ANALYZING THE EFFECTIVENESS OF USING ENHANCED ACTIVITIES WITH SIMULATION SOFTWARE IN A MOOC

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Abstract

The purpose of this paper is to present the application of an electronic circuit simulation software as a complementary tool that helps the students to better understand the theory and functioning of electronic circuits in a massive open online course (MOOC). It investigates the impact of integrating various learning activities using circuits simulation software along the course content to measure the perceived usefulness of this technique, and results obtained in terms of engagement, the degree of satisfaction, knowledge and skills acquisition in this discipline after their completion.

Nowadays, the use of computer simulation is an essential tool for explaining electronics, it allows to illustrate theory lessons by visualizing the behavior of electronic components, power supplies and measuring instruments in a quick and easy way to understand. It is the simplest and fastest way to check the operation of a circuit, it does not need any type of additional material for the assembly of a circuit or to measure the results. This study outlines the design and development of various activities in a MOOC, that were created to help students overcome the difficulties that arise in the learning of electrical circuits, improving students’ learning experience and increasing the completion rate. This work presents in detail the advantages of using simulators and the conceptual framework based on aspects of constructivism that favor the use of this type of activities in MOOCs.

This study analyzed data obtained from edX course “Introduction to electrical circuits” developed in early 2018 by a group of professors of the faculty of computer science and the department of research and development (GES) of Galileo University. The data set consisted of a pre and post-course survey, solution laboratories submission, and participant’s demographic information.

Although MOOCs provide a platform for learning in a highly scalable and flexible manner, the results show that students perceive a real benefit in the construction of knowledge when using a circuit simulation software, as well as, a high degree of satisfaction when performing learning activities that really challenge their minds and gives them the opportunity to practice and experiment by them the theory. Overall students’ learning experience is improved in a significant way, it makes a clear difference for all those students who wish to learn and want to get better in their academic and professional performance.

Keywords: MOOC, Electronic Circuit Simulation Software, Cloud-based tools.

1 INTRODUCTION

Massive Open Online Courses (MOOCs) provide students an opportunity to enrol in courses offered by prestigious Universities from all over the world, MOOCs cover an extent range of topics that attracts many students with different objectives and motivations. MOOC environment has revolutionized education; they have become very popular among students.

Usually, MOOCs are designed following a simple class model in which the content is shown through video lectures, screencasts and questionnaires place at lesson’s end that verifies students’ understanding, this type of course is known as xMOOC [1]. However, when the course is about basic electronics, practice is fundamental, the traditional learning sequences used in a MOOC do not consider the integration of assignments (activities) which provide students an opportunity to carry out an active and reflective learning process that encourages the practice and application of what has been learned [2]. In face-to-face electronics courses, this need can be met with the assistance of fully equipped laboratories that allow students to practice and experiment with real electronic circuits. However, when the course is in MOOC format, alternatives must be proposed to give students the possibility to practice and making of the learning process a meaningful and engaging experience, if
teaching process only focuses on theoretical aspects it could be insufficient and sometimes inefficient.

Another important aspect is, MOOCs don’t provide high support and student’s assistance in their quest for knowledge, students are self-taught. Taking this into account, learning activities enhanced with cloud-based tools and simulation software should be developed and integrate into a MOOC especially, when the subject required a great deal of students practice. The education field has not been indifferent to benefits and the impact a simulation software can have in teaching and learning processes. A simulator helps students to see complex relationships, it allows them to practice in a safe and controlled environment. It provides students with new and better methods to solve problems, students develop new competencies and skills in electronics themes.

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Among the advantages of using an electronic circuit simulator can be mentioned: a) It allows the student to modify the parameters of a problem, it is easy to adjust and improve the expected results, b) students can test components that are not physically available c) It is a controlled and safe environment, d) if a configuration doesn’t work, it can be adjusted and run again, e) It allows to identify and eliminate failures, f) Access any circuit node with a click of the mouse makes debugging faster and simple, g) It is easier and quicker to understand and discover a problem solution making match between theory and practice.

This work outlines the design and development of various activities with a circuit simulator in a MOOC, activities were created to help students overcome the difficulties that arise in the learning of electrical circuits, the data was obtained from edX course “Introduction to electrical circuits” developed in early 2018 by a group of professors of the faculty of computer science in conjunction with the department of research and development (GES) of Galileo University. The data set consisted of a pre and post online survey, solution laboratories submission, and participant’s demographic information.

The study is guided by the following research questions: RQ1. What was the perceived usefulness towards these types of activities enhanced with a circuit simulation? RQ2. Do students perceive a real benefit and improve their electronics knowledge and understanding by doing these types of activities in a MOOC? RQ3. Do the students show higher levels of satisfaction and engagement with a MOOC of these characteristics?

This section has established the foundation of our research. The remainder of this work is organized as follows: Section II describes the general characteristics of the course and the design process of learning activities and lab practices with a circuit simulator, section III shows the research methodology used, section IV presents the online surveys results conducted to evaluate the perceived usefulness, and the degree of satisfaction, and finally, section V presents the conclusions of this experience.

2 MOOC IMPLEMENTATION: AN OVERVIEW

In early 2018 a MOOC about electronics was developed by a group of Galileo University professors, the aim of this course was to offer a solid knowledge of basic theory of electrical circuits in DC. This knowledge is indispensable to design and develop analog and digital hardware applications. The purpose of the course was student clearly understand how circuits work by maintaining a simple model with resistors and voltage sources, this model allows them easily analyze circuits with components that provide greater functionality, such as transistors, operational amplifiers and digital circuits.

The MOOC content was structured in 5 lessons, with a student estimated effort of 6 to 8 hours per lesson. It was designed under a constructivist and pragmatic approach, so, the activities and lab practices with a circuit simulator constitute the backbone of the course. Each lesson follows an instructional sequence consisting of video lectures, interactive activities, lab practice and a
questionnaire, the latter two are summative activities, which are used to calculate student final grade. Figure 1 shows the structure of a lesson.

![Figure 1. Structure of a lesson](image)

The alignment of these components in each lesson ensures an internally consistent structure that helps students to achieve their learning goals. In general, the content of the course develops progressively.

2.1 Design process of learning activities and lab practices with circuit simulator

To support meaningful student learning, professors face challenges to find appropriate tools to introduce desirable difficulty into course content, they must to appeal to student's intrinsic motivation to get the most out of the activities [8]. Several studies show that the student's learning experience can be improved when lab practices and practical applications are added. One of the ways to increase student motivation in a MOOC is to apply a "learn-by-doing" approach. This method allows students to acquire knowledge by making or replicating problems by themselves [9]. Students experiment with different scenarios and learn how the concepts are applicable in each case.

Solving electrical circuit problems requires from student's analysis, reflection and creativity. In the course two types of activities were developed, questionnaires and lab practices with a circuit simulator. The questionnaires are problems of electrical circuits in which through an analysis and some mathematics operations, students must introduce a response to be validated by the system. Laboratories, on the other hand, make use of a circuit simulator, which allows students, to solve problems in which they can visually monitor the circuit, analyze the behavior and find the problem solution. Students can design their own circuits, make modifications and observe the results. Figure 2 shows an example.

The circuit simulator integrates seamless into the edX platform through an LTI standard, it allows students to use components such as: voltage sources, capacitors, resistors and MOSFET in an interactive network and send a CC, CA or transient analysis of their circuit to the system to be graded. Students can design and simulate electrical circuits with a few clicks, they just drag components in the editor, draw the connections between them and assign values. The circuit can be approached, moved away, moved from position or rotated.

The most important characteristic of this type of activity is students can do the simulation as many times as they wish or until they get a better understanding of the theory.
3 METHODOLOGY

This study employed a quantitative and descriptive method research applying to an exploratory case-study. The quantitative approach was used to collect data so that information can be quantified and subjected through statistical methods.

3.1 Data collection

Data was collected from two self-administered online surveys; the first (pre-survey) was composed of 12 questions designed to determine enrolled participants' general demographic information, previous experience in this type of courses and to know their learning preferences.

To analyze student's behavior to measure the impact of integrating various learning activities using circuits simulation, the degree of satisfaction after their completion, and results obtained in terms of perceived usefulness, a post-survey with 10 questions, combining closed-ended questions related to demographics data and set of questions using a weighted options of Likert scale, was used to measure the levels. Table 1 shows online survey structure and question types. This second survey was only sent to learners who completed the course and scored more than 70 points.

<table>
<thead>
<tr>
<th>Table 1. Online survey structure and question types</th>
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<tr>
<td><strong>Section</strong></td>
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<tr>
<td>Demographic Data</td>
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<td>Perceived Usefulness</td>
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<td>Degree of satisfaction</td>
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Each participant was provided with an information sheet related to the nature and purpose of the research and a consent form to be completed prior to being surveyed.
4 RESULTS

4.1 Course demographics

The experience presented corresponds to the MOOC “Introduction to electrical circuits”, implemented in edX during April 2018 with 3,867 registered students. 86% of learners were male and the median learner age was M=30 years old. Among participants, 29% had pre-university studies, 52% studied at university, 15% had professional occupations (bachelor’s degree). Most of the participants were from Mexico (20%), Spain (12%), Colombia (10%), Guatemala (10%) and Peru (7%); these countries represent 55% of all course participants. 45% of the registered participants indicated it was the first MOOC in which they had been enrolled. 38% of students enrolled in this course because they felt that the learning content would be useful for their university studies.

4.2 Students behaviour analysis

This study is based on the total number of students who completed the course with a grade greater than 70 points (83 students). For this purpose, we used the post-survey, the full sample obtained comprised 57 questionnaires (68%).

A relevant part of the study was to assess whether participants considered the use of the electronic circuit simulation software to be conducive to knowledge creation. For this purpose, a set of questions using a 5-point Likert scale (from strongly disagree to strongly agree) was used to determine the perception usefulness of electronic circuit simulation software. Table 2 shows some of the results.

<table>
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<th>Question</th>
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<td>Did the use of this type of software (simulator) allow you to build knowledge?</td>
<td>4.26</td>
<td>0.99</td>
</tr>
<tr>
<td>Do you think that the use of the simulator in the development of the exercises improved your skills in the design and solution of problems related to electrical circuits?</td>
<td>4.33</td>
<td>0.93</td>
</tr>
<tr>
<td>Do you think the use of the simulator helped you understand the concepts better and more easily?</td>
<td>4.30</td>
<td>0.98</td>
</tr>
<tr>
<td>Did the use of the simulator help you understand the theory and apply what you learned faster and more safely to what you were doing?</td>
<td>4.25</td>
<td>0.89</td>
</tr>
<tr>
<td>Do you think these types of integrated development environments (IDE) make learning more comfortable, efficient and safe?</td>
<td>4.56</td>
<td>0.78</td>
</tr>
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According to these results, the students consider that the use of the electronic simulator in the MOOC was beneficial and helped them to understand the concepts and applications of the electrical circuits in an easy and fast way.

In relation to student satisfaction with the use of this type of software to support learning activities, figure 3 shows that 54% of them are fully satisfied when using this type of resource, 30% are satisfied. In other words, more than 84% have indicated that they are very satisfied with the use of this type of tool.

![Figure 3. Degree of satisfaction](image-url)
5 CONCLUSIONS

This study presents the results obtained from the experience of designing and application of an electronic circuit simulation software as a complementary tool that helps the students to better understand the theory and functioning of electronic circuits into one MOOC "Introduction to electrical circuits, deployed in the edX platform. The overall aim of this integration was to know the student perceptions, motivation and utility towards the use of this tool, and its impact on students learning process. The integration of an electronic circuit simulation software into learning activities was simple and seamless for the students. According to the results, experience is improved in a significant way, it makes a clear difference for all those students who wish to learn and want to get better in their academic and professional performance.

Electronic circuit simulation software integration into learning activities increased student’s engagement with the course. The findings show a high degree of satisfaction when students perform activities of this type, students take a more active role, changing the way they usually learn [9]. The limitation of this study is the small size of the data. However, this subset (57 students) is representative of student participation and completion in a real MOOC. The data set has been used to mainly demonstrate the effectiveness of learning activities using a circuits simulator. It can be concluded that when activities, enriched with technology, are integrated into a MOOC, they make a clear difference for all those students who want to learn, the result is a significant improvement in their academic and professional performance.

REFERENCES


