Game-Based Assessment for Radiofrequency Circuits courses in Engineering

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***Abstract*—In addition to a high technical level and performance in their discipline, engineers of the 21st century require a high level of general or transferable skills that allow them to excel in their work environment. Engineers at the University of Antioquia in Colombia are no strangers to this situation, which is why the University has decided to face this new condition through the inclusion of activities in courses that support the development of these skills. Part of these activities includes the transformation of the traditional evaluation scheme for Radiofrequency Circuits course in Electrical and Telecommunication Engineering programs. This transformation is been performed taking advantage of the LMS (Learning Management Systems) platforms, web and mobile application and game-based learning techniques. The development of innovative practices that can leverage information and communication technologies is one of the major challenges in education. This paper shows the design of an online game-based assessment and training strategy. The new assessment and training tests were designed to help students improve their learning outcomes on the course topics; meanwhile, they promote development of general or transferable skills such as the ability to solve problems in complex situations and working under pressure.**

Keywords—Assessment strategies; Game-based learning; LMS; Mobile applications; Professional performance; Transferable skills; Web applications

I. INTRODUCTION

Engineers at the University of Antioquia, Medellin, Colombia, have been characterized by a high technical standard. However, due to high professional competition and they work for society, engineers must not only be people with great disciplinary knowledge, but also be integral professionals. Since 2005, the University of Antioquia has been developing several investigations about the lack of comprehensiveness on professionals, which has led to the restructuring of undergraduate engineering curriculums. With the curricular changes, the program added the use of virtual platforms in some courses, and also has promoted the development of student transferable skills that improve their professional and personal performance [1, 2, 3].

The Radiofrequency Circuits course, which is taught at the undergraduate level in Electrical engineering and Telecommunications Engineering programs at the University of Antioquia [4], is a deepening course in wireless communications area and is offered when the student has completed 70% of the courses on his career. The course is divided into two parts, one part is theoretical and the other one is a laboratory. Traditionally, the theoretical component assessment has been evaluated through 6 tests, using traditional strategies such as paper based tests and writing home works.

The University has been using during the last 10 years virtual platforms to support the student learning process, including assessment modules of these platforms, which simulate the behavior of paper based tests made in the classroom. Since 2014, the program, has been designed a strategy to develop new assessments schemes, changing some of the traditional assessments to game-based training and assessment schemes that not only assess knowledge of the course topics but also allowed improving transferable skills of students.

This article presents the design of a training and assessment tool, and is organized as follows: Section II presents an overview of Game-Based Assessment Scheme and transferable skills; the Section III shows the new approach of evaluation schemes in Radiofrequency Circuits course assessment; and Section IV presents the proposal study and finally the conclusions are stated.

II. TRASNFERABLE SKILLS AND GAME-BASED ASSESSMENT SCHEMC

Since the late 20th century, society has professionals with technical or disciplinary skills, and also skills that include values and attitudes that enable them to confront and solve important new century problems [2]. The transferable skills are those skills that are transversal to many activities, common to different professions and related to aptitude, knowledge and values of people [5]. These transferable skills are part of the 21 century skills [6, 7].

Studies have found a relationship between the transferable skills development in people and their subsequent educational and labor outcomes. People, who develop transferable skills on their education, has better academic results and better attitudes and behavior in several situations [6, 8], and are more effective when use this abilities in a specific contexts [9].

These competences could be developed using new assessments schemes. There are various techniques with which one student can learn about a topic and at the same time

978-1-4799-8454-1/15/$31.00 ©2015 IEEE

develop transferable skills. According to several studies, traditional tests formats such as multiple choice, essay or short answers are not completely appropriate to evaluate academic concepts and to improve transferable skills. Therefore the use of alternative assessments schemes becomes necessary [10].

For students, the assessment is important because it allows them to follow their progress and it also provides valuable information to teachers to give feedback to student, this information could be used to motivate them to keep learning. The assessment can relate the skills that the teacher hopes to teach with student expectations. Thus, a good assessment reflects good teaching [11]. A good assessment allows the teacher to know what students have understood, so the teachers can modify the way to reach the learning objectives based on this information [12, 13, 14].

Good assessment methods have to include the following characteristics: evaluate what is intended to measure, predictive validity of future behaviors and should motivate the student to work hardly in challenging scenarios [12, 13]. Assessment should be an engagement for the learner, help to improve persistence and 21th century skills, relevant for students and teacher, and provide a personalized learning environment [15].

However generally the real life problems are different from the ones students solve in their classes. This may be because real life problems do not have a standardized solving method; it needs collaborative systems, experience, diverse knowledge and especially transferable skills [16].

For that reason the teacher has the responsibility to change the traditional class assessment into one that reduces the gap between the traditional education and the real-world challenges. Alternative assessments methods involve real-world applications and ask students to create, produce, solve problems and develop their critical thinking. These assessments involve new strategies to accomplish learning outcomes [11, 14, 17].

Game-based assessment can help students to construct knowledge through trial and error, solving challenging problems that motivates students to learn intrinsically. Student can work or observe real life situations, motivating the need to reach the goals and improve their persistence [18, 19]. Digital learning environments can provide a meaningful assessment to students, where they can learn and play in scenarios where they have to improve several competences, like academic, social and personal. The really important point is to develop assessments that lead students to use their knowledge and combine it with other skills to solve different problems [12, 13].

With the Game-based assessment it is possible to transform a boring or stressing assessment into one that evaluates the knowledge and also can be enjoyable. Assessment with games, is a strategic option, because students have an inherent attraction to games, are part of their lives and “win the game” is one of the most valuable rewards. Shute and Ventura, Zapata Rivera and Bauer and DiCerbo [12, 14, 19] presents cases of success in game-based learning, where students develop class activities simulating games and finally acquire specific academic knowledge and transferable skills.

Bokyeong, Hyungsung and Youngkyun [20], present three strategies for learning with games that allows the students improve transferable skills: The self-recording which includes writing, modeling, thinking aloud, listening and speaking activities. Osman and Bakar [21] describe a method where the student is not only a player but also becomes in a playmaker. This is known as collaborative game making. Its importance lies in that students can make part of creating a game, where they can learn the class subject, inventing meaningful games and allows them to develop transferable skills, as critical thinking, creativity, innovation, problem solving and team work.

III. Proposal Assessment Scheme in Radiofrequency Circuits Course

Being in a technological age, it is necessary to potentiate and take advantage of information and communication technologies ICT. There are several Learning Management Systems LMS like Moodle, Canvas, Sakai, Blackboard, Desire to Learn [22, 23, 24, 25, 26] among others, all of them includes modules that allows interoperability and flexibility for assessment and training process [27].

The technological architecture includes the integration of services through standards such as LTI (Learning Tools Interoperability), Tin Can API (XAPI), XML- Moodle [28, 29, 30] and using the LMS and mobile apps as interfaces of interaction for students. The figure 1, shows the interaction between users and modules of the system.

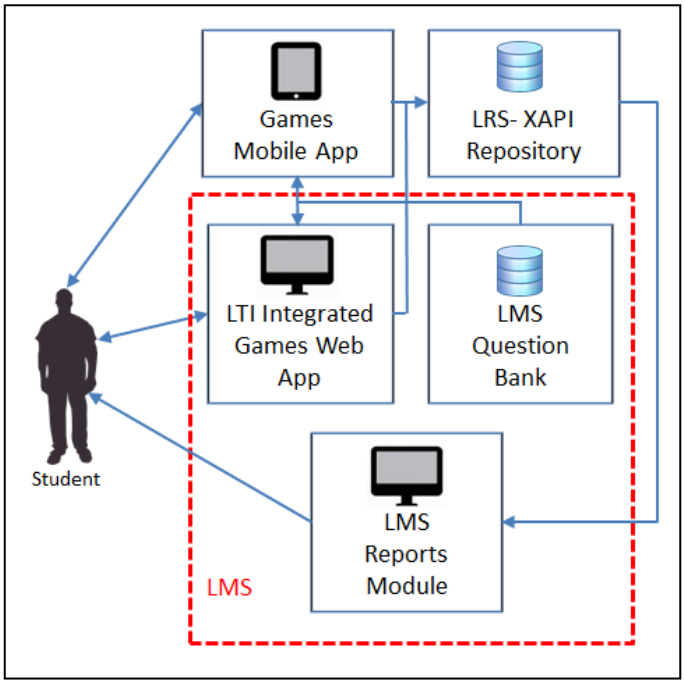

Fig. 1. User interaction with system modules.

The games for Radiofrequency circuits course are being developed in a web and mobile application versions. The web application could be integrated to LMS platform via LTI standard or could be used directly in Android devices like cell phones or tablets. These applications use the LMS question

banks as inputs for all games. In both cases (LMS integrated web and mobile application) the interactions will be stored in the LRS (learner record store) and the results of interactions could be included into student LMS reports. Figure 2 and 3, shows mobile app Mockup.

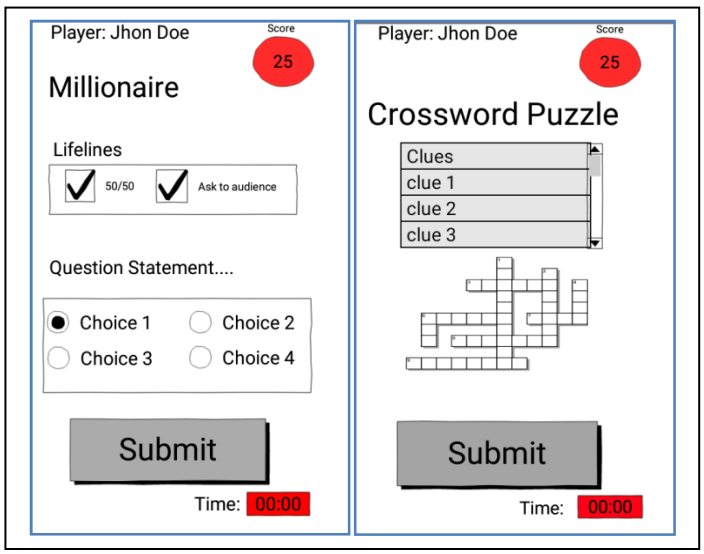

Fig. 2. Mobile app Mockup of Millionaire And Crossword Puzzle

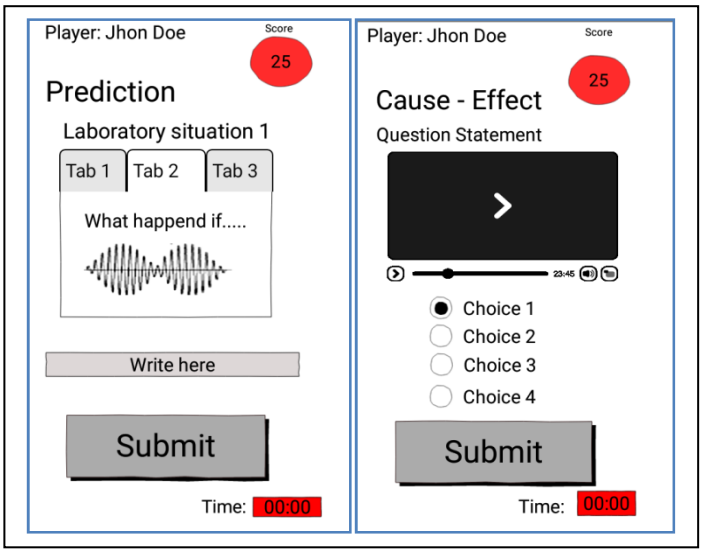

Fig. 3. Mobile app Mockup of What happens if? and Cause-effect problems

The games where divided into four groups: Trivia Games, Word Games, Prediction and Decision making. The style of question planned for different games includes multiple-choice questions, short answer and essay. Games are different each other according to particular intentions, some of them are focused in development of solving problem skills, while others have the goal of improve the agility of giving solution to a complex situation when time is a limited resource. The difficulty level of each interactive game has direct correspondence with the skills level defined in the course topics. These games are aligned with transferable skills like: decision making, working under pressure, problem solving, willingness to learn, self-motivation and analytical thinking.

Descriptions of each game, type of question used for develop them and an example of real question that will be used in the Mobile app Mockup (see figure 2 and 3) are:

- Trivia game: Millionaire. The aim of the activity is answer a series of questions, where each new level of questions increases difficulty. If the student answer correctly, (s)he goes to the next question. The student has 1 minute to answer each question. The activity has two types of lifelines: 50-50 where the platform deletes 2 wrong answers and ask the public, where the student can go to an internet page using hyperlink and consult the question during 30 seconds. The type of questions used to develop the game was: Multiple choice questions. The student can decide not continue with the game on any moment, but (s)he cannot answer the question before leaving. Example:

  If you have a circuit with R_S = 10 ohm and R_L=50 ohm, which coupler do you use?:

  a. Resonant Coupler
  b. Coupler type T
  c. Coupler type L
  d. Coupler type π

  Helps:

  - 50 – 50
  - Ask the audience (consult internet)

- Word games: Crossword Puzzle: the activity presents a track to student and (s)he should interpret it and write the concept that is reference. The student has 30 minutes to develop the activity. On this game, short answer questions were used. Example:

  5. (Across) RF output power and DC power ratio.

- Prediction of future events: "What happens if?". In this activity, a real life or laboratory situation is presented to the student, then (s)he have to predict what happens later. On this game, the student has 5 minutes to write the answer. Multiple choice questions, short answer question and assay were used. Example:

  What happened if you are in a laboratory with a BJT mixer circuit and you change the transistor for another with higher transconductance. If the initial mixer has a low amplitude output, what would you think is the amplitude of the mixer with the new transistor?

- Decision making game: Cause – effect problems. The activity presents a series of real life situations, where the student should make a decision. These decisions affect subsequent situations, and then the activity has multiple ways of solve it. The student has 2 minutes to take each decision. If the student does not choose any answer, the game will end. Type of questions used: multiple choice or short answer questions, according to the previous response. Example:

You have a video transmitter with 3 blocks: an oscillator, a low signal amplifier and a power amplifier. If the central frequency should be 56.92 MHz and the output amplitude 1.92V, but the oscilloscope shows 51.87 MHz and 1V and you use T band-pass couplers, you can:

a. Change the output T type coupler of the power amplifier.

b. Change the T type couplet between the low signal amplifier and the power amplifier.

c. Change the value of the mechanical capacitor of the oscillator.

d. Change the T type coupler of the low signal amplifier.

Currently, there are platforms that offer the possibility of bring training and evaluation processes through trivia games in different areas of knowledge. Kahoot and Duolingo [31, 32] are examples of mobile applications where questions can be created and solved through a playful interaction. One of the important contribution of the proposed scheme is that allows to link the gaming environment used by students and the formal on-line environment used for learning, commonly LMS platforms. This integration favors the monitoring and reporting processes in terms of time investment and student results on their gaming sessions. And also it helps to take advantage of the 70% of informal learning or experience learning that occurs outside the classroom, that when is mixed with 10% of formal learning, best results are expected to achieve in the course [33, 34].

Moreover, there are two reasons for using this evaluation scheme based on games. The first reason is based on the investment of time of students in interaction with course concepts involved along levels or stages of games. The second reason is to propose an additional learning challenge to student, because traditional methods of education generate some level of challenge, but games generate the additional addictive and engaging component. This motivates the player to achieve progress and increasing their score of previous attempts; this is commonly known as persistence. The evaluation scheme can transform an assessment moment in a learning process based on training and experimentation, allowing the existence of formative assessment and feedback schemes and even more, a development of transferable skills.

IV. Study Proposal

The system will be used in the second semester of 2015 in the radiofrequency course to probe if the use of the new scheme of training and assessment can improve the student' motivation and scores on the course, and moreover if can help to develop some transferable skills. The course will use the game-based assessment system in each test, and a training session will be done before every quiz and laboratory practice. The periods of training with the system correspond to the periods in which each topic is taught. The students assessment scores will be measured according to the number of clear levels, scores obtained on the games and time required.

At the end of the semester the student scores will be compared with the scores of the past courses that have used traditional assessments methods. And also a survey will be applied to know the perception of the students about the proposed scheme and transferable skills improvement. Some questions of the survey are:

1. If you compare the training and assessment games proposed with the traditional training and assessment, you would say proposed games are:
    a. More entertaining but does not allow me to acquire knowledge
    b. More entertaining and allow me to acquire knowledge
    c. Equally entertaining and acquire the same knowledge
    d. Less entertaining but allow me to acquire knowledge
    e. Less entertaining and not allow me to acquire knowledge
2. Will you consider investing more time training with the games proposed that in traditional homework?
3. Do you think that using the training and assessment games helps you to acquire transferable skills?
    a. True
    b. False

    Which?_____

V. Conclusions

Implementation process imply high technical skills like: design and implementation of web and mobile applications, integration of web services through educational standards and LMS management, which requires a multidisciplinary work.

The game-based training and assessment strategy proposed have the potential to be implemented in other undergraduate courses.

The development of more games and activities could help to mapping other transferable skills like: team work, communication skills, co-operation among other, that are not included on this version of the system.

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