Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu

Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Chapter 6

Learning in the Laboratory:
Accessing Videos With Quick Response Codes

Marina Duarte
Polytechnic of Porto, Portugal

Andresa Baptista
Polytechnic of Porto, Portugal

Gustavo Pinto
Polytechnic of Porto, Portugal

ABSTRACT

Using QR codes to access videos in engineering laboratory classes might be a successful way of building a bridge from concrete to digital content. With QR codes placed on an apparatus, students know exactly which video to watch, allowing them to view the videos while performing the experiment or at home when writing the report. Low-cost videos do not require expensive equipment and software, and keeping them short assures a minimum download time for use with smartphones and tablets. The aim of this chapter is to evaluate the importance undergraduate engineering students attribute to these videos and their reaction to the possibility of accessing them with QR codes scanned by a smartphone or a tablet, using access statistics and video viewings to support the findings. Results show students attributed some importance to the videos, and that the QR codes are very helpful as means to quickly and easily access the videos.

DOI: 10.4018/978-1-5225-5279-6.ch006

Copyright © 2018, IGI Global. Copying or distributing in print or electronic forms without written permission of IGI Global is prohibited.

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

INTRODUCTION

The aim of this chapter is to report the findings of research that evaluates the importance students attribute to low-cost, educational, short videos that explain the operating procedure of laboratory apparatuses and the students' reaction to the possibility of accessing videos with QR codes by using a smartphone or a tablet. For a better understanding and support of the results, access statistics and video viewings will also be used.

The rest of this chapter is structured as follows. Following this introduction, the second and third sections address the state of the art regarding the use of videos and QR codes in higher education. In the fourth section, solutions and recommendations are described and presented, namely the case study, the methods used in this research and the results. The final section presents a discussion of results and conclusions.

Background

Active learning in engineering is impossible without laboratories, and the recognition of their importance by engineering teachers dates back to 1980 (Fishenden & Markland, 2006). From the earliest days of engineering education, instructional laboratories have been an essential part of study programs (Feisel & Rosa, 2005; Pandermarakis, Sotiropoulou, Passa, & Mitsopoulos, 2012; Surgenor & Firth, 2011). This is expected because the overall goal of engineering education is the preparation of students to practice engineering and because students' understanding of a domain can be enhanced when they engage in laboratory experiments (Litzinger, Lattuca, Hadgraft, & Newstetter, 2011). In addition, many studies have emphasized the role of laboratory education in students' motivation, which is particularly important considering 'the continuous drop in student numbers taking engineering and science courses' (Abdulwahed, Nagy, & Blanchard, 2008, p. 2).

Krivickas and Krivickas (2007) argue that engineering education is inconceivable without laboratory instruction, but the modernised laboratory presents a challenge to the academic staff in developing new and more effective instruction and facing the 'many disadvantages such as constraints on time, resources, maintenance, expensive equipment, and safety hazards' (Abdulwahed et al., 2008, p. 2).

Undoubtedly, the massification of higher education is a challenge as laboratories requiring human and material resources depend directly on the number of students. But if, as Feisel and Rosa (2005) mention, this works against a quality laboratory experience, the introduction of Information and Communications Technology (ICT) works for it.

The broad use of ICT, which can be seen as an obstacle to conventional hands-on classes in the laboratory, really is an opportunity because almost every student has the

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

technological means to access the World Wide Web, having technology that 'walks in' classes (Gradel & Edson, 2013). Students are used to accessing 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 (2001) describes as digital natives because of their familiarity with and reliance on ICT. They live 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' (Prensky, 2001, p. 1). Bennett, Maton, and Kervin (2008, p. 776) point 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 (2015) highlight the difficulty in implementing new methods and technologies in the classroom and the resistance of students to learning in a new way. Rogado et al. (2015) also report the difficulties students have in incorporating new technology in their learning.

It therefore is important that ICT is used in the laboratory with moderation and in an integrated way, blending it with hands-on experimental activities. Resorting to new and current devices and applications that students use in their everyday life and recognize as good practices (Ricoy & Couto, 2014) might be a good way to capture their interest and increase motivation, and by doing so, improve learning.

This purpose is well served by low-cost, educational, short videos that can be used to explain operational procedures, show what is expected to happen during a certain experiment, and allow students to watch them over and over again while performing the actual experiment. As these videos can be made available in a platform like YouTube, it is important that students know exactly what video to watch when in the laboratory. That is why the possibility of accessing videos with Quick Response (QR) codes is essential to building what Gradel and Edson (2013, p. 62) designate as a 'bridge from concrete to digital content'.

VIDEOS AND QR CODES

Teaching and Learning With Videos

Although the use of educational videos has been widely employed in past decades (Cruse, 2006), recently interest in their use has increased incrementally because of platforms such as YouTube (Chan, 2010; Giannakos, 2013; Meseguer-Martinez, Ros-Galvez, & Rosa-Garcia, 2017), video-based learning systems such as Khan Academy

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

and edX, new for-profit companies such as Coursera and Udacity (Giannakos, 2013) and new teaching/learning models such as flipped learning (Fulton, 2014; Observatory of Educational Innovation of the Tecnológico de Monterrey, 2014). Moradi, Liu and Luchies (2016, p. 2) conclude that 'interactive instructional videos are an essential tool in student-centred curriculum'.

According to Caspi, Gorsky and Privman (2005), educational videos can be divided into three categories: demonstration (or procedural) videos, narrative videos and lecture session videos. In the laboratory, demonstration videos usually are used, as they are really good tools that allow and improve autonomous learning and are becoming much more effective than methodologies based on more traditional methods. Therefore, this methodology enables faculty, especially in technology-related areas, to develop new teaching and learning strategies, adding a new dimension to the teaching material, increasing learners' motivation and enhancing their learning experience (Cruse, 2006).

Being able to watch a demonstration of procedures in a video, while also hearing an explanation and reading the actual procedure, is more effective than just reading about them because of the opportunity to visualize the interaction with the apparatus. The presence of different stimuli (image, sound and text), are what makes it appropriate for more learning styles or preferences (Alqahtani, Al-Jewair, AL-Moammar, Albarakati, & ALkofide, 2015). When motion is involved, video is the more adequate educational resource (Telg, 1999). In a study conducted by Goset and Espinoza (2014, p. 93), 'the results showed a clear preference for the use of the demonstrative type of videos, specifically for information transmission'. The benefit of using videos is the fact that:

The procedures display, reinforced with text or narrative creates a common language and shared meanings. The complexity of the oral language to explain technical activities or situations is remedied by the visual language, giving the possibility to create a meaningful and relevant common conceptual basis. (Goset & Espinoza, 2014, p. 93)

Videos have the advantage of using

… audiovisual language that is synthetic and integral. It is entirely synthetic, since it merges audio and visual to create a new communication. It is not an addition, but a merging of sound and moving image, which allows the brain to integrate, at the same time, the information that it understands and the information that visual and acoustic memories have preserved, which give the whole its meaning. (Cloutier, 1975, p. 136)

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Videos also offer the possibility to match learning pace with students' own needs (Caspi et al., 2005; Chan, 2010), and the increasing use of smartphones and tablets (Giannakos, 2013) make it possible to watch videos while operating the laboratory apparatuses. Furthermore, students can watch the videos at home as many times as needed, taking notes, pausing, and moving backward and forward according to their own needs (De la Fuente Sánchez, Hernández Solís, & Pra Martos, 2013). This makes learning more flexible (Montoya & Hernández, 2016), 'and allows students to review technical procedures before, during, or after the laboratory sessions' (Alqahtani et al., 2015, p. 1).

On the down side, students can experience some technical problems (Montoya & Hernández, 2016), and instructors need to have the knowledge, design skills and creativity to create the videos in addition to having the appropriate hardware and software. Although this endeavour may be time consuming, a good video can be used for years and easily can be made available on YouTube, which is free, user friendly and mobile friendly (Chan, 2010). Nowadays, the 'easy creation, distribution and instantaneous uploading and downloading of digital media is the norm' (Bramhall, Radley, & Metcalf, 2008, p. 2). It is not necessary to be an expert to make a good quality video as 'the fast development of new technologies and the decrease of costs related to video recording, editing and production, make this tool available to faculty, allowing self audiovisual creation, according to the own needs and by means of economic tools' (Fernandez et al., 2011, p. 3).

Using QR Codes

The video's purpose and audience determine how to present it and where to host it (Bolorizadeh, Brannen, Gibbs, & Mack, 2012). In the laboratory, it is essential for students to know which videos to watch and to be able to access them not only while operating the equipment and apparatuses, but also whenever it is needed. So, what is necessary is a way to add virtual information to the real world because by doing so, 'field and lab work may be enhanced by connections to existing content' (Gradel & Edson, 2013, p. 62). Bolorizadeh et al. (2012, p. 375) 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'. Because nowadays there is a widespread use of smartphones (with cameras and internet connection), every one of these users has the means to read codes that store not only a lot of information, but also can provide a link to all kinds of resources online. From the codes available, the one that serves this purpose better is the QR code.

QR codes are two-dimensional matrix codes, easy to use and to create, that can be freely generated online. They were designed in Japan by Denso Wave Inc. in 1994

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

to meet the increasing market demands of information storage capacity, character types, and print size limitations of standard bar codes (Denso Wave Incorporated, n.d.-a), and they have been widely adapted for advertising purposes. Compared with other codes, like the barcodes, that are very popular because they can be scanned very quickly and accurately provide information with multiple features (Mobile-QR-Codes.org, n.d.-a), the QR codes have the advantage of storing more information- up to some hundred times more than the barcodes (Mobile-QR-Codes.org, n.d.-b)- while taking up a smaller printing area. These features of the QR codes, allows the delivery of information with speed and convenience, eliminating the need to manually key text when accessing documents, videos or an internet website (Bonifácio, 2012; Law & So, 2010; Lombardo, Morrow, & Le Ber, 2012). Because of their general use, like accessing promotions and additional information for consumers, purchasing a variety of items, initiating phone calls and sending short messages or emails, it is likely that students will be familiarized with them.

To read QR codes, a mobile device with a camera and a scanning application is needed. If the content being accessed is online, a connection to the internet also is required. When using QR codes, users' scanning history is saved in their QR readers, just as with internet browsers. This redundancy may hold a special valence for educational purposes because, once scanned, resources accessed by QR codes become immediately 'clickable' in the students' mobile devices (Gradel & Edson, 2013).

There are two kinds of QR codes: static and dynamic. Dynamic QR codes are preferable because it is possible to update the content without changing the address since the codes are an online service that redirects the user to the new content. Even if the content changes, the URL remains the same and reprinting of the code is not necessary. The online management of a dynamic QR code also makes it possible to retrieve statistics from the code's usage. This is not the case for static QR codes that point 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 is needed.

Nevertheless, the use of a free, online, dynamic QR code service is not without risks, as Lombardo et al. (2012, p. 22) point out, because '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 (Law & So, 2010), but with 'usage across both P-12 and higher education settings' (Gradel & Edson, 2013, p. 50). According to Law and So,

The low technical barrier of creating and reading QR codes allows innovative educators to incorporate them into their educational endeavours. The operations

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu

Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

to retrieve or store QR codes are incredibly simple and quick, and with mobile devices, make them the ideal educational tools for teaching and learning. (Law & So, 2010, p. 85)

Many research studies focus on the usefulness of QR codes because ‘any new technology needs to be perceived as being useful in order for it to be accepted and assimilated into people’s daily routines’ (Shin, Jung, & Chang, 2012, p. 1417), pointing out its attractiveness for students (Ali, 2017; Durak, Ozkeskin, & Ataizi, 2016). The settings for much of this research are nursing practice (Jamu, Lowi-jones, & Mitchell, 2016), undergraduate classrooms, libraries, and museums (Traser et al., 2015).

SOLUTIONS AND RECOMMENDATIONS

Context of the Case Study

The current study was conducted in the School of Engineering of Polytechnic of Porto, in Portugal. Founded in 1852, the school has more than 6,000 students and 500 faculty and staff members, organized in departments that are responsible for 12 Bachelor of Science and 11 Master of Science degrees. As a polytechnic school, the emphasis is on students learning how to apply knowledge to become agents of global progress. This tradition of applied knowledge and research is grounded in a large number of laboratories and technical staff, enabling students to have a hands-on approach to learning.

The research took place in the Heat and Fluids Laboratory (H&F Lab). This lab is one of the laboratories of the Department of Mechanical Engineering, which is attended mainly by students earning a Bachelor of Science degree in mechanical engineering or civil engineering.

The H&F Lab has 339 square meters, with several apparatuses and instruments in hydraulics, fluid mechanics, thermodynamics, heat transfer, turbomachinery and refrigeration (see Figure 1). To help students to better use the equipment and understand underlying concepts, the laboratory has made available manuals and written operational procedures.

Videos in the H&F Lab

In the H&F Lab there are written operational procedures for all the apparatuses and experiments. Although these procedures are well illustrated, videos make many details more understandable because they present motion. Using written procedures as a

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Figure 1. Heat and Fluids Laboratory (H&F Lab)

starting point, the authors planned to create two low-cost, educational videos: one regarding an operational procedure that is needed in several apparatuses (video 1) and another featuring an operational procedure only used in a particular apparatus (video 2). The educational purpose of the videos was to complement a teacher's live explanation of the operational procedures, namely by including (a) a brief explanation of the main features of the apparatus, (b) safety instructions, (c) how to operate the apparatus and its instrumentation and (d) what to measure and how to measure it. The videos were not associated with any particular course or programme.

The low-cost option relates to the ease with which this methodology can be applied in other contexts. Fernandez et al. (2011, p. 3) define low-cost educational video 'as a short demonstration stream video which has a very specific goal and has been created in a very short period of time, with few resources and that can be combined or embedded within other materials of a course'. The creation of these kind of videos implies, according to Simo et al. (2010, p. 2939), 'finding ways to produce and distribute audiovisual teaching equipment minimizing the costs(…) both in terms of physical resources and economic, as in actual time spent by faculty in the design and creation of audiovisual material'.

The choice was made to create mini-videos, defined as 'short videos that constitute a technological educational resource to convey particular information that will help

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

to consolidate a certain learning' (De la Fuente Sánchez et al., 2013, p. 180). Hsin and Cigas (2013) recommend using short videos as a way to address several issues presented by long videos such as the difficulty in maintaining students' attention and the problem of a lengthy file download. Some authors (De la Fuente Sánchez et al., 2013; Hsin & Cigas, 2013; Sexton, 2006) report the use of videos under five minutes.

For the videos in the H&F Lab, the intention was for students to be able to download them with smartphones or tablets, which would be easier with very short videos. Because of that, the published videos were 1:51 minutes and 1:38 minutes long, for video 1 and video 2 respectively. Although this implied that the action taking place on the video would happen at a relatively fast pace, this possible limitation could be overcome by students stopping the video or rewinding it.

In the making of these short videos, planning was very important to ensure that the educational purpose of the videos was met. Resorting to the plan-shoot/capture-edit-deliver methodology (Bolorizadeh et al., 2012), the making of the videos comprised the following steps.

First was the development of the plan: the team chose two written operational procedures as the subject for the videos. These procedures were used to write the storyboard and the script, and the location was checked for light and sound conditions. The authors installed free or common license software for the editing of film, images (photos) and audio; the software included a video editor, an audio editor, an image and photo editor and a presentations editor. Free versions of software tend to include only a portion of the features available in the paid version of the software, which often is enough as long as the essential features are maintained. This simplifies its use and does not require advanced levels of computing.

The second step was shoot/capture. The team checked all equipment, using a standard digital camera to capture film (with audio) and photos, and made image and audio tests in the location, capturing film and audio using different plans (different angles and views), and different zoom (zoom in and zoom out). Finally, the image and audio quality was checked before finishing the shooting session. At this stage, .avi files were used for the recording, because of their high quality and ease with which they can be imported into editing software (Malaga & Koppel, 2016).

The third stage was the editing. The team downloaded all film and photos. Photos were edited for better quality (contrast, brightness and colour). All relevant film scenes were selected and still images and film were combined, in order to match the script and storyboard. The team included some text whenever it improved comprehension of the video content. This led to the first version of the video. Using this video, the script was adjusted, and the timing of narration was rehearsed to assure a correct diction and pronunciation of all the words. The team recorded the narration while watching the video, to ensure synchronization. The narrator was a person of the team and not a computer, for a more natural result. The audio file of the narration was

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

cleaned of all background noises, and the tone of the voice was slightly improved (bass and treble). The team added this narration to the video, maintaining the location's audio whenever it was needed. Next, the team obtained feedback and included the suggestions in the final version, adding finishing elements before having experts in this scientific/technical field validate the content and accuracy of the information conveyed by the final version of the videos.

The final stage was delivering the videos, considering file size, portability and distribution. According to Malaga and Koppel (2016, p.11) 'the two main file formats that are appropriate for online teaching seem to be WMV and MPEG-4'. We chose MPEG-4 because it can play natively on newer computers and mobile devices (packs of codecs can be downloaded for older computers). The authors chose to host the videos on the YouTube platform (currently, the streaming video platform with the most visits, with a billion users; YouTube for Press, n.d.) and selected the appropriate quality/size for publishing the video. Links and other necessary access features for the video were created, and tested with several smartphones and tablets.

QR Codes in the H&F Lab

To overcome the difficulty of accessing the virtual world in the real world environment of the H&F Lab, the videos were linked to QR codes. The authors made a thorough search of free editors (online and offline) of dynamic QR codes and found a free online website. This website also provides access statistics and has no limit for the number of codes generated. These dynamic QR codes are black and white, black representing foreground squares and white representing background squares. The number of modules is 29 x 29 (version 3), which allows the storage of 32–127 characters, depending on the type of information (Denso Wave Incorporated, n.d.-b). This was enough for each video link.

QR codes include redundant information with the purpose of making corrections possible. So, even if damaged, this redundant data ensures the readability of QR codes. The correction level of data in the free dynamic QR codes generated online is 30% (The Marketing Bureau UK Ltd, n.d.), and the three pattern-detection squares on the corners allows the scanning of the code in any direction (omnidirectional).

The team conducted tests with several smartphones and tablets in a multitude of circumstances to ensure that these technical features were appropriate and that the codes worked in less than perfect conditions. Because there are a number of free apps available to scan QR codes, we downloaded and tested several, choosing the ones with higher ratings. All the apps were adequate.

The QR codes were printed (testing the appropriate size) and made available on the apparatus (see Figure 2 and Figure 3) and on information boards in the H&F Lab. All the students participating in the study were told how they could access

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu

Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Figure 2. Student accessing a QR code with the smartphone

the videos using their smartphones and tablets and how to save this information for further use. Almost all the students had the technological means to access the videos, which was expected because in Portugal 46.4% of cell phones bought in 2012 were smartphones. For people 15–24 years of age, this value was 60% above average. These numbers represent an increase in smartphone use of 80% since May 2012 (Gaspar, 2014), and the more recent information shows that the number of smartphones users, in Portugal, continues to grow (GrupoMarktest, 2016), reaching in 2017 a 65% penetration (Wikipedia, 2017). Because most common uses amongst consumers of smartphones under 25 years old are accessing social networks (83%), finding information (67%), and weekly watching videos online (75%) (Fernandes, 2017), resorting to smartphones as educational tools will not require a different use.

Method

The participants were 41 students (36.6% female and 63.4% male) studying to earn a bachelor of science degree in civil engineering in the School of Engineering of Polytechnic of Porto. This was a convenience sample that represented 57% of the students attending the H&F Lab (72 students). Students attended the laboratorial classes in October and November of 2014, and had a deadline of two weeks to write

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu

Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Figure 3. QR code of Video 1 (general procedure used with several apparatuses) and Video 2 (specific procedure used in one apparatus)

a report on each one of the different experiments done in the H&F Lab. Students worked in groups of three to four students, which means that there were 20 to 22 different groups.

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

All participants collaborated voluntarily with this research.

To evaluate the importance of educational videos as pedagogical resources, the instrument used was an adapted version of the VINCERE questionnaire (FEUP-LEA, n.d.). Responses on the survey were measured using a 7-point Likert scale, where 1 is unimportant and 7 is full importance. The items are aggregated in three dimensions: ease and motivation, appropriateness to the contents and objectives and role in the evaluation. Three of the original 12 items were not used because they did not apply, and a new item was included because of the type of videos used. This adapted 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 also were asked to comment on the strengths and weakness of the videos.

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

The procedures adopted for data collection and analysis began by approaching the participants during classes (with the permission and cooperation of their teachers) in December 2014 and asking them to complete a paper-and-pen questionnaire.

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Participation was voluntary. The data were collected after the participants had attended practical classes in the H&F Lab.

The data collected was prepared and checked for errors. Then, the validity and reliability of the VINCERE questionnaire was assessed (with SPSS 21.0). To measure the validity of the scale, we evaluated the adequacy of data for exploratory factor analysis 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 ($\chi2$ (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 weaknesses of the videos, using emergent categories.

Results

The 10-item VINCERE questionnaire first was subjected to exploratory factor analysis (principal components analysis extraction method; varimax rotation). Three items (items 1, 3 and 5) were dropped, and two factors were identified. Factor 1 (appropriateness to the contents and objectives) was comprised of items 2, 4, 7 and 9 and explained 44.7% of the variance. Factor 2 (ease and motivation) was comprised of items 6, 8 and 10 and explained the remaining 30.6% of the variance. Table 1 presents the factor loadings.

Communalities ranged from 0.471 to 0.838. The alpha levels were good, being 0.830 for the total scale, 0.864 for Factor 1 (appropriateness to the contents and objectives) and 0.763 for Factor 2 (ease and motivation).

Table 1. Results of the Factor Analysis

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

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu

Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Table 2 includes descriptive statistics such as means, standard deviations and standard errors for the importance students attributed to the videos (total of VINCERE scale; maximum 49 points) and for its factors (maximum 28 points for Factor 1 and 21 points for Factor 2). The overall score was 57%, with 36% for Factor 1 and 21% for Factor 2.

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

On average, the audio and video quality was considered good; no participant found it bad while others considered it very good.

The videos were viewed 1.54 times on average (most participants reported watching 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 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 of being able to access information about the experimental procedure, the ease in accessing information and the clarity of the explanation given. Regarding the weaknesses, participants mentioned some difficulty in the first viewing, the videos being too fast and the explanation given not being enough. Participants also referred to the unavailability of more videos 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. They had trouble understanding that it was the H&F Lab that created the videos and made them available, regardless of courses and study programmes.

Additional information was also obtained with statistics from YouTube. Video 1 (general procedure used in several apparatuses) was mainly viewed on a computer or smartphone (53% and 44%, respectively; 3% used a tablet). Views of this video spanned from October 2014, when students were in the laboratory, to January 2015, when the classes of this course ended. The majority of these views occurred in the

Table 2. VINCERE Scale Descriptive Statistics

Factors	N	M	SD	SE
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

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu

Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

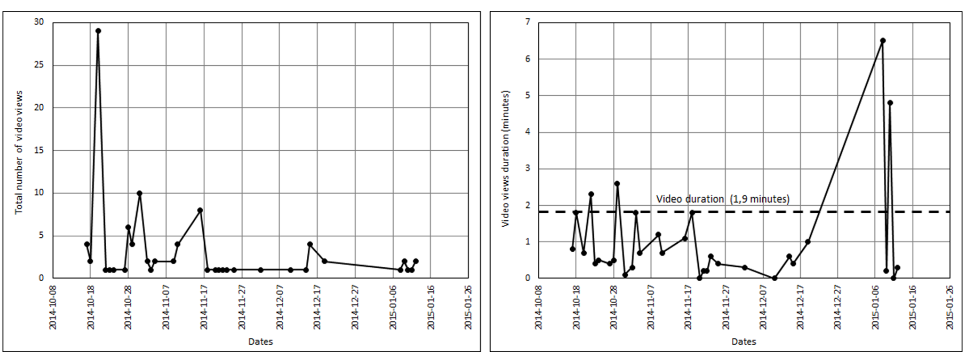
period that students were doing this procedure in the H&F Lab (October to November, as shown in Figure 4). Video 1 had a total of 100 views, with 25% having at least one minute (half the duration of video 1) and 50% having only the initial 30 seconds (see Figure 4) that correspond to the portion of the video in which the description of the apparatus is done. Although students had to hand-out to the teacher the report of the laboratorial coursework, two weeks after being in the laboratory, some students did it much later, which would explain some views in January. Because a long time had passed, these students probably relied on the view to write their reports, which explains why these visualizations are several minutes long.

Video 2 (specific procedure used in one apparatus) was mainly viewed on a computer or smartphone (57% and 36%, respectively; 7% used a tablet). Views of this video spanned from November 2014 to December 2014 (as shown in Figure 5), when students were in the laboratory doing this procedure. Video 2 had a total of 14 views, with 30% being of the full video and 20% having only the initial 30 seconds (see Figure 5).

CONCLUSION

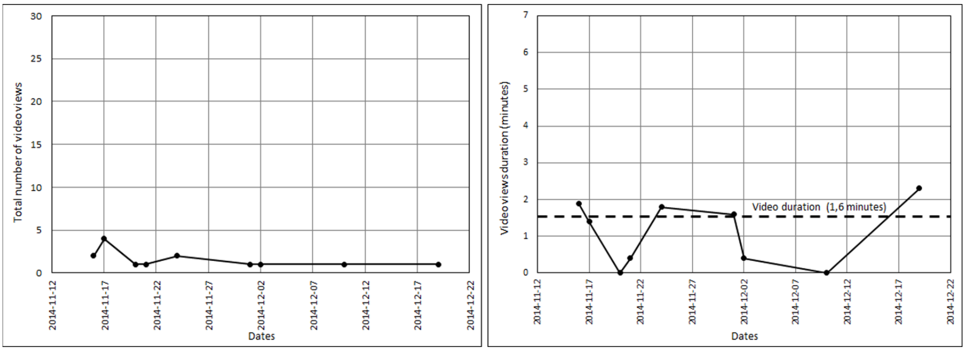
Laboratories are of paramount importance for engineering education, but traditional hands-on classes face several challenges, which also can be seen as opportunities. Having students connected to the digital world, bringing to the classroom their own devices, widens the educational possibilities. Although we could argue that the teacher is totally dependent on students having smartphones with internet connection, in order to resort to this educational resources, it is also true that with the use of smartphones growing globally every year (Statista, 2017), this issue is becoming less and less of a problem by the day. This indicates that not only is it more and

Figure 4. Viewing pattern of video 1



Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Figure 5. Viewing pattern of video 2



more likely that students have the resources to use ICT in classes, but also that they are used and motivated to resort to them in a variety of contexts.

With that in mind, two low-cost, educational short videos that explained operational procedures were created and made available in the H&F Lab through the use of QR codes. The aim of the research was to evaluate the importance students attribute to these instructional videos and their reaction to the possibility of accessing them with QR codes.

As the videos were created with free software by the laboratory staff, not multimedia experts, it was important to assess the quality of the final product. Students found them good or very good, showing that is possible, with modest means and some creativity, to make appropriate educational short videos.

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

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

The videos complemented other educational resources provided by the course teachers, and it was never intended to use them as substitutes. This explains why the item that was related to not using other information sources because of the videos scored lower on average.

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

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Most of the views, for both videos, were done during classes, but views pattern show that video 1 (related with several apparatus) was useful for students preparing the report after the deadline.

In conclusion, students attribute some importance to the videos, the videos used both in classes and also later on, and the QR codes in the laboratory were well received by the students who considered them very helpful as a means to access the videos.

ACKNOWLEDGMENT

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. The authors thank Dr Ana Mouraz for sharing the Portuguese version of the VINCERE questionnaire and allowing its use in this research.

REFERENCES

Abdulwahed, M., Nagy, Z. K., & Blanchard, R. (2008). The Tri Lab, a Novel View of Laboratory Education. In *Proceedings of the EE2008 - International conference on innovation, good practice and research in engineering education*. Loughborough, UK: HEA Engineering Subject Centre.

Ali, N. (2017). Pre-service Teachers ' Perception of Quick Response (QR) Code integration in Classroom Activities. *TOJET: The Turkish Online Journal of Educational Technology*, *16*(1), 93–100.

Alqahtani, N. D., Al-Jewair, T., AL-Moammar, K., Albarakati, S. F., & ALkofide, E. A. (2015). Live demonstration versus procedural video: A comparison of two methods for teaching an orthodontic laboratory procedure. *BMC Medical Education*, *15*(1), 199. doi:10.1186/s12909-015-0479-y PMID:26537393

Bennett, S., Maton, K., & Kervin, L. (2008). The 'digital natives' debate: A critical review of the evidence. *British Journal of Educational Technology*, *39*(5), 775–786. doi:10.1111/j.1467-8535.2007.00793.x

Bolorizadeh, A., Brannen, M., Gibbs, R., & Mack, T. (2012). Making Instruction Mobile. *The Reference Librarian*, *53*(4), 373–383. doi:10.1080/02763877.2012.707488

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Bonifácio, V. D. B. (2012). QR-Coded Audio Periodic Table of the Elements: A Mobile-Learning Tool. *Journal of Chemical Education*, *89*(4), 552–554. doi:10.1021/ed200541e

Bramhall, M., Radley, K., & Metcalf, J. (2008). Users as producers: students using video to develop learner autonomy. In *Proceedings of the EE2008 - International conference on innovation, good practice and research in engineering education*. Loughborough, UK: HEA Engineering Subject Centre.

Caspi, A., Gorsky, P., & Privman, M. (2005). Viewing comprehension: Students' learning preferences and strategies when studying from video. *Instructional Science*, *33*(1), 31–47. doi:10.1007/s11251-004-2576-x

Chan, Y. M. (2010). Video instructions as support for beyond classroom learning. *Procedia: Social and Behavioral Sciences*, *9*, 1313–1318. doi:10.1016/j.sbspro.2010.12.326

Cloutier, J. (1975). *A era de Emerec ou a comunicação audio-scripto-visual na era dos self-media* [The age of EMEREC or the audio-script-visual communication in the era of self-media]. Ministério da Educação e Investigação Científica - Instituto de Tecnologia Educativa.

Cruse, E. (2006). *Using Educational Video in the Classroom: Theory, Research and Practice*. Retrieved 6 June 2017, from http://www.libraryvideo.com/articles/article26.asp

De la Fuente Sánchez, D., Hernández Solís, M., & Pra Martos, I. (2013). El mini video como recurso didáctico na aprendizagem de materias cuantitativas [Mini videos as didactic resources in quantitative subjects]. *Revista Iberoamericana de Educación a Distancia*, *16*(2), 177–192. doi:10.5944/ried.16.2.9911

Denso Wave Incorporated. (n.d.a). *Answers to your questions about the QR code*Retrieved 14 November 2017, from http://www.qrcode.com/en/about/version.html

Denso Wave Incorporated. (n.d.b). *Information capacity and versions of the QR code*. Retrieved 15 March 2016, from http://www.qrcode.com/en/

Durak, G., Ozkeskin, E. E., & Ataizi, M. (2016). QR codes in education and communication. *Turkish Online Journal of Distance Education*, *17*(1), 42–58. doi:10.17718/tojde.89156

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Feisel, L. D., & Rosa, A. J. (2005). The Role of the Laboratory in Undergraduate Engineering Education. *Journal of Engineering Education*, *94*(1), 121–130. doi:10.1002/j.2168-9830.2005.tb00833.x

Fernandes, J. (2017). *Estudo da Google indica que adopção de smartphones triplica em Portugal* [Google report indicates that smartphones use in Portugal triples]. Retrieved 6 July 2017, from http://wintech.pt/53-noticias/google/23040-estudo-da-google-indica-que-adopcao-de-smartphones-triplica-em-portugal

Fernandez, V., Simo, P., Ines, A., Maria, A.-S., Nuria, S., Amante, B., & Federico, G. et al. (2011). 'Low-Cost Educational Videos' for Engineering Students: A New Concept Based on Video Stream and Youtube Channels. *International Journal of Engineering Education*, *27*(3), 1–10.

FEUP-LEA. (n.d.). *Vincere: Ciências e Engenharia em português* [Vincere: Science and Engineering in Portuguese]. Retrieved 15 March 2016, from https://paginas.fe.up.pt/~lea/projvincere/

Fishenden, C., & Markland, E. (2006). A systems approach to elementary laboratory instruction. *European Journal of Engineering Education*, *4*(3-4), 293–302. doi:10.1080/0304379800040306

Fulton, K. P. (2014). *Time for Learning: Top 10 Reasons Why Flipping the Classroom Can Change Education*. Corwin Press. doi:10.4135/9781483332772

Gaspar, A. (2014). Metade da população portuguesa já utiliza smartphones [Half of the Portuguese population uses smartphones]. *Jornal de Notícias*. Retrieved from http://www.jn.pt/PaginaInicial/Tecnologia/Interior.aspx?content_id=4114579

Giannakos, M. N. (2013). Exploring the video-based learning research: A review of the literature. *British Journal of Educational Technology*, *44*(6), E191–E195. doi:10.1111/bjet.12070

Goset, J., & Espinoza, P. (2014). Perception of the use of teaching videos in preclinical training of Chilean dentistry students. *Journal Oral Of Research*, *3*(2), 90–94. doi:10.17126/joralres.2014.022

Gradel, K., & Edson, A. J. (2013). QR Codes in Higher Ed: Fad or Functional Tool? Journal of Educational Technology Systems, 41(1), 45–67. doi:10.2190/ET.41.1.e

GrupoMarktest. (2016). *Smartphone continua a crescer em Portugal* [Smartphone continues to grow in Portugal]. Retrieved 5 July 2017, from http://www.marktest.com/wap/a/n/id~2046.aspx

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Halupa, C. M., & Caldwell, B. W. (2015). A Comparison of Two Engineering Statics Courses: Traditional Lecture-based and Lecture-based with Online Supplemental Video. *International Journal of Higher Education*, *4*(1), 232–240. doi:10.5430/ijhe.v4n1p232

Hsin, W.-J., & Cigas, J. (2013). Short videos improve student learning in online education. *Journal of Computing Sciences in Colleges*, *28*(5), 253–259.

Jamu, J. T., Lowi-Jones, H., & Mitchell, C. (2016). Just in time? Using QR codes for multi-professional learning in clinical practice. [doi:10.1016/j.nepr.2016.03.007 PMID:27428702]. *Nurse Education in Practice*, *19*, 107–112.

Krivickas, R. V., & Krivickas, J. (2007). Laboratory instruction in engineering education. *Global Journal of Engineering. Education*, *11*(2), 191–196.

Law, C., & So, S. (2010). QR codes in education. *Journal of Educational Technology Development and Exchange*, *3*(1), 85–100. doi:10.18785/jetde.0301.07

Litzinger, T., Lattuca, L. R., Hadgraft, R., & Newstetter, W. (2011). Engineering Education and the Development of Expertise. *Journal of Engineering Education*, *100*(1), 123–150. doi:10.1002/j.2168-9830.2011.tb00006.x

Lombardo, N. T., Morrow, A., & Le Ber, J. (2012). Rethinking mobile delivery: Using Quick Response codes to access information at the point of need. *Medical Reference Services Quarterly*, *31*(1), 14–24. doi:10.1080/02763869.2012.641817 PMID:22289092

Malaga, R. A., & Koppel, N. B. (2016). A Comparison Of Video Formats For Online Teaching. *Contemporary Issues in Education Research*, *10*(1), 7–12. doi:10.19030/cier.v10i1.9876

Meseguer-Martinez, A., Ros-Galvez, A., & Rosa-Garcia, A. (2017). Satisfaction with online teaching videos: A quantitative approach. *Innovations in Education and Teaching International*, *54*(1), 62–67. doi:10.1080/14703297.2016.1143859

Mobile-QR-Codes.org. (n.d.a). *History of QR Codes*. Retrieved 5 July 2017, from http://www.mobile-qr-codes.org/history-of-qr-codes.html

Mobile-QR-Codes.org. (n.d.b). *How Are QR Codes Better Than Barcodes*. Retrieved 5 July 2017, from http://www.mobile-qr-codes.org/qr-codes-vs-barcodes.html

Montoya, M. S. R., & Hernández, D. (2016). Inverted Learning Environments with Technology, Innovation and Flexibility. *Journal of Information Technology Research*, *9*(1), 18–33. doi:10.4018/JITR.2016010102

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Moradi, M., Liu, L., & Luchies, C. (2016). Identifying Important Aspects in Developing Interactive Instructional Videos. In *ASEE Midwest Section Conference*. Retrieved from https://conferences.k-state.edu/aseemidwest2016/files/2016/06/Paper-Moradi-Liu-Luchies-29kd4x4.pdf

Observatory of Educational Innovation of the Tecnológico de Monterrey. (2014). *Flipped Learning. Monterrey*. Retrieved from http://observatorio.itesm.mx/edutrendsaprendizajeinvertido

Pandermarakis, Z. G., Sotiropoulou, A. B., Passa, D. S., & Mitsopoulos, G. D. (2012). The Role of Engineering Educational Laboratories at a Thesis Level. *SEFI (European Society for Engineering Education) 40th Annual Conference Proceedings*.

Prensky, M. (2001). Digital Natives, Digital Immigrants Part 1. *On the Horizon*, *9*(5), 1–6. doi:10.1108/10748120110424816

Ricoy, M. C., & Couto, M. (2014). As boas práticas com TIC e a utilidade atribuída pelos alunos recém-integrados à universidade [Good practices with ICT and the use attributed by higher education freshmen]. *Educação e Pesquisa*, *40*(4), 897–912. doi:10.1590/S1517-97022014005000005

Rogado, A. B. G., Quintana, A. M. V., Conde, M. J. R., Martín, I. R., Abad, F. M., Miguelañez, S. O., & Diego, P. B. (2015, March 11). Adquisición de la competencia de prevención de riesgos en el laboratorio mediante tecnología móvil. *Revista del Congrés Internacional de Docència Universitària i Innovació* (CIDUI). Retrieved from http://www.cidui.org/revistacidui/index.php/cidui/article/view/663

Sexton, R. L. (2006). Using Short Movie and Television Clips in the Economics Principles Class. *Journal of Economic Education*, *37*(4), 406–417. doi:10.3200/JECE.37.4.406-417

Shin, D.-H., Jung, J., & Chang, B.-H. (2012). The psychology behind QR codes: User experience perspective. *Computers in Human Behavior*, *28*(4), 1417–1426. doi:10.1016/j.chb.2012.03.004

Simo, P., Fernandez, V., Algaba, I., Salan, N., Enache, M., Albareda-Sambola, M., & Rajadell, M. et al. (2010). Video stream and teaching channels: Quantitative analysis of the use of low-cost educational videos on the web. *Procedia: Social and Behavioral Sciences*, *2*(2), 2937–2941. doi:10.1016/j.sbspro.2010.03.444

Statista. (2017). *Smartphone users worldwide 2014-2020*. Retrieved 6 July 2017, from https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/

Marina Duarte (mic@isep.ipp.pt)
Instituto Politécnico do Porto - B-on Consortiu
Downloaded: 4/17/2019 8:09:13 AM
IP Address: 193.136.60.226

Surgenor, B., & Firth, K. (2011). The role of the laboratory in design engineering education. *Proceedings of the 2nd Canadian Engineering Education Association*. doi:10.24908/pceea.v0i0.3848

Telg, R. (1999). *Producing an Educational Video*. AEC343/WC024. Retrieved from http://edis.ifas.ufl.edu/wc024

The Marketing Bureau UK Ltd. (n.d.). *FAQs*. Retrieved 15 March 2016, from http://www.freeqrcodetracker.com/pages/faqs

Traser, C. J., Hoffman, L. A., Seifert, M. F., & Wilson, A. B. (2015). Investigating the use of quick response codes in the gross anatomy laboratory. *Anatomical Sciences Education*, *8*(5), 421–429. doi:10.1002/ase.1499 PMID:25288343

Wikipedia. (2017). List of countries by smartphone penetration. Retrieved 14 November 2017, from https://en.wikipedia.org/wiki/List_of_countries_by_smartphone_penetration

YouTube for Press. (n. d.). Retrieved 14 November 2017, from https://www.youtube.com/yt/press/statistics.html

KEY TERMS AND DEFINITIONS

Digital Native: A person who grows up surrounded by technology using it in everyday tasks.

Dynamic QR Code: A QR code with an online resource that can be changed without the need of changing the QR code.

Educational Video: A video that is used with an educational purpose.

Low-Cost Educational Video: A video made with inexpensive equipment and software.

Mini-Video: An educational video of short duration that conveys a particular information.

QR Code: Two-dimensional matrix codes that can be freely generated online and are scanned by a camera.

Static QR Code: A QR code with an online resource that cannot be changed.