Effects of an Android App on Mechanical Engineering Students

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Abstract.
This paper describes the development and assessment of a Native Android App for learning Mechanical Engineering.

The designed App is an interactive and portable tool. The proposed application has been programmed with Android Studio, and is presented as an executable file accessible from smartphones and tablets. It allows the student to interact and check the conceptual understandings, and it provides the student with the required level of knowledge.

The results of the subjects "Mechanism and Machine Theory" have been compared before using this app and afterwise. The assessment results show that there has been a significant improvement.

Key words: Android App, E-learning, computer simulation and animation, interactive test, portable

1 Introduction

It is required for the students to have solid conceptual understandings [1] and procedural skills [2]. Theoretical compression is considered "conceptual knowledge" in instruction [3].

Due to this lack of conceptual knowledge of the students, the professors are forced to find new ways to help the students to settle these notions. Over the last decades, a variety of strategies have been developed to improve students conceptual understanding. E-learning and new technologies can be useful tools for finding solutions. For example, Radinschi et al. [4] and Botelho et al. [5] have applied computer simulations in engineering education. Kresta employed full scale lab experiments [6] and Fu T. uses also CSA to learn mechanism [5]. In general, as a powerful tool for teaching and learning, computer simulation and animation has been widely adopted in engineering education [7, 8]

But not only teaching has changed, also students have changed over the years, and nowadays students are always connected using their mobile devices. They belong to a digital world, but educators, on the other hand, often see these technologies as a distraction for students [9]. There are many methods on these new technologies that can make learning easier for students and teachers.

The high penetration rate of mobile devices at global level sets new challenges, and universities can move with this tendency. The virtual mobile networks provide mobility of knowledge and the contents can be accessible at any moment and at any place [10].

Specifically for a Mechanical Engineer, "Graphic Expression" and "Mechanism and Machine Theory" are fundamental disciplines in the training structure. The purpose of these subjects is not only to provide students with theoretical knowledge, but also to enhance their comprehension of it. For this reason, the subject must be divided into theory, problems, and laboratories. This division of the subject is observed in many other matters during the engineering career. The normal method of learning is correct when the student devotes the right time. But, because in the regular assessment the student does not have much time, the student tries to learn to solve the problems without understanding the concepts. The students do not realize that they will need the knowledge in future subjects. This forces professors to find new ways to help and motivate students to reach the desired level. This has caused professors to search for new training methods based on new principles and using computer technologies [11] [7]. Nowadays, the subjects "Mechanism and Machine Theory" and "Graphic Expression" at Universidad Carlos III of Madrid have already been updated with e-learning, but the problem that e-learning does not solve is the lack of time. Thus, the aim is to create an application that allows students to spend extra time studying, so the focus is on helping the student with a tool that can be used at any place and any time[12]. As a first approach, the apps have been designed to be used in Android, the most widely used mobile operating system. Because every student has a smartphone or tablet, this gives us the opportunity to teach them in this manner.

Nowadays, a new method used for e-learning is the knowledge pills or virtual laboratories [13]. The pills are widely used for theoretical explanations. Knowledge pills are a tool that has been used recently. This type of resource is useful in e-learning processes, exclusively for distance teaching or to support classroom teaching [14]. The knowledge pills are often called learning objects. But the biggest disadvantage that they have is the need of a pc or laptop, and the time that they require. As it was commented before, this research is more focused on helping the student with a tool that can be used at any place and any time without spending much amount of time.

This paper describes our recent efforts in developing and assessing the App. Following the idea of promoting the student's personal work, the designed tool is an interactive and portable tool. The proposed application has been programmed with Android Studio, and is presented as an executable file accessible from smartphones and tablets. It allows the student to interact and check the theoretical concepts, and it provides the student with the required level of knowledge.

The results of the theoretical concepts of the subjects “Mechanism and Machine Theory” and “Graphic Expression” have been compared before using this app and afterwise. We are proud to show the improvement of the student’s results. There has been a significant improvement.. This is due to the fact that being an android application, it was very entertaining and very accessible. This type of application also looks for student weaknesses so that it can easily find what the student should solve.

2 Objective of the App

It is desired to improve the theoretical understanding of “Mechanism and Machine Theory” in the students. The main aim of this new technique is to pass on from the cognitive activity to the search activity and intends to use modern technologies and new training methods which are based on new principles and techniques that are closely associated with the computer technologies.

It was thought that the best way is not only with theory (just memorizing). Mayer and Chandler found that interaction with the multimedia learning allows the students to acquire knowledge faster [16]. It is needed for the students to think, understand, and also memorize as Clark et Al. shows in the based guidelines to manage cognitive load [18]. For this reason, it´s needed an App that not only provides theory concepts, but also checks if they know them or not, and also, explains and shows the concepts to learn. It is possible to achieve all the goals using interactive tests.

The Apps are designed to use interactive tests. Using them, students can check if they have acquired the concepts. If they haven´t, the test shows the correct answer and some explanation if it is necessary. Also, the test is a great tool for the students to check their level of understanding. Sometimes, the students think that they have already understood all, and nevertheless, they haven´t.

The tests can easily show theoretical concepts that the students didn’t understand or know. Using the app, the student must understand the question and the theory and think in order to find the correct answer.

Another aim is that the tests are short and to the point. This is because we wanted the possibility that the students could check fast if they are ready, and what are the concepts that are not well understood.

And the last objective, but not least, is the portability. This is managed thanks to Android system, smartphones and tablets. It is important, that the student can do this test fast and without the necessity of a computer. The students can do the test in the way of a library to know where they should start to study, or just in some free time while they are waiting, and check if they need more time to study or if they are ready for the exam.

By fulfilling all these goals, this tool can greatly help students to understand concepts and to solve theoretical gaps.

3 Operating System: Android

As mentioned previously, the apps have been developed with Android, the mobile Operating System (OS) more widely extended all over the world. Currently, we live in a new reality, where mobile phones and tablets are the changing tools in our lives. These new devices can offer capabilities similar to personal computers, but with the advantage that they can be carried in our purse or pockets.

This new technological revolution dates back to July 2005, when Google acquired Android Inc., a small startup company, engaged in the production of applications for mobile terminals. Then, the Open Handset Alliance was created in November 2007, led by Google and other companies, with the goal of developing the Android OS with the release of the first beta version of the Android Software Development Kit (SDK) that year. The first commercial version, Android 1.0, was released in September 2008. Also, with the introduction of tablets, wearable devices and Google TV, Android has expanded beyond its roots as a mobile phone operating system, providing a consistent platform for application development across an increasingly wide range of hardware until the release of the version 7.0 in August 2016, [17], [18]. The last version 8.0 has been recently released in August 2017.

Because Android is already the most widely used way of creating interactive clients using Java language [19], it offers a unified approach for application development for mobile devices, which means developers need to develop only for Android, and their applications should be able to run on a wide range of different devices powered by Android [17]. So, Android has become the dominant alternative to other platforms like iPhone or Windows Phone, reaching an 85% of world market share, with a 90% market share in Spain [20], reason enough for being the chosen system for this project.

The advantages that have got Android to be leader in the world market share are, first of all, that the source code for Android is available under free and open source software licenses. Android offers new possibilities for mobile applications by offering an open development environment built on an open-source Linux kernel. Furthermore, Android has a powerful API (Application Programming Interface), that is, hardware access is available to all applications through a series of API libraries, and it’s adaptable to any type of hardware.

Other advantages are that it has portability assured, which means that the final apps are developed in Java, which assures they can be executed at any type of CPU. Also, there is an acceptable level of security, and it is optimized for low power and low memory [20]. Besides, there is excellent documentation and a thriving developer community that will probably assure the Android leadership worldwide in the next decade.

5 Mobile App development

Android Studio is the official IDE (Integrated Development Environment) created by Google for Android apps development, and that is the reason why we have chosen it for creating our project.

For creating an Android application, it is necessary to have some files that are mandatory and some that are optional. Figure 1 shows the structure of our android project, the 'MaqTest' application, that it is consisted of several files or directories which will be explained next.

The main and most important file of the app is the *Android Manifest.xml*, which is the Android application descriptor file, where the name, the contents and behavior of the application are defined, and it lists all application's activities and services, along with the permissions and features the applications which need to run.

Then, the *java file* is a folder containing all of the source codes of the application, that is, the java code.

The *res file* is the folder containing the resources used by the application, consisting of the following folders:

- *drawable*, that contains all the images needed by the app
- *layout,* where are the XML files that create the views of each screen
- *mipmap* contains the icon image to launch the application in different sizes for the different screen dimensions
- *value* is formed by other resources such as styles and colors, and the strings file which contains all the texts used in the tests

Finally, the *Gradle* is the build system.

It should be noted that for creating each screen of the app, it is necessary at least two types of files, the *Activity.java* file, that describes the logic part, and the *activity.xml* file, that describes the graphic part. Furthermore, an activity represents the graphical user interface, and we can only see an activity on the screen at the same time.

In short, an Android application is usually structured in a set of independent activities that work together. Andan Android activity is both a unit of user interaction and a unit of execution [19].

6 App Scheme

In the present study, we have developed an interactive test. During the development, we reviewed and analyzed relevant research findings and adopted best practices of E-learning and computer simulation and animation, as documented in the previous literature review section. The interactive tests are often employed in engineering education.

The scheme of the app is shown in Figure 2. Firstly, the students access the Main Activity and then they start the application. After the desired i-Test, they can Check the Results or see the Correct Answer. Finished this, the student can go to the next test or come back to choose test Activity and choose another desired test. Every app has their own style in order to make the apps more motivating.

In figures 3, the scheme of the activities of Main Activity, Test Activity and i-Test are shown. The Main Activity is shown in figure 3. In this Main Activity, the name of the App and the description appears. After this, the next Activity offers the student to choose the desired test. It is named Test Activity and it is shown on figure 3. In the chosen i-Test Activity, the student can select the answer.

After, the student can check the results: Check Result or seethe correct answer: View the answers. See Figure 4. Finished this, the student can go to the next test or come back to choose test Activity and choose a desired test.

7 Research Design and Data Collection

The Native Android App developed in the present study was implemented in an engineering course taught at public university in Spain, Madrid. The research question is: To what extent did the App improve student learning and helped them?

In order to answer the above research question, the grades before using the App with the students and after using it are compared. Both group were taught by the same instructors (i. e., the first and second of this paper) using the same textbook and the same level of exams.

The grades of "Mechanism and Machine Theory" of the semester of 2016 and the semester of 2017 are compared. The comparison consisted of two groups on the order of 180 students each one. The first group in the semester of 2016 learned the course material form lectures only without the developed App. In 2017, the App was given to the students, and the students of 2017 learned the course material from lectures and with the developed App.

Also, the students of the semester of 2017 completed a quiz about the App and their opinion. The opinions are calculated in percent.

The Learning Gain of the students was calculated using the following equation [21]:

$$Learning\ Gain = LG\ = \frac{post\ app\ score - pre\ app\ score}{10 - pre\ app\ score}$$

Where the “pre app score” is the average over 10 of the grade of students in the semester of 2016 and the “post app score” is the average over 10 of the grade of students in the semester of 2017. This measure, Learning Gain, can give us an estimate of the increase of the students learning.

Also, an Approving Gain of the students was calculated using the following equation:

$$Approving\ Gain = AG\ = \frac{post\ app\ approved - pre\ app\ approved}{100 - pre\ app\ approved}$$

Where the “pre app approved” is the average number of students approved as a percentage in the semester of 2016 and the “post app approved” is the average number of students approved as a percentage in the semester of 2017. This measure, Approving Gain, can give us an estimate of the increase of students who have approved thanks to the help of the app.

8 Results

The present study was implemented in an engineering subject: “Mechanism and Machine Theory” at public university of Carlos III in Spain, Madrid.

Figure 5 shows the historical of the approved students of “Mechanism and Machine Theory” in percent. It can be seen clearly the improvement of the results. The percentage of students who passed has increased from 14.84% in 2016 to 37.76% in 2017. We consider that it is a considerable increase and we believe that the motivation of the app and the extra time spent by students due to its usefulness have been the cause.

Figure 6 shows the historical average grade in the exam of the subject (in this case: “Mechanism and Machine Theory”), which was falling until 2017. In 2017, because of the app it experimented an increase.

The number of students of 2016 was 128, of which only 19 have approved. In 2017, the number of students was 143 and 54 approved. The Approving Gain=AG is equal to 23.6%. This is a high improvement. And the Learning Gain=LG is equal to 10.2 %. The improvement of the Approving Gain is higher than the Learning Gain because the students were able to solve the gap of conceptual knowledge with the app and approve the exam. The students that already knew and understood the conceptual knowledge didn´t improve the grade too much.

Some surveys were also carried out to the students, where 96% confirmed having used the app, of which 91% confirmed that it was used due to its easy access through the smart phone (Android).

The general opinion of the students is shown in figure 7, where 68% of the students were very satisfied, 25% were satisfied and 6.59 % were not satisfied.

Figure 8 shows that 89% of the students consider that the app has helped them to improve grades and approve the subject.

And 91 % of the students consider it appropriate to do more apps for more subjects.

8 Conclusions

This paper has described an assessment of a Native Android App for learning in engineering. A new and interesting tool for the process of learning has been presented. It is an accessible and portable tool to help students to understand the theory of Mechanism and Machine theory.

The assessment results show that the number of approved students has increased from 14.84% to 37.76%. This notorious improvement shows that the application has been useful for students.

The survey also shows the high degree of student satisfaction with these new teaching methods. The survey showed that 89% of the students consider that the app has helped them to improve grades and approve the subject, and 91 % of the students consider it appropriate to do more apps for more subjects.

With the results obtained, it can be concluded that it is a complementary method to the traditional methods and the e-learning.

Another important point to remark is that Android is a free software, and it does not imply any cost to the students. Besides, there is no need for them to buy any new computer or to have a good internet connection, once the app is installed.

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