.3	3.5	3.8	3.7	3.6
Q4. Does the video summarize all the information in the required time?	3.3	3.7	3.9	3.8	3.7
Q5. Are ideas and concepts explained in an understandable way?	3.5	3.5	3.9	3.4	3.6
Q6. Are the instructions on how to create the lab experience clear?	3.3	3.8	4.3	4.2	3.9
Q7. Are physical concepts clearly stated?	3.2	3.3	3.4	3.2	3.3
Q8. Does the video show how to process the data?	3.1	3.4	3.3	3.6	3.3
Q9. Have you utilized supporting elements (posters, text) to make the explanations clear?	Yes	Yes	Yes	Yes	
Q10. What can be improved in your video?					
TEAM WORK EVALUATION					
Q11. Have you worked as a team?	3.8	3.8	3.5	4.1	3.8

Q12. Critically evaluate your work	3.5	4.1	3.8	3.9	3.8
Q13. What would you improve about your work?					
Q14. Assess the director's performance	3.8	NA	4.0	3.1	3.6
Q15. Assess the presenter's performance	4.1	3.3	4.8	NA	4.0
Q16. Assess the screenwriter's performance	3.8	3.5	NA	3.2	3.5
Q17. Assess the camera's performance	NA	3.4	4.5	4.0	4.0
SKILLS EVALUATION					
Q18. Did making the video help you learn about your skills and abilities?	3.7	3.7	4.1	3.8	3.8
Q19. Has making the video helped you to learn the concepts of physics?	3.7	3.3	3.6	3.9	3.6
Q20. Have you always felt comfortable in the role assigned to you?	3.5	3.3	3.6	3.5	3.4
Q21. Note down two qualities your role should have.					
Q22. What have you learned from the experience of taking on your role?					

Table 1: summary of the survey taken by the students after the experience.

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