Prappctices in Physics For Engineering Students

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Abstract

Digital technologies are changing our communication way and are crucial and essential in our everyday lives, entertainment, study, and work. The educational sector incorporates more and more Information and Communication Technologies (ICTs) to create a more creative, participatory and socialising learning environment. In this challenging context, some pr*APP*actices with embedded use of apps have been introduced in our Physics laboratory as part of the new active teaching strategies to increase student satisfaction and motivation. We present three examples of the most representative newly introduced pr*APP*ctices regarding acoustics, lighting and elasticity in our subjects in two different degrees (building engineering and mechanical engineering). Students become main actors in a smarter, portable, reproducible, and more exciting learning environment and the teacher role is set on a second layer. Creating a new, more exciting, personal and customised working and learning environment has improved student's engagement and satisfaction and the quality of the laboratory reports with direct and positive consequences on the grades.

Keywords: *APP, Practice of Physics, Learning Environment*

Introduction

Digital technologies are changing our communication way (Huang, 2018) and are crucial and essential in our everyday lives, entertainment, study, and work. In the last years, this new interacting element has appeared in the classroom to meet all kinds of students' different needs and the objective of training digital competences in the new learning environment (Kaminski, 2005).

The educational sector incorporates more and more Information and Communication Technologies (ICTs) to create a more creative, participatory and socialising learning environment (Sife, Lwoga & Sanga, 2007). There is an increasing interest in collaborative working, and universities must meet students' and society's new educational needs (Khvilon & Patru, 2002). Furthermore, there is an increasing need in science education to fit the technological society's new challenges (Wieman, 2005).

E-books, online platforms, e-learning, electronic blackboards, online tools, apps, online just in time research of information, the possibility of assigning tasks and checking it online, have

been introduced in many subjects. A revised "student centred" perspective (Salandin, 2014) has reached the classroom and at the same time a kind of classroom community, that can better encourage, support and develop the learning process (Cognition and Technology Group at Vanderbilt, 1992), is becoming more and more common.

Nowadays, more participative learning activities and strategies are used. Classic and low interactive lectures where the instructor used slide presentations for explaining theoretical and practical contents are somehow over. Ancient students took notes almost without options to ask for further information or solve doubts in the classroom. Lecturers have many new and useful interesting tools for improving the learning process (Martín-Blas & Serrano-Fernández, 2009; Jeng et al., 2010)). Furthermore, in order to develop new meta-competencies (problem-solving, teamwork, metacognitive aspects and use of new information technologies), as indicated by Garcia et al. (2002) and Lopez Aguado (2010), new tasks and assignments should be included in the teaching methodologies.

In this more connected world, smartphones are a primary tool for communication, socialising, information exchange, new experiences, networking, studying and distance learning if correctly integrated into the classroom environment (Motiwalla, 2007). As Socrative and Kahoot, some existing online software can help assess knowledge through smartphones and have great acceptance (Coca, 2017). Student's engagement with deeper customisation of the learning process can be increased by using integrated digital tools (Imbriale, 2013) and enhancing student's self-concept and motivation (Neuman, Bialo & Sivin-Kachala, 2001; Cabrero, 2014).

The theoretical and field studies of Bråten & Olaussen (1998) and Pintrich (2000) explain the influence in the learning process of emotional and motivational competencies beyond the teaching aspects. Alonso Tapia (1997) and Keller (1983) explained the importance of transforming students into active actors in their learning process by promoting a more strategic approach to internalising the final objectives. In this context, Kolb's theory is an important theoretical reference point (McLeod, 2013). We recognise in the learning process four main elements: concrete experience, CE (doing or having an experience), reflective observation, RO (reviewing or reflecting on the experience), abstract conceptualisation, AC (concluding or learning from the experience) and active experimentation, AE (planning or trying out what has been learned), as indicated by Lozano (2000) and Sauaia (2010).
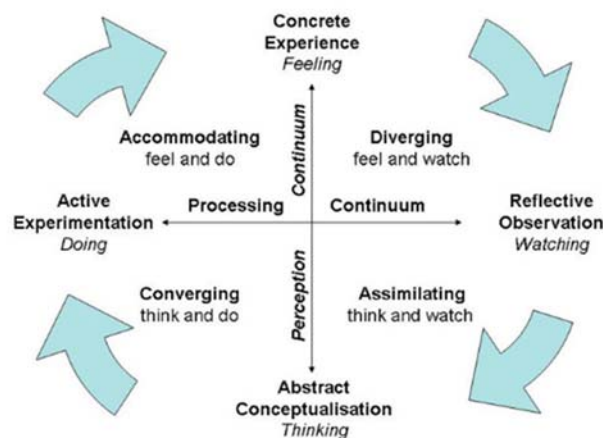

Figure 1. *Resulting learning styles from the Kolb theory (McLoad).*

In other words, we can have a functional sequence of experience, reflection, conceptualisation and test. The combination of those elements brings to four learning styles: diverging CE+CO, assimilating AC+CO, converging AC+AE and accommodating CE+AE, as shown in Figure 1. We can also recognise the two fundamental variables (axes) of the process related to Processing and Reflection.

There is undoubtedly a direct and close connection between this model and the active methodologies. After experiencing, observing, and reflecting, students will be able to assimilate abstract concepts better and give feedback through new associated experiences. The Experiential Learning Theory (ELT) as described by Baena & Mattera (2015), is another relevant element. Students usually process the experimental information and either act consequently or wait and observe others' actions for later action or consideration.

In this challenging context, some pr*APP*actices with embedded use of apps has been introduced in our Physics laboratory as part of the new active teaching strategies. The main aim is to increase the student's satisfaction and motivation. In accordance with the new given background situation, we intend to bring the learning process into a personal, more attractive, stimulating, motivating and portable environment.

This paper first briefly discusses the new learning process's pedagogical background by applying new technologies in the classroom. Second, some available apps for physics practices in engineering degrees are described, and the third three examples of prAPPctices (acoustics, elasticity and lighting) are presented. Finally, some conclusions and final comments are included in the last section.

Description of the APPs

A description of the most important characteristics and features of the used apps is included in this section and displayed in Table 1 (Android), Table 2 (iOs) and Table 3 (Android and iOS). The involved physical magnitudes and data about developer and size are also listed for more exhaustive information and choice options. Some other apps have been included in our list to offer a wider range of options for new practices in other topics.

Table 1. Android APPs

logo	APP	Physical magnitude	Developer	Size
	Lux Light Meter Free	Illuminance (lux)	DOGGO apps	2.3 MB
	Physics Studio	virtual physics laboratory	Maza Learn	23.5 MB
	Learn Physics via video	many physics topics	SuperSimpleVideo	20.0 MB

The app Lux Light Meter Free for Android provides an accurate light measurement in Lux and Foot-candle units. It measures minimum, average and maximum brightness. Calibration of the measurement is possible with easy controls and the storage of measurements with title, date and time. Data can also be shared or exported. This app is suitable for professional and students.

Physics Studio Lab for Android is a virtual lab for a better understanding of physics fundamentals in a richer learning environment. Thousands of physics concepts from

magnetism to wave and states of matter are presented, and students can get a clear picture of these concepts by playing and virtually experimenting.

The app Learn Physics via video for Android provides a quick summary of essential concepts in Physics for electricity and magnetism, heat and temperature, relativity, dynamics and motion, waves, force and torque, sound and thermodynamics.

Table 2. iOs APPs

Logo	APP	Physical magnitude	Developer	Size
	Lux Light meter free	Illuminance (lux)	Nipakul Buttua	8.1 MB
	Physics Toolbox Spectrum Analyzer	Frequency check	Chrystian Vieyra	13.0 MB

The app **Lux Light Meter Free** for iOs is an easy-to-use, functional light intensity meter (lux or candle) perfect for measuring, comparing, and adjusting lighting levels in an enclosure. This app collects light intensity data, real-time measurements, as well as average and maximum values.

Using a Fast Fourier Transform (FFT), the app Physics Toolbox Spectrum Analyzer for iOs displays a real-time spectrum of the captured noise. Frequency check is always interesting due to humans' differential sensitiveness to frequencies, especially to low frequencies (16-256 Hz).

The Physics Toolbox Sensor Suite app for Android and iOs uses device sensor inputs to collect, record, and export data as .csv for G-force, pressure, temperature, and illuminance. Data can be plotted against elapsed time on a graph or displayed digitally. Users can export the data for further analysis, and this app also generates tones, colours and a stroboscope light.

Decibel X for Android and iOs is a noise meter app that gives highly reliable, pre-calibrated sound level measurements and supports dBA, dBC. Measurement and graphs are displayed in real-time as well as the predominant frequency. The standard measurement ranges from 30 dBA up to 130 dBA, making it usable in almost all conditions.

Floor plans can be created on a very simple way with your smartphone's camera and using the app Magicplan for Android and iOs and materials list, cost estimations and 3D models or virtual tours. Photos and notes can be added, and statistics data can get automatically for distances, surroundings or surfaces. This APP also supports some laser distance meters.

The Sun Surveyor Lite app allows architects, solar industry professionals, and real estate agents to check the natural lighting conditions and sun elevation and azimuth to study further sun captation or shading devices in an architecture project.

The Physics Formulas app help users quickly refer to any physics formulas related to seven categories: mechanics, electricity, thermal physics, periodic motion, optics, atomic physics and constants. Extra options include tools for calculating magnitudes from users data as well as a favourite folder.

The Khan Academy app offers over 10000 videos and explanations at your fingertips in math, physics, science, economics, history and other knowledge areas for free. A wide range of interesting and captivating video is available for flipped teaching or autonomous learning.

Table 3. Android and iOs APPs

logo	APP	Physics magnitudes	Developer	Size
	Decibel X	noise/sound level	SkyPaw Co. Ltd	25.6 MB
	Magicplan	metric survey (dimensions for a plan)	SensopiaInc	166.6 MB
	Physics Toolbox Accelerometer	acceleration vs time G-force	Vieyra Software	2.1 MB
	Sun Surveyor Lite	latitude, azimuth, solar elevation	Adam Ratana	145.1 MB
	Physics Toolbox Sensor Suite	G_force, lux, pressure, humidity	Vieyra Software	5.0 MB
	Physics Formulas Free	many physics topics	NSC Co	10.0 MB
	Khan Academy	many physics topics	Khan Academy	162.7 MB

Examples of pr*APP*ctices for engineering students
This section presents three examples of the newly introduced pr*APP*ctices in our subjects of two different degrees (Building Engineering and Mechanical Engineering) for the topics: acoustics, lighting and elasticity. Students become main actors in a smarter, portable, reproducible, and more exciting learning environment and the teacher role is set on a second layer. We also used the flipped teaching approach to make the experience even more personal with specific instructions about the pr*APP*ctices and the associated app through the online platform. The app's use is shown and explained with a video or at the beginning of each laboratory session. In some cases, apps in English are used as part of the foreign language training.

PrAPPctice of Room Acoustics for Building Engineering degree
The main objective of this pr*APP*ctice is to check the inverse-square law for sound intensity ($I = \frac{W}{4\pi r^2}$) where W is the power in Watts of the source and r the distance between source and receptor and better understand the characteristics and the behaviour of a sound wave in an enclosure. This pr*APP*cticeis included in the subject Physics in the degree of Building Engineering.

Students start with a dimension survey of the enclosure using the app *MagicPlan* in to describe the enclosure in terms of dimension and materials better. To measure ground noise and the acoustic level LI in dB at representative positions (1, 2, 4 and 8 m from the source), we use the app, *Decibel X*. At least ten measures are taken at each point, and average values and the standard deviation will be calculated. The sound source is an online available pink noise. We also simulate the acoustical behaviour of the enclosure in order to calculate the power level ($LW = LI + 11 + 20\log r$) as crucial data for further analysis. Furthermore, students are asked to apply the room acoustics theory (acoustics rays) to calculate direct and reflected level at the same positions to compare measured and calculated values and better

understand all acoustics magnitudes and related interactions. Students can also finally perform a frequency check of the ground noise by using the app

Physics Toolbox Spectrum Analyser.
Pr*APP*ctice of Elasticity for Building and Mechanical Engineering degree
The objective of this Pr*APP*ctice is to check the Hook law on a spring. Springs are widely used for ground behaviour simulation and are a simple elastic element with a simple harmonic movement. Springs are studied both dynamically and statically. Students prepare a "spring+mass+smartphone" system and start recording the oscillations of the resulting system with the app *Physics Toolbox Accelerometer* after pulling the mass on the spring and releasing it for the system to oscillate as shown on Figure 2.

Figure 2. *"Spring+mass+smartphone" oscillating system.*

At least 10-15 oscillations should take place in order to get correct results. Different masses from 50 g to 500 g, depending on the spring characteristics, may be used. Using this simple correlation formula between the involved magnitudes - $T^2 = \frac{4\pi}{K_{dyn}} \cdot m$ - where T is the period in second and m the mass in kg. After a least-square fitting, students can get the value of the dynamic elasticity constant of the spring K_{dyn}. Static conditions are also considered by using some mass and by simply measuring the new length L that can be compared with the initial one L_0. The calculation of the static elasticity constant K_{sta} is also a simple issue because $L = \frac{g}{Ksta} m + Lo$, where G is the gravity acceleration and m again the mass in Kg. Uncertainties are also calculated in order to have a more exhaustive overview of the laboratory data collection experience.

PrAPPctice of Lighting for Building Engineering degree
The main objective of this pr*APP*ctice is to check the illuminance in the enclosure. Light is an important topic of the subject Light, Sound and Heat in the degree of Building Engineering and a key magnitude for an enclosure's lighting quality with the direct implication in the building energy efficiency. Its main magnitude is the Illuminance $E = \rho \frac{flux}{area}$, defined as the amount of light (luminous flow) illuminating a given surface area. The correlation factor ρ depends on the frame conditions of the enclosure.
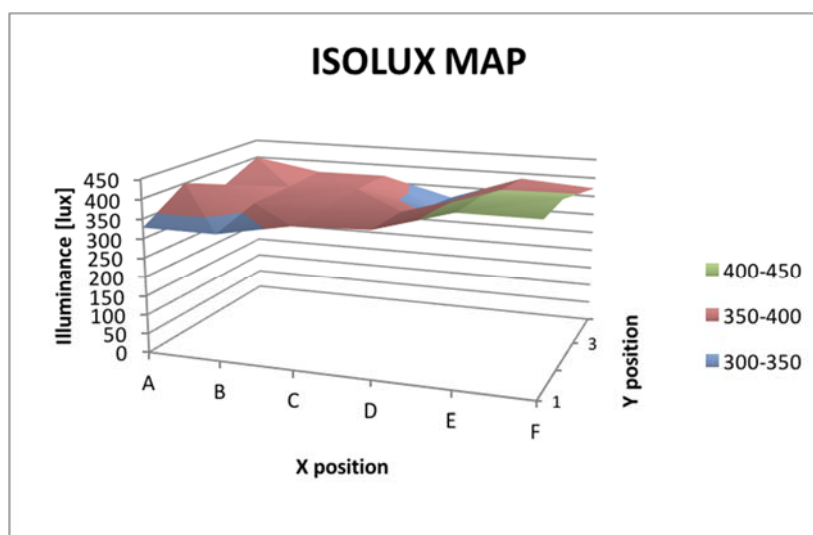
Figure 3. *Resulting isolux map for the artificial lighting scenario*

After a preliminary description of the enclosure by *MagicPlan,* students can check and study the lighting conditions by measuring the illuminance in lux under two different scenarios (natural lighting, artificial + natural lighting) according to a grid of representative measuring points (A to F and 1 to 4) with the app *Light/Lux Meter FREE*. At least ten measures are taken at each point, and all data will be statistically checked. As part of the collaborative learning, training students finally share the online platform, all measured data to create anisolux map, as shown in Figure 3. The use of Sun Surveyor Lite's app gives extra information about the solar, external, natural lighting conditions at the location of the enclosure, which could be useful for the study of existing capitation or shading devices.

Conclusions

A simply survey confirmed the great acceptance of this new way of approaching laboratory practices by students. Creating a new, more exciting, personal and customised working and learning environment has improved student's engagement and satisfaction. A significant improvement of the quality of the laboratory reports with direct and positive consequences on the grades has also been confirmed. The implementation of pr*APP*ticaces throughout more topics of other subjects will be developed in the next semester in parallel with Flipped Teaching's introduction. Transversal competencies and skills (cooperative learning, language training, improving digital skills) have been trained, and students took on a greater role as usual. Lecturers become effective facilitators, though maintaining an adapted teaching profile. Finally, the "portability" of many measuring devices in the smartphone and the laboratory experience's reproducibility in other environments (outside the laboratory) are an added value. They could be used, for example, in the final project.

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