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MOBILE LEARNING: A CASE STUDY IN PHYSICAL CHEMISTRY LABORATORY

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Abstract:
The use of mobile devices is increasing every day and they are quickly becoming an indispensable tool for everyone. In today's environment, mobile devices have the potential to give valuable contribution in different areas, and one of them is learning and teaching. The purpose of this article is to study the support that mobile devices can give especially during laboratory works. In order to study and prove the usefulness of these devices in such environment, we have implemented an application that integrates a mobile android app and a web application, to support students and also teachers during and after the experiments. We tested the application during a Physical Chemistry laboratory work and asked students and teachers through a questionnaire about their opinion in regard of the usefulness of the tested application and the potential to use it with all laboratory works and even in other learning and teaching fields. At the end, we present and study the results of this questionnaire.

Keywords: mobile learning, laboratory, chemistry

Introduction

Mobile devices are becoming an integral part of our everyday life. With the high usage, the fast improvements in storage and computational power, mobility and possibility to connect at any time and any place, these devices have all the potential to become a support in many activities, and one of them is the teaching and learning process. In this paper, we have focused on the support that mobile devices and mobile applications can offer during laboratory works on the Faculty of Natural Sciences, at the University of Tirana. The paper is organized as following; first, we focus on the current situation of laboratory classes at the Faculty of Natural Sciences and especially on the Physical

Chemistry laboratory, taking in consideration the actual needs of students and teachers in regard to these laboratories. After that, we study and illustrate the advantages of mobile devices and more specifically on the possible support that these devices can give during laboratory works. Then we have focused on the presentation of the application we have implemented to practically prove the support that mobile devices would give. We have focused on the implementation architecture and more specifically on the server side and client side components. We have tested the application with students and teachers and at the end have illustrated their experience and opinions about the application. Their opinion was taken with the help of a questionnaire and the results are illustrated in a graphical form.

2. Current situation of laboratories at the Faculty of Natural Sciences

The Faculty of Natural Sciences at the University of Tirana is composed of eight departments and almost all of them have laboratory classes, in which take place very frequently various experiments for different courses, like Chemistry, Physics, Biology, Physical Chemistry, Industrial Chemistry, Bio-Technology, etc. In general, during these laboratory experiments, students have to work in groups and perform calculations in various measurements. These measurements then are used and analyzed to find results and conclusions that have to be presented in front of the teachers in different ways depending on the course.

We have considered and focused especially in Physical Chemistry laboratory classes to study and develop a way that mobile devices can facilitate and improve the whole process from performing the experiments, to students collaboration, teacher communication and presenting results.

Chemistry students have to perform eight different laboratory works during their Physical Chemistry course [1]. During each of these works they have to cooperate in small groups to perform and observe different experiments and then take note of different measurement values. Sometimes these measurements are related to other measurements taken from prior experiments. After performing the experiment, students have to make calculations of different levels to find the final results that have to be presented in a detailed graphical form. In these regard, teachers say that very often, students have difficulties in building these graphs. It is also very difficult for them to understand if they have done the right observations and measurements and identify where they have done wrong, in order to change experiment's parameters. On the other hand, teachers express the difficulty to monitor all the students at the same time and help all of them step by step to perform the right experiment and have the right results.

3. Mobile devices in laboratories

Using technology during teaching and learning process has given very positive results in the last few years [2, 3]. Using it during laboratory classes would give a big contribution in supporting experiment conduction, offering extra storage, computational power, high connectivity, etc. Desktop computers could help for this purpose, but they are not very suitable, especially when compared to mobile devices because of their lack of mobility and flexibility and also high cost. On the other hand, mobile devices have many characteristics that make them more advantaged in these situations. Among them, we can mention:

- Mobile devices are portable and more flexible.

The main characteristic of mobile devices is their portability and possibility to access at any time and any place. This characteristic makes them a more flexible tool to use during laboratory works. According to a survey we did with the students of the Faculty of Natural Sciences [4], 95% of them have a smartphone and 99% of them said they always take their phone with them wherever they are.

- Direct access to internet connection

Mobile devices give the opportunity to access internet at any time, using mobile data or a wireless connection. In this way, they offer a direct link for real time communication. According to the same survey [4], students have almost every time internet connection in their mobile devices.

- Lower cost

Mobile devices have lower costs compared to desktop computers and this cost is also decreasing every day, making them a more affordable device for most of the people. This is the reason why almost every student is in possession of minimally one mobile device [4].

- High computational power and storage capacity

Mobile devices have experienced a huge development in the recent years [5, 6, 7]. Now their computational power is comparable with desktop devices of only few years ago and also have the possibility to store more information locally.

Considering the above characteristics, mobile devices have the potential to facilitate and improve laboratory works in different ways:

- Sometimes during laboratory classes, students need to consult the book for necessary information and instructions, to complete the experiment successfully. This laboratory material can be better accessed from mobile devices that can give students more flexibility.

- Mobile devices can facilitate the process of entering and saving measurement values. These data can be accessed again at anytime and anywhere students want. This can be very useful when is needed to access data from different experiments that have been done in different days.

- They facilitate communication and sharing information between teachers and students in real time. Student's supervision is very important [8], and mobile devices gives teachers the opportunity to better supervise groups during the experiments and help them in real time to understand and correct their mistakes.

- Working in groups have always many advantages [9]. Mobile devices can facilitate the group work offering an additional tool that supports communication, share information or divide groupwork between group members.

- The usage of mobile devices can increase students' engagement during the learning process [10].

4. The architecture of our implementation

To test the contribution that mobile devices can give to laboratory classes, we have implemented an application that supports students and teachers during one of the laboratory classes of the Physical Chemistry course. The purpose of this laboratory work is to experimentally study the dependence of saturated vapor pressure from temperature and to calculate the heat of evaporation [1]. At the end, students have to make the appropriate calculations and build the graphic presentation of collected data with the formula $\ln(P/Po) = f(1/T)$. The application was tested with students of the second year of bachelor program at the Faculty of Natural Sciences. The architecture of the application as shown in the figure combines the client side components to offer the opportunity to students to use their mobile devices through a mobile app, and the server side components to offer the opportunity to communicate with the teachers.

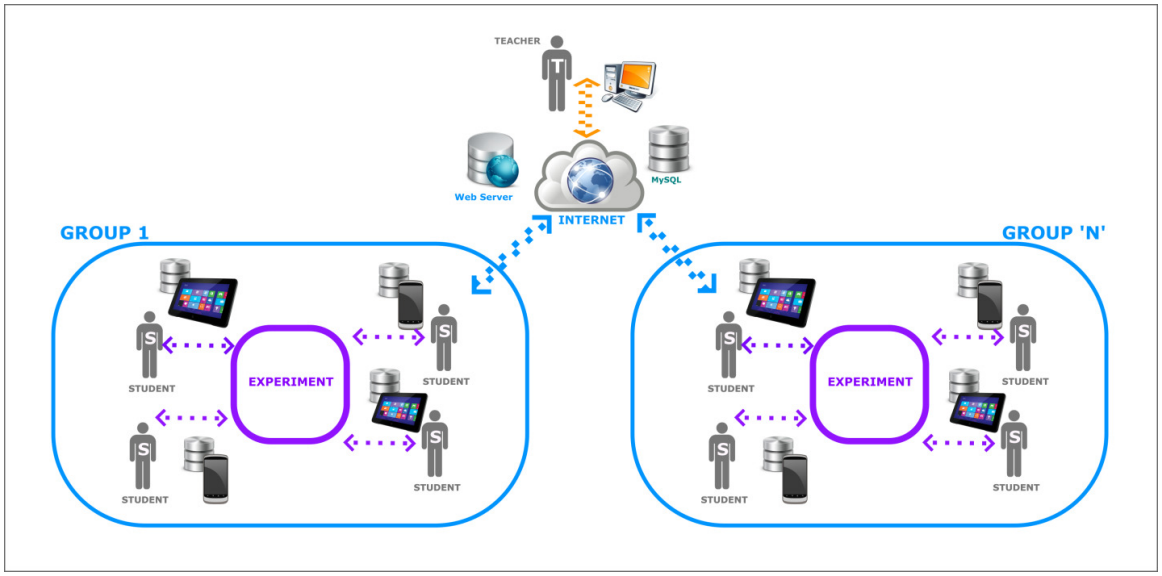

Figure 1: The architecture of the implementation. Server side and Client side components

4.1. Client side components

On the client side of the architecture, we have implemented an android app that can be directly installed on students' smartphone from Play Store. This app is used to collect different data from the experiments. This data is stored locally on the device, inside a SQLite database. At the same time, with the use of an internet connection, the data measured are sent to the web server in order for the teacher to see the progress of experiments step by step and in real time, for each group in the class. The communication of the android app with the web server is implemented using Volley library, which offers a very efficient way to exchange data in these scenarios [11, 12]. The data entered can be updated as many times as needed and the students can access them even outside the laboratories whenever they want. Different students of the same group can use the app to enter different data of the same experiment for the purpose of dividing workload between different group members.

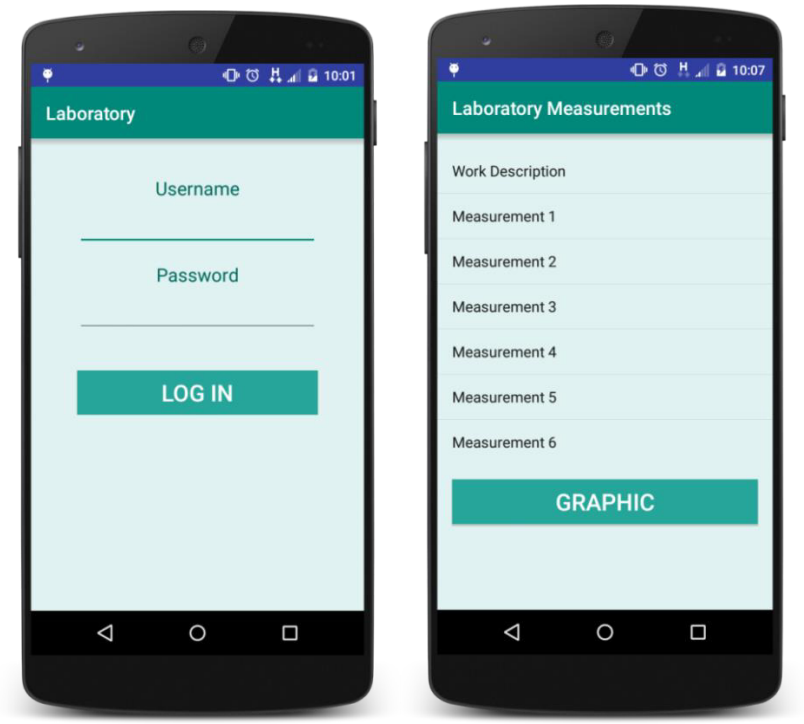

Figure 2: The interface of login on the mobile app and the interface of entering measurements' values

Data collected from the experiments and stored using the app, are used to make calculations and help students to build the graphical presentation of the results using Google Charts.

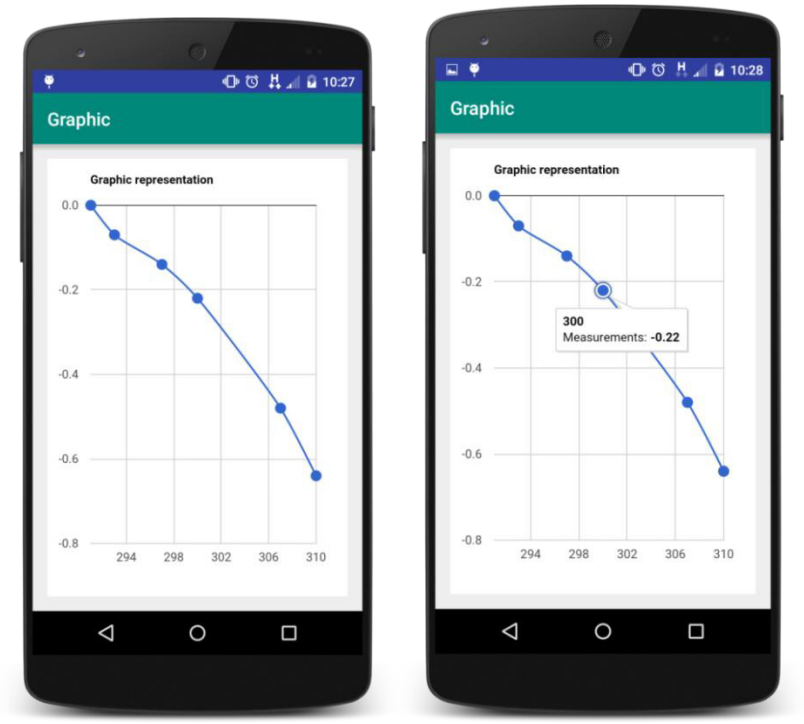

Figure 3: Graphical presentation of experiment data in the mobile app.

The processes of data entry, calculations and graphic presentations can be done with or without internet connection because data are stored and processed locally on the SQLite database. Users only need to login to identify the group for which they are going to use the app. To send and synchronize data with the server, internet connection is needed.

4.2. Server side components

On the server side, we have implemented a web application that is hosted on a web server and gives the opportunity to the teacher to monitor the experiments' progress for each group in the laboratory. The web application communicates with a MySQL central database that collects data from students' mobile apps. We have implemented a responsive design to give the opportunity to the teacher to access from desktop or mobile device.

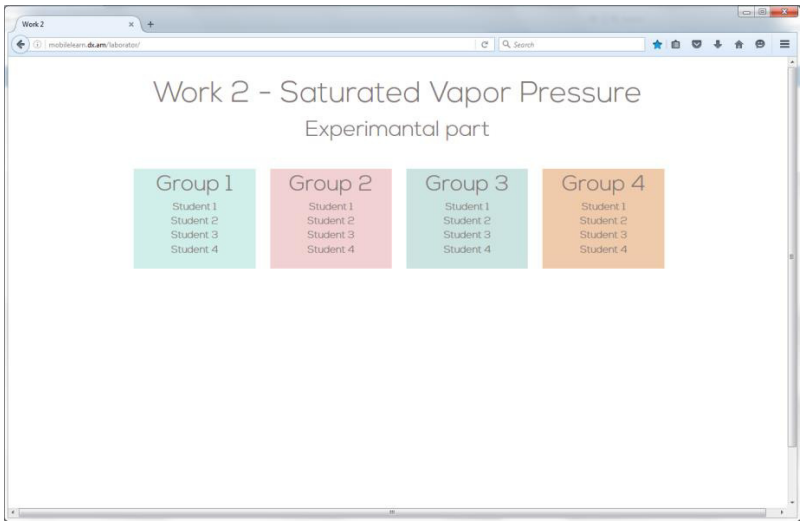

Figure 4: The teacher's web interface that gives access to the progress of different groups

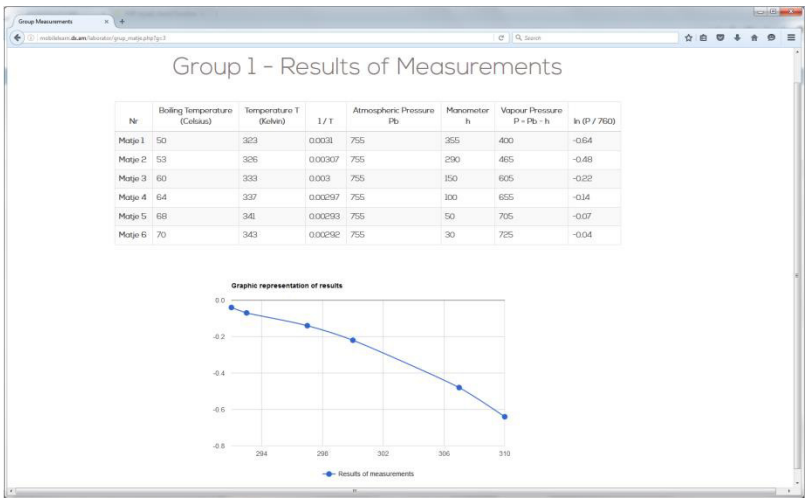

Figure 5: The teacher's web interface that shows detailed results of a specific group experiment

5. Survey results

We have tested the implemented application during a laboratory work of the physical-chemistry course, with two teachers and 17 students. At the end of the experiment, we offer to each of the participants a questionnaire to have a clearer idea of the effectiveness of our implementation and the impact that this application gave to students and teachers that tested it. Some of the most important questions of students' questionnaire and the reason we included them is explained in Table 1.

Question	Possible answers	Reason
How much did you understand the usage of the app?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand if the app is user friendly and also if students have experiences in app usage
How much did this app help you to better understand how to perform the laboratory work?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand if the description of the laboratory provided by the app is useful for the students
How much did this app help you during laboratory work?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand if the app facilitate the process of saving data, reuse them, make calculation and help with the graphic presentation
Would you use this app for all other laboratory works?	**a.** Yes **b.** No	To understand if students need the app assistance for the other laboratory class and indirectly understand if this app was valuable at the point they would use it again
How much would this app help you to get better grades?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand if this app could help students for a better school performance
How much does this app help to make learning more interesting for you?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand if the app would increase student engagement for learning
How much do you think would help similar apps during learning process?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand the interest to use mobile devices in other fields of learning process.

Table 1: The main questions of the questionnaire asked to the students

The results of the survey were very positive and made us understand that mobile devices can give a big contribution during laboratory works from students' point of

view. In large part, they all agree that the usage of mobile devices can improve learning and teaching and can make learning more interesting, as a result, they would get better grades. They strongly recommend using the app for all laboratory works and possibly include it in other learning processes. These results are illustrated by the graphics in Figure 6.

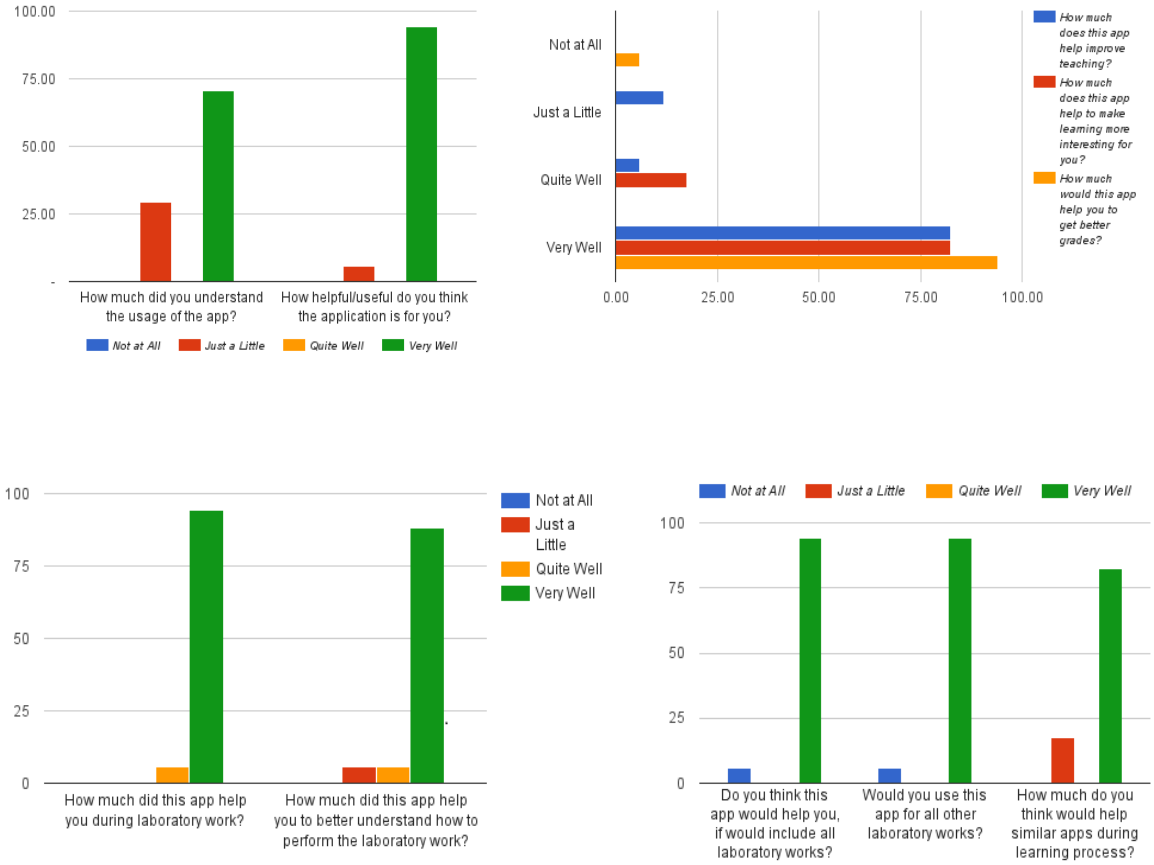

Figure 6: Survey results in graphical form

Some of the most important questions of teachers' questionnaire and the reason we included them, is explained in Table 2.

Question	Possible answers	Reason
How much did you understand the usage of the application?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand if the app is user friendly for the teachers
How helpful/useful do you think the application is for you?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand the level of usefulness of the application for the teacher during laboratory works.
How much does this app help improve teaching?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand if the application helped teachers during their teaching practice to make the experiment more understandable for the students.
How much would this app help with student supervision during laboratory works?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand if the application facilitated student supervision step by step for all groups at the same time.
How much would this app help with student evaluation?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand the level of help that the application offer toward student work evaluation
Would you use this application for all other laboratory works?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand if teachers need the application assistance for the other laboratory class and indirectly understand if this app was valuable at the point they would use it again
How much do you think would help similar applications during teaching/learning process?	**a.** Not at all **b.** Just a little **c.** Quite well **d.** Very well	To understand the interest to use similar applications to support other fields of teaching/learning process

Table 2: The main questions of the questionnaire asked to the teachers

Teachers gave us a very positive feedback about the application tested and from their point of view; the application is very valuable and is a must to incorporate all the laboratory works, other learning, and teaching processes in order to achieve a better learning and teaching performance.

6. Conclusions and future works

Taking in consideration the results of the survey, we can clearly say that mobile devices can give a big support during laboratory classes. They can facilitate students' work offering the possibility to save and access data wherever and whenever they want, supplying extra experiment information or help with graphic presentation. They can also facilitate teachers' work, offering the possibility to better supervise students and follow their progress step by step, with all the groups at the same time. Our future work will consist in expanding the implemented application to support also other laboratory classes in the Faculty of Natural Sciences and study the possibility to use mobile devices and mobile applications to support other learning and teaching processes.

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