Doing Physics Experiments and Learning with Smartphones

Manuel Á. González, Juarez B. da Silva, Miguel Á. González, Willian Rochadel, Óscar Martínez, Juan C. Cañedo, Diego Esteban, Félix Huete & Javier Manso

@GID_TIA
http://apprendiendofisica.blogspot.com.es

University of Valladolid (Spain), Universidade Federal de Santa Catarina (Brazil)

Technological Ecosystems for Enhancing Multiculturality (TEEM’15)
Porto (Portugal), October 7 – 9 2015
Introduction

The use of mobile devices in teaching and learning follows and increasing trend.

In physics teaching, smartphones and tablets can be used not only as knowledge facilitators, but also as powerful experimental tools thanks to their sensors: accelerometer, gyroscope, magnetometer, sound, light, ...

Students can use their own smartphones either in teaching laboratories or in daily activities.
Using the smartphone can foster conceptual learning

González et al. (UVa, UFSC) Learning Physics with Smartphones TEEM’15
Using the smartphone can foster conceptual learning

Physics teachers and education researchers commonly believe that students learn a physics concept more deeply if it is explored experimentally with familiar everyday tools. "Results of pilot studies in physics (both high school and university level) show that using such devices as experimental tools could foster conceptual learning," said physics education researchers Jochen Kuhn and Patrik Vogt in an email. Kuhn and Vogt are also the editors of iPhysicsLabs, a column dedicated to smartphone physics in The Physics Teacher journal.

But the smartphone can become another black box in the lab. Recently Lanz Countyman wrote an article [1] for The Physics Teacher in which he highlighted the need for students to understand how their physics actually measure physical quantities. He noted that "a common tripping point for students is that a modern smartphone displays an acceleration of 9.8 m/s^2". By describing the internal acceleration sensor as a suspended test mass, a teacher can help students understand this measurement.

The adoption of smartphones in the classroom has been growing over the past few years, and in 2012 The Physics Teacher started the "iPhysicsLabs" column to highlight the use in introductory physics labs. The first article, by Kuhn and Vogt, described a simple way to study free fall (and gravity) by dropping a smartphone onto a cushion and recording data during the fall. Since then iPhysicsLab has featured a number of smartphone experiments. A recent project investigated the effect of sound on a cup, where water is added, motion and data were taken before the smartphone was dropped into the cup, and the experiment was repeated with the smartphone at a different distance from the cup.
and has a positive influence on students’ motivation

We expect the motivation as well as the learning outcome to be increased by using smartphones as experimental tools, compared to traditional physics class with experiments of the same content. This is based first on the theoretical framework of context based learning, after which the connection of an experimental tool to everyday life has a positive influence on motivation. In this aspect, self-efficacy as one important component of motivation is of special
Our work

- Developing apps:
  - Learning apps with theory, examples, tests, simulations, ...
  - (learning) Apps to use the smartphone as an experimental tool.

- Thinking on how to use the smartphone in laboratory or everyday activities experiments.
Some of our works: SensorMobile
Some of our works: SensorMobile

González et al. (UVa, UFSC) Learning Physics with Smartphones TEEM’15
Some of our works: Audia
Some of our works: Audia
Examples of experiments: overtones of vibrating rods of different shapes and composition

\[ \nu_n = \frac{ck}{L^2 C_n} \]
\[ c = \sqrt{\frac{Y}{\rho}} \]
\[ C_n = \frac{r_n^2}{2\pi} \]
\[ r_n = (2n - 1)\frac{\pi}{2} \]

Rectangular rod: \( k = \frac{\text{thickness}}{\sqrt{12}} \)

Cylindrical rod: \( k = \frac{\text{radius}}{2} \)

González et al. (UVa, UFSC)  Learning Physics with Smartphones  TEEM’15  10 / 14
Examples of experiments: overtones of vibrating rods of different shapes and composition

Results: Sound recording and FFT for frequencies determination

<table>
<thead>
<tr>
<th>Theoretical frequency</th>
<th>Experimental frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>140</td>
<td>140</td>
</tr>
<tr>
<td>393</td>
<td>398</td>
</tr>
<tr>
<td>770</td>
<td>775</td>
</tr>
<tr>
<td>1273</td>
<td>1292</td>
</tr>
<tr>
<td>1902</td>
<td>1884</td>
</tr>
<tr>
<td>2656</td>
<td>2616</td>
</tr>
</tbody>
</table>
Other experiments in everyday activities:

Traveling from home to the university

Different sensors: The students can measure simultaneously accelerations, light and sound intensities, magnetic fields, position, etc.

Analysis: Dependences, repeatability, experimental noise, ... all of them characteristics of the scientific experimental work.
Other experiments in everyday activities:

Traveling from home to the university

Some examples: A rough figure with many data (accelerometer, gyroscope, GPS, time)

acceleration - gyroscope - magnetic field
speed - acceleration
Other experiments in everyday activities:

Traveling from home to the university

Some examples: Numerical relationships (accelerometer, GPS, time)
Other experiments in everyday activities:

Traveling from home to the university

Some examples: Dependences on the position (GPS, time)
Examples of experiments imagined and developed by high school students

Work with high school students:

- Analysis of available apps
- Simple guided laboratory experiments
- Free autonomous experimentation
Examples of experiments imagined and developed by high school students

Work with high school students:

- Analysis of available apps
- Simple guided laboratory experiments
- Free autonomous experimentation
- Measurement of acceleration and calculation of speed

González et al. (UVa, UFSC)
Examples of experiments imagined and developed by high school students

Work with high school students:

- Analysis of available apps
- Simple guided laboratory experiments
- Free autonomous experimentation

Measurement of acceleration and calculation of friction coefficient
Examples of experiments imagined and developed by high school students

Work with high school students:

- Analysis of available apps
- Simple guided laboratory experiments
- Free autonomous experimentation

Measurement of acceleration and calculation of displacement and friction coefficient
Examples of experiments imagined and developed by high school students

Work with high school students:

- Analysis of available apps
- Simple guided laboratory experiments
- Free autonomous experimentation

Measurement of resonant frequency for pipes of different lengths and calculation of the speed of sound

<table>
<thead>
<tr>
<th>Longitud (m)</th>
<th>Frecuencia Hz</th>
<th>Velocidad del sonido (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.12</td>
<td>73.7</td>
<td>330.17</td>
</tr>
<tr>
<td>0.78</td>
<td>104.5</td>
<td>328.13</td>
</tr>
<tr>
<td>0.42</td>
<td>196.5</td>
<td>330.12</td>
</tr>
</tbody>
</table>
Conclusions

Using mobile devices can rise interest on physics, ease its understanding and increase engagement in physics subjects, opening also the possibility of more active learning techniques.

By analyzing everyday activities, the students can observe nature, test their knowledge and acquire abilities necessary in the experimental work in the laboratory.

The use of smartphones as experimental tools can help building low cost laboratories and enhance learning in less favored environments.

To have reliable results on the influence on students’ academic results and engagement more data are required: different students and conditions, more learning experiments ...
Doing Physics Experiments and Learning with Smartphones

Manuel Á. González, Juarez B. da Silva, Miguel Á. González, Willian Rochadel, Óscar Martínez, Juan C. Cañedo, Diego Esteban, Félix Huete & Javier Manso

@GID_TIA
http://apprendiendofisica.blogspot.com.es

University of Valladolid (Spain), Universidade Federal de Santa Catarina (Brazil)

Technological Ecosystems for Enhancing Multiculturality (TEEM’15)
Porto (Portugal), October 7 – 9 2015