CREATION AND USE OF LOW-COST LEARNING COMPONENTS

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ABSTRACT

This paper presents the creation of an e-learning ecosystem for the course Instruments and Measurements, taught in the Electronics Engineering undergraduate program at Pontificia Universidad Javeriana in Bogotá, Colombia. The ecosystem consisted in a set of virtual learning objects including 95 tutorial videos, 20 simulation scenarios, interactive class notes and assessment material, all available online. The created material received high acceptance from the students while showing great potential as combined tools to reinforce the learning process.

KEYWORDS

Virtual Learning Objects, E-learning, Video-tutorial, laboratory, Active learning, Standards 8, 9

INTRODUCTION

Since the adoption of the CDIO initiative in the Electronics Engineering program at the Pontificia Universidad Javeriana in Bogotá, Colombia, different implementations and innovations have been carried out to stimulate active learning in the students within the subjects that compose the curriculum. One of the courses that have been extensively subjected to a set of innovative strategies is Instruments and Measurements. This course is responsible for providing the students with the technical skills for operating electronic measurement equipment. Some of the topics taught during one semester are: apply measurement methods, techniques for presenting experimental results, analysis techniques to interpret experimental information, operation and use of instruments in the development of laboratory measurements and theoretical validation of knowledge acquired in previous courses about electrical circuits and signals. Since electronic design is a fundamental part of our program, working in the laboratory is a permanent activity and therefore the operation of equipment for the realization of measurements are skills and knowledge that our students must acquire and maintain thanks to the practice and the bibliographic material, which includes equipment manuals, class notes made by teachers, guided laboratory practices, and online self-assessment.

An extensive search was carried out throughout Internet to find potential tutorial videos available that deal with the operation and management of the laboratory equipment to offer the students complementary material to the topics seen in the theoretical part of the course. Unfortunately, the available material did not meet the expectations in terms of production quality in both image and sound, clarity and development of concepts, security, specificity, shallow depth, even including strong conceptual errors, and finally, language – Spanish in this case.

For this reason, a project to create video tutorials was proposed, and a first pilot was developed with a further assessment of the acceptance of the students. The positive opinion received from the pupils in this first stage, motivated a larger project dedicated to producing e-learning tools to complement and enhance the theory of the course. This paper presents the creation of an e-learning ecosystem consisting of a total of 95 tutorial videos, 20 simulation scenarios, and assessment material. As an additional strategy, the students were prompted to produce their video tutorials presenting the use of a specific equipment or conducting a particular experiment. In this manner, the students took the role of prosumers, i.e. producers of the content of which they are also users (Sarsa, 2014).

The paper is structured as follows: the first section shows previous work in VLOs. The following section details of implementation and operation of our VLOs, technical production of them, including some examples of final products. Then we present the results about student perception and use of the VLOs and finally, in the last section, we provide the conclusions and future work.

RELATED WORK

Virtual Learning Objects (VLO) emerged during the 90s decade, because of the need to share and reuse content in any area of knowledge (Colomé et al., 2012). VLOs is defined as "digital or non-digital" tools supported by technology (Wiley, 2000), that can be used, reused and referenced to facilitate the learning process, encouraging the student autonomy throughout self-learning, while at the same time shifts the role of the teacher to a "mentor, guide and evaluator" of the process (Montagud et al., 2013). VLOs help to develop and expand the landscape of active learning (CDIO Standard 8), including self-assessments and formative assessments with real-time feedback. The emergence of different technologies such as Internet, tablets and digital blackboards, have opened the door for a change in traditional models of teaching inside a classroom to a model based on self-learning using VLOs as new educational tools (Arango et al., 2014). In this new paradigm, it can be observed a convergence of didactic theories, methods, technologies and services intertwined to facilitate and enhance the learning process.

Most online learning environments available can be related to an "information warehouse", where users can browse and retrieve information from a repository without any learning support. VLOs can facilitate significative e-learning if they are oriented to construct learning ecosystems, where the participation of users is part of an instructional strategy in which not only the learning objects and digital repository are available to share and reuse, but also the system can keep learner profiles to achieve personalized learning experiences. In this case, the instructional paradigm shifts from instructor-centred to learner-centred (Lin & Kuo, 2005).

Several reports have shown that video becomes a highly effective educational tool (Allen and Smith, 2012; Kay, 2012; Stockwell et al., 2015). Arango, et al (2014) proposed a set of VLOs to teach Differential Calculus that includes two elements: a video-lesson where the contents are presented systematically and comprehensively, and a motivational program as a video-support material, where the authors claim that the learning occurs. This video-support is a set of interactive material that demonstrate the verbal speech to stimulate student participation during and after the viewing. It is important to remark that authors recognize the necessity of supplementary tools add to the audio-visual lessons to assure a significative learning process. Rodriguez and Romero (2019) go further in the creation of VLOs proposing a model where the students take the role of prosumers, producing video-lectures for their classmates as mean to report a research assignment of a particular topic in the course of History of the English Language. With this approach, the authors claim that students reach a higher level of autonomous learning since they know in advance that the objective of the course is to produce high-quality videos for their peers, in addition to the widely discussed advantages of peer instruction model (Mazur, 1997). Finally, in a more qualitative evaluation, the students manifested high satisfaction with the course after the participation in the video projects. Similar approach was attempted in this project, where the students generated video tutorials to be added to the course repository.

Another interesting approach of the use of VLOs is their use for teaching technical skills as operation of equipment in virtual scenarios. Lin and Kuo (2005) discussed a learning environment prototype called Best Virtual Worlds (BVW), where learners are immersed in a virtual world, where they can manipulate the VLOs while the learning scenario can be created instead of simple static information browsing. Similar concept was presented by Lazarou, et al. (2019) using VLOs for teaching technical skills as operation of equipment in virtual laboratories where objects can be experienced by the students in a realistic and user-friendly way, using virtual and augmented reality. Authors report that this kind of environment, allow the students to accelerate the learning and working process while simultaneously learn a large amount of information involving all their senses and react to it with "language, actions and body language". Following this idea, a total of 20 oscilloscope simulation scenarios were developed, including control, manipulation and measurement of signal parameters.

IMPLEMENTATION AND OPERATION

As the intention was to have a set of VLO's available to students, the first step was to create a visual identity to give a consistent image and format to all the material that was planned to be created. In addition to easily identifying the material, a visual identity gave a sense of belonging to the students. Figure 1 shows the banner and logo created to brand the tools developed for e-learning ecosystem.

Figure 1. Image of the visual identity of the VLO's set. "Electronics Engineering. Instruments & Measurements"

All the material created incorporated the logo observed in Figure 1, including the videos, the simulation scenarios and the tests and written information such as the class notes and the laboratory guides. Figure 2 presents a screenshot of one of the class notes with the corresponding logo that identifies it.

Figure 2. Class notes with the visual identity of the VLO's. "Vertical Sensitivity"

The second stage consisted in the production of 95 video tutorials. A joint work was developed with an audiovisual team to plan the pieces, 60 of them between 2 and 5 minutes long, 26 between 5 and 10 minutes long, and 9 between 10 and 20 minutes long. The videos were produced with the help of a technical group specialized in audiovisual production and with the appearance of professors and laboratory technicians. All of the videos are available both in the digital learning space of the class, and in a YouTube channel, called "*Instrumentos Lab 101*". The tutorials cover different topics regarding the work in the laboratory such as safety standards, handling equipment, methodology for performing measurements in the laboratory, etc. The topics covered by the tutorials are distributed as follows: 10 videos on metrology, 36 on oscilloscopes, 40 on multimeters and 9 on welding. The main objective was to maintain the safety of the people who handled the equipment, since improper use could cause accidents such as electrical shock or fires. Likewise, guarantying the integrity of the equipment and reducing the probability of damage due to misuse. Finally, to reduce the number of working hours in the laboratory for students due to an incorrect measurement process as a result of a lack of knowledge of equipment management. As an additional strategy, students where encourage to produce their video tutorials. The videos are also available on a free access YouTube channel: "*Instrumentos Lab 101*". Although the videos were initially created for internal consumption, the channel has about 200 subscribers and the videos have reached a combined audience of more than 16,000 views. Figure 3 shows one frame of a single video, incorporating the visual identity.

Figure 3. Image of a video tutorial on YouTube channel "*Instrumentos Lab 101*"

To complement the videos, 20 simulation scenarios were designed with an analogue oscilloscope, in which the students had to move the controls to answer the questions of each scenario as seen in Figure 4. Similarly to the videos, the simulation scenarios are available on a freely accessible web page. The rest of the information and the material created is placed on the learning management system belonging to the course, hosted in this case in the platform Blackboard. In addition to indicating if the answer of a particular problem has been answered correctly or not, the software issues a feedback that indicates if that a possible mistake could have been made if that is the case or in turn, it explains why the provided answer is indeed correct. Each session includes a set of videos regarding a topic, interactive class notes, exercises and the use of simulation scenarios. Once completed, students are assessed through a formative evaluation, so that they monitor their level of learning.

For the production of the videos, professional help was received provided by the centre of technical resources of visual audio production within the University, called the *Centro Ático*. The realization of the videos was staged at the "*Sala Ágil*" (Agile Room) within *Centro Ático*. This is a space created to make low-cost videos at an accelerated pace so that professors can create their content simply and efficiently without the need to cover advanced technologies, while at the same time, maintaining product quality.

The room was adapted as a small TV studio of approximately 20 m^2. This studio is equipped with a 21" IMac computer with an Intel Core i7 3.1 GHz processor and an NVIDIA GeForce GT 650M graphics card, a 512MB hard drive and a 2TB backup hard drive, 16 GB of Memory MHz DDR3. A second integrated 21" screen complements this system so that the teacher can observe in real-time the process what is being recorded as seen in Figure 5. Thus, in this small space, it is now possible to make audiovisual products almost in real-time with only the help of a technician who guides the capture process by operating the software and subsequently the final edition of the product made by placing banners, music and input and output messages.

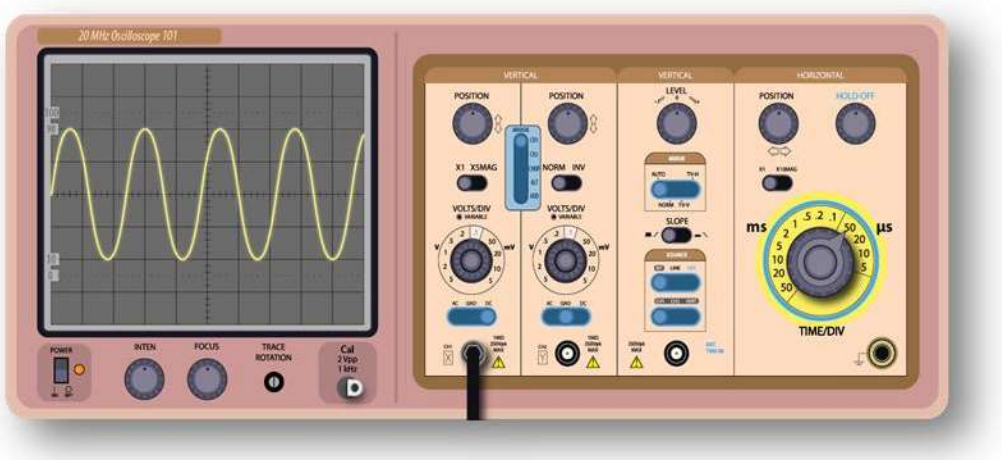

Figure 4. Analog oscilloscope of simulation scenarios

Figure 5. Equipment and physical space of the agile room.

As part of the classwork, students were asked to make a video regarding laboratory equipment management or measurement methods. The purpose of this assignment was for the student to become an expert in the management of a specific equipment or the realization of the specific measure, so that he could create the video accordingly. This goal was achieved, but additionally, it worth to mention that the videos produced by students were made with high technical quality and appropriate academic content. Several of these videos have been selected to be part of the YouTube channel.

RESULTS

Students were asked to fill out an online survey, which had 20 questions about the content of the VLOs, their relevance, their usefulness and about the process of creating videos made by themselves. Around 83% of the students agreed that the videos were clear and less than 20% of them consider that the new concepts presented in the videos were difficult to understand. Nevertheless, 100% of them considered themselves prepared to address the topics shown in the videos. More than 85% of the students agreed that the VLOs helped them to understand the management of the equipment, to make better measurements, to complement the class learning and to promote their autonomous learning. Regarding the preference of videos as bibliographic resources, more than 85% consider that it has been more useful than other types of resources and about 96% of them prefer the videos as study material.

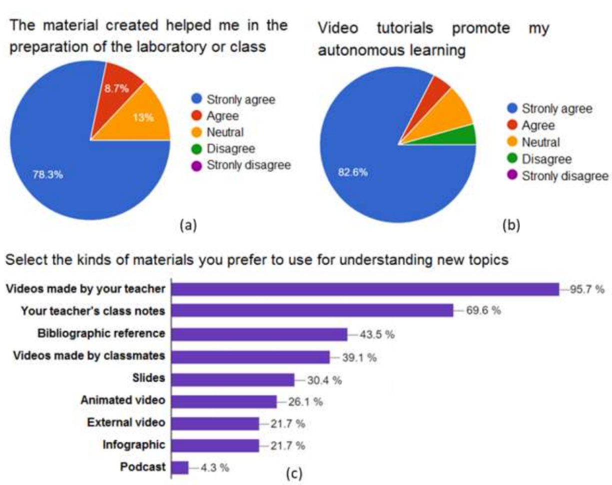

Figure 6. Sample result from survey of Instruments and measurements students

Only 25% of the students consider that making a video tutorial is easy, but about 70% of them felt qualified to do it and more than 80% felt they had the academic as well as technological mastery to do it. About 80% consider that videos should be considered as a percentage of evaluation within the class as seen in Figure 6(a)-(b).

Regarding to the material they prefer to study, there is a strong tendency to choose the material made or recommended by the teacher (Videos 96%, class notes 70%, course guidebook 43.5%). Then comes in the preference the videos created by classmates and later the teacher's slides, all of them well above the material created by external people, animations with Powtoon or Podcasts, as reflected in Figure 6(c).

Worth to mention that the efforts and the amount of work necessary for the creation of VLOs, tend to be much more demanding than preparing a traditional course in a classroom. Behind each new object, some extra work is required that involves among others: identification of the object in the syllabus of the course, the definition of the object, design, creation, realization and testing. A suitable approach consists in to gradually generate each VLO along the semester, and even in consecutive versions of the course. In our favour, the professor in charge of the course invested time during a sabbatical semester to carry out this work. Despite the extra effort involved in the preparation of the material, this is a one-time endeavour, and at the end, the reward is observed in the improvement of the learning process and comments from the students.

CONCLUSIONS

Lecture classes correspond to traditional teaching model, although some modifications and innovations have been incorporated, including active learning, providing tools that expand the offer of content flipped classroom, blended and online classes (Brame, 2016). This paper has discussed the creation of an e-learning ecosystem for the course Instruments and Measurements, a course taught in the Electronics Engineering undergraduate program at Pontificia Universidad Javeriana in Bogotá, Colombia. The ecosystem consisted in a set of VLOs including a total of 95 tutorial videos, 20 simulation scenarios, interactive class notes and assessment material, all available online.

The tools were highly valued by the students, who manifested high acceptance of the material. The highest rating received is for the videos, however, they indicate that the material created has helped them to improve their learning process and it has promoted self-learning practices. On the other hand, the experience of creating their videos, helped the students to increase their self-confidence in their academic capabilities and technological knowledge to perform the videos, becoming prosumers. These exercises, in addition to promoting the deepening of concepts in the development of video, strengthen communication and teaching skills, increasingly demanded in the workplace. Improvement in the communication skills of engineers must be monitored as part of future work.

Finally, results have shown the feasibility of producing videos tutorials at a reduced budget. However, the authors of this paper recommend that professors in charge must be released in time to develop quality material. The generation of this type of tools is demanding in terms of time and resources. For instance, the team in charge of the project reported in this paper was granted with incentives in time by reducing teaching and administrative hours, and nevertheless, only around 50% of the syllabus of the course is covered with the material currently produced. The time invested in the production of the tools was one semester.

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