Exploring the use of Quick Response Codes: accessing videos in the laboratory

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ABSTRACT
Bringing the digital world and "digital natives" to hands-on engineering laboratory classes can be a challenge and an opportunity. Videos can be used, but is important that students know exactly what video to watch for each apparatus. That is why the possibility of accessing videos with QR codes is essential to build a bridge from concrete to digital content. The aim of this research is to evaluate the importance undergraduate engineering students attribute to instructional videos that explain the operating procedure of laboratory apparatus, and their reaction to the possibility of accessing them with quick response (QR) codes. Results show students attributed some importance to the videos and the QR codes in the laboratory are very helpful as means to quickly and easily access the videos.

Categories and Subject Descriptors
• Information systems~Multimedia content creation

Keywords
Videos; QR codes; laboratory; higher education

1. INTRODUCTION
Active learning in engineering is not possible without laboratories, and the recognition of its importance by engineering teachers dates back to 1980 [7]. From the earliest days of engineering education, instructional laboratories have been an essential part of studies programmes ([6], [16], [19]), as it should, because of the overall goal of engineering education being the preparation students to practice engineering and also because students' understanding of a domain can be enhanced when they engage in laboratory experiments [14].

Krivickas and Krivickas [12] argue that engineering education is inconceivable without laboratory instruction, but the modernised laboratory is a challenge to the academic staff to develop new and more effective laboratory instruction.

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Undoubtedly the massification of Higher Education is a challenge, as laboratories required human and material resources depend directly of the number of students. But if, as mentioned by Feisel [6], this works against a quality laboratory experience, the introduction of ICT (Information and Communications Technology) works for it.

The ICT broad use, which can be seen as an obstacle to hands-on conventional laboratories classes, is really an opportunity, because almost every students have the technological means to access the worldwide web, having technology that "walks in" classes with students [10]. Students are used to access information with a click or a slide, and laboratories must keep up to date, and not be restricted to the physical space of the laboratory itself.

The great majority of higher education students are what Prensky described as 'digital natives' [17] because of their familiarity with and reliance on ICT. They are described as living lives immersed in technology, "surrounded by and using computers, videogames, digital music players, video cams, cell phones, and all the other toys and tools of the digital age" [17]. Bennett [1] points out that "they are held to be active experiential learners, proficient in multitasking, and dependent on communications technologies for accessing information and for interacting with others", but this might not be entirely true, as students' everyday technology practices may not be directly applicable to academic tasks.

In their literature review, Halupa and Caldwell [11] highlight the difficulty in implementing new methods and technologies in the classroom, and the resistance of the students themselves to learning in a new way.

That is why it is important that the use of ICT in the laboratory is done with moderation and in an integrated way, blending it in the hands-on laboratory, and by doing so, improving learning.

We argue that this purpose is well served by instructional videos that can be used to explain procedures and show what is expected to happen when performing a certain experiment, allowing students to watch them over and over again, while performing the actual experiment. As these videos can be made available in a platform such as YouTube, is important that students know exactly what video to watch when in the laboratory. That is why the possibility of accessing videos with QR codes is essential, to build what Gradel and Edelson designate as a "bridge from concrete to digital content" [10].

The aim of this research is to evaluate the importance students attribute to instructional videos that explain the operating procedure of laboratory apparatus, and their reaction to the possibility of accessing them with quick response (QR) codes.

2. VIDEOS AND QR CODES

2.1 Teaching and learning with videos

Although the use of learning videos has been widely employed in the past years, recently the interest has been incrementally increased, because of platforms such as YouTube [4], [9], and video-based learning systems, such as Khan Academy and edX, and new for-profit companies, such as Coursera and Udacity [9].

According to Caspi, Gorsky and Privman [3], educational videos can be divided into three categories: demonstration videos, narrative videos and lecture sessions videos. In the laboratory, demonstration videos are used, being a really good tool in order to allow and improve autonomous learning, becoming much more effective than other methodologies based on more traditional methods. Therefore, this methodology allows faculty, especially in technology related areas, to develop new teaching and learning strategies, adding a new dimension in the teaching material.

When it comes to demonstrating procedures, being able to watch them in video, while also hearing an explanation and reading the actual procedure, is more effective than just reading de procedure, because of the possibility to visualize the interaction with the apparatus.

Videos offer the possibility to match learning pace with students own needs [3], [4], and the increasingly use of smartphones and tablets [9] make it possible to watch the videos while operating the apparatus in the laboratory.

On the down side, instructors need to have knowledge on how to do the videos, having the design skills and creativity needed, besides all appropriate hardware and software [4]. Although this endeavour may be time consuming, a good video can be used for years, and made available easily in YouTube, mainly because it is free, user friendly and mobile friendly [4].

2.2 Using QR codes

How to present and where to host a video are determined by the video's purpose and audience [2]. In the laboratory it is essential for students to know what videos to watch, being able to access them, not only while operating the equipments and apparatus, but also whenever is needed. So, according to Gradel and Edelson [10] "field and lab work may be enhanced by connections to existing content".

Bolorizadeh et al. [2] found that "students are willing to use video resources as long as the videos can be found easily, the videos are short and present the desired information quickly, and the information is accurate".

QR codes are two-dimensional matrix codes, easy to use and to create, and that can be freely generated online. They were designed in Japan, by Denso Wave Incorporated, in 1994, to meet the increasing market demands of information storage capacity, character types, and print size limitations of standard bar codes [5], and have also been widely adapted for advertising purposes.

For Lombardo [15], the real value of QR code access is the speed and convenience with which the information is delivered, eliminating the need for manually key text when accessing documents, videos, or an internet website.

To read QR codes, mobile devices need a camera and a scanning application. If the content being access is online, a connection to the internet is also needed.

When using QR, users' scanning history is saved in their QR readers, just as with internet browsers. This redundancy may hold a special valence for educational purposes, since, once scanned, resources accessed by QR codes become immediately "clickable" in the students' mobile devices [10]. To use this feature properly, dynamic QR codes should be use.

In dynamic QR codes it is possible to update the content being accessed without changing the address, because it is an online service that generates an address that redirects the user to the content. So, even if the content is changed, the URL is the same, and, reprinting of the code is not necessary after changing the information. The online management of dynamic QR codes also makes it possible to retrieve statistics from its usage.

This is not the case of static QR codes that point out to a certain address. If the information is changed (for example, a new version of a video is uploaded to YouTube), it is likely that a new address is created, which means that a new static QR code will be needed.

Nevertheless, the use of a free online dynamic QR code service is not without risks, as Lombardo et al. point out [15], as "relying on free services, based somewhere out on the Internet, creates the risk that the service can increase the pricing, or disappear altogether". So a paid service might be a good investment.

In education, the use of QR codes is still in its infancy [13], but with "usage across both P-12 and higher education settings" [10]. Many of the research regards the usefulness of QR codes, or similar technologies, in undergraduate classroom settings, libraries, and museums [20], but not engineering's education laboratories.

3. METHOD

3.1 The context

This study was conducted in one of the laboratories of the Mechanical Engineering Department of a Higher Education Institution in Portugal, which is mainly attended by undergraduate students.

The laboratory has several apparatus that are used by the students with manuals and operational procedures that are available for consultation. A video of an operational procedure that is common to several apparatus was made available in all the apparatus that required it, with a dynamic QR code (figure 1). The video was 1:51 minutes long. Another video, of an operational procedure of a particular apparatus (figure 2) was also available in its apparatus, with a dynamic QR code. The video was 1:38 minutes long. The videos and QR codes were all created with free software.

Figure 1. QR code of a video of an operational procedure

Figure 2. Laboratory apparatus with QR codes

It was explained to all students how they could access the videos in the laboratory using their smartphones and tablets (figure 3), and also how to save this information for further use. Almost all the students had the technological means to do it, which was expected because in Portugal, 46.4% of cell phones bought in 2012 were smartphones, and in young people with ages ranging from 15 to 24 years old, this value is 60% above average [8].

Figure 3. Student accessing a QR code with the smartphone

The videos were intended as a complement for a more detailed explanation provided by teachers, and were not associated with any particular course or studies programme.

3.2 Participants

The participants were 41 students (36.6% female and 63.4% male) of a civil engineering studies programme in a Portuguese Higher Education Institution, being a convenience sample that represented 57% of the students attending the laboratory (72 students). All participants collaborated voluntarily with this research.

The age of the participants ranged from 19 to 66 years old (M=27.59, SD=9.439); 34 participants (82.9%) were Portuguese and seven (17.1%) had other nationalities; 32 (78.0%) were second year students and seven (17.1%) were in the third year (4.9% were missing values); 29 (70.7%) attended classes during the day, while nine (22.0%) did it at night (7.3% were missing values).

3.3 Instruments

To evaluate the importance of instructional videos as pedagogical resources, VINCERE questionnaire was applied. It is Likert-type scale, with a total of 12 items, with responses organized on a scale 1-7, where 1 is "unimportant" and 7 means "full importance". The items are aggregated in three dimensions: ease and motivation; appropriateness to the contents and objectives; role in the evaluation. Three of the original scale items were not use and a new item was included. This adapted VINCERE questionnaire had 10 items for a maximum of 70 points.

Some additional questions were included, namely regarding audio and image quality of the videos, and the importance of accessing them with QR codes.

Participants were also asked to comment on the strengths and weakness of the videos.

A socio-demographic and academic questionnaire was used to characterise the participants, including items as age, nationality, gender, studies course, curricular year and classes' schedule.

3.4 Procedure

Participants were approached during classes (with the permission and cooperation of their teachers) in December 2014 and asked to answer to a paper-and-pen questionnaire. The participation was voluntary. The data was collected after the participants had attended the practical classes in the laboratory.

After collecting the data, the validity and reliability of VINCERE was assessed. For the validity of the scale, the adequacy of data to exploratory factor analysis, was evaluated using the Kaiser-Meyer-Oklin criteria and Bartlett's test of sphericity. The sample size was adequate with a Kaiser-Meyer-Oklin value of 0.773 and Bartlett's test of sphericity (Chi-square(21)=117.412, p=0.000) was statistically significant as required. These results allowed exploratory factor analysis with the principal components analysis extraction method and varimax rotation. Factors with an eigenvalue greater than one were retained. The indicator of the scale's reliability was internal consistency, and Cronbach's alpha was performed.

Content analysis was used for the participants' comments on the strengths and weakness of the videos, using emergent categories.

4. RESULTS

The 10 items VINCERE questionnaire were first subjected to exploratory factor analysis (principal components analysis extraction method; varimax rotation) in SPSS 21.0. Three items (item 1, 3 and 5) were dropped and two factors were identified (appropriateness to the contents and objectives: item 2, 4, 7 and 9; ease and motivation: item 6, 8 and 10). The two factors identified accounted for 75.30% of the variance and included seven items. Factor one (appropriateness to the contents and objectives) explained 44.7% of the variance and factor two (ease and motivation) explained the remaining 30.6%. Factors' loadings are included in table 1. Communalities ranged from 0.471 to 0.838.

Table 1. Results of the factor analysis (factors' loadings)

Scale items	Factor loading	
	Factor 1	Factor 2
2	0.887	---
4	0.876	---
7	0.830	---
9	0.867	---
6	---	0.636
8	---	0.876
10	---	0.914

The alpha levels were good, being 0.830 for the total scale, 0.864 for factor one (appropriateness to the contents and objectives) and 0.763 for factor two (ease and motivation).

Table 2 includes descriptive statistics such as means, standard deviations and standard errors for the importance students attribute to the videos (total of VINCERE scale; maximum 49 points) and for its factors (maximum 28 points for factor one and 21 points for factor 2). The overall score is 57%, being 36% for appropriateness to the contents and objectives and 21% for ease and motivation.

Table 2. VINCERE scale descriptive statistics

Factors	N	M	Std. Deviation	Std. Error
Appropriateness to the contents and objectives	32	17.69	4.915	0.869
Ease and motivation	32	10.41	3.934	0.695
Total VINCERE Importance of the videos	32	28.09	7.346	1.299

The item that scored lower, on average (M=3.41), was the one related to not using other information sources because of the videos. The item that scored higher, on average (M=4.81), was the one related with the video being a clear example of what was intended to demonstrate.

As for the audio and video quality it was, on average, considered good. No participant found it bad. Some participants considered it very good.

The videos were viewed 1.54 times on average (most of the participants watched them once; 25% of participants watched them two or more times to a maximum of five times).

When questioned about the importance of being able to access the videos with QR codes in the laboratory, the average score of the participants responses was 4.53, with the 75% quartile scoring 6.75 (the highest of all items).

Participants' comments on the strengths of the videos included the quickness on accessing information about the experimental procedure, the easiness in the access to information, and the clarity of the explanation given. As the weakness are concerned, participants mentioned some difficulty in the first viewing, the videos being too fast, and the explanation given not being enough. Also the unavailability of more videos was referred as a weakness.

Some confusion seemed to exist, with students thinking the videos were related to a particular course or teacher, and not understanding why the videos were not available as resources for the courses.

5. DISCUSSION AND CONCLUSIONS

We argued that laboratories are of paramount importance for engineering education, but that traditional hands-on classes face several challenges, which can also be seen as opportunities. Having students connected to the digital world, bringing to the classroom their own devices, widens the educational possibilities.

With that in mind, two instructional videos that explained operational procedures were created and made available in the laboratory apparatus by QR codes, being the aim of this research: (1) to evaluate the importance students attribute to these instructional videos, and (2) their reaction to the possibility of accessing them with QR codes.

As the videos were created with free software by the laboratory staff, that are not multimedia experts, it was important to assess the quality of the final product. Students finding it good or very good, makes evidence that is possible, with modest means and some creativity, to make appropriate instructional videos.

The fact that these videos are very technical procedures explanations might account for ease and motivation scoring lower than appropriateness to the contents and objectives.

Students attributed only some importance to the videos (the overall score of VINCERE questionnaire were 57%), which was expected, as only two very short videos were available.

The videos were a complement of others educational resources provided by the teachers of the curricular units, and it was never intended to use them as substitutes, which explains why the item related to not using other information sources because of the videos was the one that scored less, on average.

The clarity of the explanation provided, that is fundamental in instructional videos of procedures was rewarded by the students with the highest score, and the demand for more videos. Other positive aspects were quickness and easiness on accessing information, showing that the QR codes are a helpful solution in the laboratory.

So, in conclusion, students attribute some importance to the videos and the QR codes in the laboratory were well received by the students and very helpful as means to access the videos.

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