Discovering *EnjoyCircuits*: the Mobile App for Fundamentals of Electric Engineering

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Abstract- Mobile applications have experimented a huge evolution in the last years. These applications are already an important tool in our daily life. From the point of view of the penetration of this mobile technology in the different scales of the society, university students are one of the main users of this mobile technology. For this reason, this work proposes a learning mobile application entitled *EnjoyCircuits* for Fundamentals of Electric Engineering of the Industrial Technology Engineering Bachelor. This mobile application is a learning tool based on the resolution of quick problems of circuit theory. With *EnjoyCircuits* students can do a dynamic review of the Fundamentals of Electric Engineering anywhere and anytime. Moreover, they can compete with other users in the *EnjoyCircuits* ranking.

Index Terms- Mobile application; Bachelor of Industrial Technology Engineering; Fundamentals of Electric Engineering.

I. INTRODUCTION

The world experiences a continuous evolution due to the advances in technology. From the point of view of the academic community, it is worth exploring the new opportunities provided by new technologies. These advances have allowed the use of novel communication channels to expand the knowledge around the world. In summary, this new academic era matches perfectly with the concept of anywhere and anytime.

This current technology situation has particularly promoted the development of learning tools based on the distance learning concept (d-learning). The d-learning concept can be defined as a way of remote learning without a regular face-to-face contact with a teacher in the classroom. In this regard, different platforms of d-learning have been proposed during the last decade [1-4]. Although there are different d-learning variants, all of them must satisfy the universal instructional design principles for d-learning tools [5-6]. These universal principles can be summarized in the following points:

P1) equituable use
P2) flexible use
P3) simple and intuitive use
P4) perceptible information
P5) tolerance for error
P6) low physical and technical effort
P7) community of learners and support
P8) instructional climate

Even though different d-learning platforms based on the previous universal principles have been developed, the real turning point in the d-learning history appears with the arrival of the handheld computers and smartphones, due to their relative low cost and their great integration in the worldwide population. The d-learning methods based on the mobile technology are defined as mobile learning (m-learning) [5]. This version of d-learning is relatively novel, however different alternative of m-learning tools have been explored [5-]. In this regard, mobile applications are an interesting alternative due to their high integration in our daily life. In fact, nowadays there is a large number of mobile applications based on language learning language [7] or basic scholar concepts (mathematics, geography ...) [8]. However, there is still an emptiness in the development of mobile applications for university subjects. This fact surprising when the college students are precisely one of the main consumers of mobile applications [9]. For this reason, this work proposes an m-learning application entitled *EnjoyCircuits* for Fundamentals of Electric Engineering in the Bachelor of Industrial Technology Engineering at the University of Malaga (Spain). This m-learning application has been developed by researchers of the ACETI research group. Although this research group already has some experience in educational publication based on electric engineering [10-15], this work is presented as a new teaching research line for ACETI.

Obviously, the objective of this m-learning application is not to replace the master classes of Fundamentals of Electric Engineering. *EnjoyCircuits* must be employed only like a support of these master classes. The proposed learning mobile application is based on the resolution of quick problems related with the main modules of Fundamentals of Electric Engineering. These modules are available in *EnjoyCircuits* with the following titles:

M1) basic concepts
M2) knots and meshes methods
M3) basic theorems
M4) ac-current problems
M5) three-phase problems.

This initial version of *EnjoyCircuits* includes a set of 116 problems. The users of this m-learning application can find in this set of problems: multi-option problems, numeric problems and matrix problems. Although the nature of these problems is different, all of them are close problem that can be quick solved. In order to increase the motivation of the students in the use of *EnjoyCircuits*, a ranking based on the final score of users is implemented. For this purpose, a score system has been developed. In the proposed system, the final score is function of the resolution time, since
EnjoyCircuits is an m-learning tool based in the resolution of quick problems.

The paper is organized as follows. Section II describes the academic context of EnjoyCircuits. The development of this m-learning application and the software employed in the building process are detailed in the section III. Section IV discovers the main modules of the proposed learning mobile application and conclusions are finally summarized in the last section.

II. ACADEMIC CONTEXT

As noted above, EnjoyCircuits is an m-learning tool for the students of Fundamentals of Electric Engineering. This subject is lectured in the second course of the Bachelor of Industrial Technology Engineering from the University of Malaga (Spain). Fundaments of Electric Engineering has been historically known as Theory of Circuit and it is a basic subject in the majority of engineering bachelor. The academic information of Fundamentals of Electric Engineering is included in the Verifica Memory of the Bachelor of Industrial Technology Engineering [16]. Following the above mentioned memory, the Fundamentals of Electric Engineering syllabus can be shifted in five modules where the modules 1, 2 and 3 have an important teaching load (see Table I for more details).

Although the table 1 shows that the modules of EnjoyCircuits match with the syllabus of Fundamentals of Electric Engineering of the Bachelor of Industrial Technology Engineering, the use of EnjoyCircuits is not only restricted to students of this bachelor degree since Fundamentals of Electric Engineering is a common subject in different engineering bachelors. For example in the University of Malaga the syllabus of this subject is common in the following bachelor degrees: Industrial Technology Engineering, Electric Engineering, Electronic Engineering, Mechanic Engineering, Energy Engineering, Industrial Design Engineering and Mechatronic Engineering. Therefore, due to the basic nature of the proposed subject, EnjoyCircuits can be a useful learning tool for a large number of students at the University of Malaga.

III. MOBILE APPLICATION DEVELOPMENT

The developed application is based on the Android technology. This mobile operative system (MOS) was selected due to its popularity in the development of mobile applications. However, other mobile operative systems could be used without technical restrictions.

On the other hand, although Android Studio is the main employed software in the building process, several software tools have been used in the development of EnjoyCircuits. This section introduces these software tools and describes their main features. Fig. 1 shows a scheme of the main building process of EnjoyCircuits and the different software tools employed in the development of these building process.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>FUNDAMENTALS OF ELECTRIC ENGINEERING SYLLABUS</th>
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<tbody>
<tr>
<td>B1.</td>
<td>Fundamental elements and circuit analysis (22.5h)</td>
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<td>-</td>
<td>Basic concepts</td>
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<td>-</td>
<td>Basic theorems</td>
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<td>-</td>
<td>Knots and meshes methods</td>
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<tr>
<td>B2.</td>
<td>Analysis of ac-current circuits (18h)</td>
</tr>
<tr>
<td>B3.</td>
<td>Three-phase circuits (13.5h)</td>
</tr>
<tr>
<td>B4.</td>
<td>Transient process (4.5h)</td>
</tr>
<tr>
<td>B5.</td>
<td>Electric machines (1.5h)</td>
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</tbody>
</table>

Fig. 1. EnjoyCircuits scheme and employed software.

A. Android Studio

EnjoyCircuits was designed using the software Android Studio. This software is the official integrated development environment (IDE) of Android. It was announced in 2013 and replaced Eclipse as official IDE of Android. This IDE is written in Java and it is available for Windows, Linux and Mac OS. Android Studio supports all the languages of IntelliJ IDEA (one of the first available Java IDEs). Two building options are available in Android Studio. The first of these building modes is based on the employed of Java language (see Fig. 2). The application body was bought using this Android Studio mode while the EnjoyCircuits graphic design was realized with the second building mode. This other mode is a graphic interface which allows the development of the graphic design of the mobile applications (see a screenshot of this mode of Android Studio in Fig. 3).
B. CircuiTikZ

EnjoyCircuits presents a huge number of problems with electric circuit schemes. For this reason, it is necessary to select a suitable tool for the electric circuit design. There are two requirements in this design process: i) a suitable quality of the figures and ii) a low computational weight of the figures. Attending to these two requirements the CircuiTikZ tool was selected to design the electric circuit schemes of EnjoyCircuits. CircuiTikZ was initiated by Massimo Redaelli in 2007 and was created as a tool for creating exercises and exams. This design platform is based on the LaTeX language. The use of CircuiTikZ is, of course, not limited to academic teaching. The package gets widely used by engineers for typesetting electronic circuits for articles and publications all over the world. CircuiTikZ provides the necessary electric components to build the different implemented electric schemes of EnjoyCircuits. An electric circuit designed using CircuiTikZ is represented in Fig. 4.

C. Web server and database

The EnjoyCircuits ranking needs a web server to establish the communication between the smartphones and the database where the global ranking of EnjoyCircuits is calculated. For this purpose, a virtual machine was employed to define the communication between the EnjoyCircuits application and the database of the web server. This database must receive the registration information of the users and the user score in the different exercises. On the other hand, the web server must deliver to the EnjoyCircuits application the position and the final score of the users in the EnjoyCircuits ranking. The management of the database is realized with MySQL. This software is employed in the management of database and is the open source database most popular in the world.

IV. DISCOVERING ENJOYCIRCUITS

This section allows discovering the proposed mobile application. A tour by the different sections of EnjoyCircuits is realized. In this tour a brief description of the different screens of EnjoyCircuits is also provided.

A. EnjoyCircuits initial screen

The initial screen of EnjoyCircuits presents two access options for the users. The new users can access the registration process if the Sign Up option is selected. On the other hand, the previously registered users can access to their personal accounts with the Log In option. Fig. 5 shows the EnjoyCircuits initial screen with the two previously mentioned access options.

B. EnjoyCircuits sign up screen

In Fig. 6 the registration screen of EnjoyCircuits is depicted. As it is usual, the users must provide some personal data on this type of screen. The personal information is necessary to realize the sign up process in EnjoyCircuits in the following: name, surname, nick, university, email, national document of identification (DNI) and password. This sign up process is necessary to realize the suitable tracking of the student evolution in the mobile application. For this reason, EnjoyCircuits is programmed to avoid the duplication of users. Hence, two users cannot share nick or email, this fact also allows preventing problems in the access or in the calculation of the EnjoyCircuits ranking. Moreover, in order to realize a suitable tracking of the Fundamentals of Electric Engineering students, the national documents of identification are also verified.

C. EnjoyCircuits Log In screen

On this screen, the users can access their personal account with their previously registered nick and password. In order to reduce the time in the login process, the proposed mobile application allows remembering the required personal information of the Log In screen. To do it, the users must select the available Remember me tick. A screenshot of the Log In screen is represented in the Fig. 7, where the abovementioned option is included.
D. EnjoyCircuits main screen

The EnjoyCircuits main screen presents the five problems modules of this learning mobile application. Fig. 8 shows these five blocks of EnjoyCircuits where the abovementioned set of 116 quick problems are distributed. Moreover on this main screen, the user can refer the EnjoyCircuits ranking or the EnjoyCircuits information screen. During the first seconds in this screen, a toast message appears with the total user score.

E. EnjoyCircuits evolution screen

Fig. 9 shows the evolution screen of one module of EnjoyCircuits. In the first access to the block, the problems appear marked in a gray tone, indicating that the problem has not yet been solved. EnjoyCircuits employs a green tone for problems resolved satisfactorily. On the other hand, if the answer is erroneous, a yellow tone is employed to identify the problem. The proposed scale of colors can be observed in Fig. 10. This fact allows the user to identify in a simple way which problems he/she has failed and need to be reviewed. Moreover, a toast message informs the user about the obtained score in the corresponding block.

F. EnjoyCircuits problems

Android Studio allows defining different type problems. EnjoyCircuits exploits this important advantage of Android Studio providing different type problems in this initial version. These problems can be structured in the following three groups:

i) multi-option problems (see Fig. 11)
ii) matrix problems (see Fig. 12)
iii) numeric problems (see Fig. 13)

These problem types are obviously different, but all of them are quick resolution problems. This feature has been considered in the score system of EnjoyCircuits, including the resolution time in the final problem score. In other words, the final score is inversely proportional to the time employed in the resolution of the problem. Of course, if the response is erroneous the final score of that problem is zero. Furthermore, that problem will never count for the ranking score, even if the user provides the correct answer in a new attempt (keeping always the previously mentioned yellow color).

On the other hand, the EnjoyCircuits problem screen also offers information about the evolution of the user in the corresponding block. The user evolution is indicated through the EnjoyCircuits progress bar. This progress bar employs the number of EnjoyCircuits logos on the screen to provide a certain information about the evolution in the block (see Fig. 11 for more details).

G. EnjoyCircuits ranking screen

Since the competitive nature of humans is a powerful learning tool, the implementation of competitive activities is a usual practice nowadays in the academic community. For this reason, this learning mobile application presents the EnjoyCircuits ranking. With the implementation of this ranking the authors hope to increase the motivation of the students in the use of EnjoyCircuits.

As previously mentioned, this ranking is calculated using the database implemented in the web server. In order to safeguard the identity of the users, the EnjoyCircuits ranking provides only the user nick and the final score (see Fig. 13).

H. EnjoyCircuits information screen

As usual in these mobile applications, EnjoyCircuits presents an information screen. This information screen provides the main objectives of this learning mobile application.

On the other hand, this information screen also gives more details about the EnjoyCircuits score systems. In this regards, the influence of the resolution time in the final score is described in details. The proposed score system can be observed in the Fig. 14.
Fig. 8. EnjoyCircuits main screen.

Fig. 10. EnjoyCircuits evolution screen. Fig. 12. Example of numeric problem.

Fig. 9. EnjoyCircuits initial evolution screen.

Fig. 10. Example of multi-option problem with tactile response.

Fig. 11. Example of matrix problem.
V. CONCLUSIONS

Attending to the new technology situation in the academic world, this work proposes a learning mobile application entitled EnjoyCircuits based on the resolution of quick problems of Fundamentals of Electric Engineering. The users of this mobile application can perform a dynamic review of the basic concepts of Fundamentals of Electric Engineering while they compete with other EnjoyCircuits users. Although, this work only introduces the first version of EnjoyCircuits, this initial version is already available in the Google Play Store. To validate the goodness of EnjoyCircuits, the authors suggest the following validation methodology. Firstly, a satisfaction survey must be realized to the students of Fundamentals of Electric Engineering. Moreover, the authors also propose the analysis of the variation in the number of students that pass the Fundamentals of Electric Engineering subject. However, several courses of experience are necessary to obtain conclusive results with this validation methodology. Therefore, in this regards this work cannot yet provide information about the goodness of EnjoyCircuits if this validation methodology is used.

REFERENCES


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