STUDENTS PERCEPTION OF VIDEOS IN INTRODUCTORY PHYSICS COURSES OF ENGINEERING IN FACE-TO-FACE AND ONLINE ENVIRONMENTS

Abstract

Digital videos have an important (and increasing) presence in learning processes, especially within online universities and schools. However, creating videos is a time-consuming activity for teachers, who are usually not expert in video creation. Therefore, it is important to know which kind of video is perceived as more satisfactory and useful by students, among the videos that docents usually create.

In this paper we show a structural model with the relation between satisfaction, the way in which a video has been created, the kind of video (with or without the hands of the teacher and with or without the body/head of the teacher), perceived usefulness, contents of the video (theory or problems) and the potential impact of videos on passing rates.

The experiment has been performed in an introductory Physics of Engineering course with over 200 first year students in both: at 100% online university, Universitat Oberta de Catalunya (UOC); and at a face-to-face university, Salesian University School of Sarrià (EUSS). Tests have been performed with around 100 videos of two types: videos created with a digitizing tablet and screen capture and videos created by recording the hands of the teacher. Results have been quantitatively analysed .

The research shows that results are independent of the environment and that students prefer videos with hands. On the other hand, little effect has been found regarding the content of the video in the perceived usefulness or satisfaction. The performance results show that videos can improve the chances of passing the subject. Thus, the paper shows that *videos with hands* are a useful complement to challenging subjects, like introductory physics in Engineering, to effectively assimilate scientific knowledge.

The main contributions of this paper are: to analyse the perception that students have of video in a specific context, introductory course of Physics in Engineering, in different environments; and to analyse the perception of the video regarding the way in which it has been created, and the kind of content.

Key words: educational videos, videos with hands, non-verbal information, e-learning, physics education, STEM, sciences education.

INTRODUCTION

Nowadays, the use of videos is the most common type of social medium (Joost Scharrenberg, 2011) in the context of the classroom and elsewhere (Mike Moran, Seaman, & Tinti-Kane, 2011) .

However, creating videos is a very challenging task, requiring many hours for just a few minutes of video (Koumi, 2006). There are several kinds of videos: teachers that record their lectures, which are easy to create for teachers but have the lowest engagement (Einspruch, Lynch, Aufderheide, Nichol, & Becker, 2007; Guo, Kim, & Rubin, 2014) ; videos created by using screen capture software and tablets (screen capture); and videos created with a camera that films the hands of the teacher when writing (**videos with hands**). Videos with hands also provide to the students an emotional link with the teacher (Ouwehand, van Gog, & Paas, 2015; Westfall, Millar, & Walsh, 2016).

Screen capture and videos with hands could be easy to create for teachers. However, it is important to know: 1) whether videos have any impact to students; and 2) how students perceive them.

These elements have been addressed previously in MOOCs, but with three main limitations: 1) a MOOC is an environment where videos are the core; 2) abandon ratings are around 90% (Ho et al., 2014); and 3) they are not the regular graduate programs.

In this research, we analyze the perceived satisfaction of students with videos (the perceived usefulness and usage), with the type of videos (screen capture and video with hands) and the kind of contents (theory or problems, which is a typical distinction in physics subjects). The relation between all these elements has been tested following the technology acceptance model (TAM) proposed by Nagy (Nagy, 2018).

To provide results environmental-independent, the study has been performed in an introductory course in Physics, but in two different scenarios: at the Open University of Catalonia (UOC after Universitat Oberta de Catalunya) that is a 100% online university, and at the Escola Universitària Salesiana de Sarrià (EUSS) which is a face-to-face university. A similar research has been performed for mathematics at Open University of Great Britain (Loch, Jordan, Lowe, & Mestel, 2014).

A Physics course for engineers has been chosen because it offers a stressful and challenging scenario for most students (Green et al., 2003) . The challenge is even more accentuated in the case of 100% online universities, because of the difficulties of the distance education (Levy, 2007) that drives to a higher dropout (Grau-Valldosera & Minguillón, 2011).

Thus, the present study analyses: Satisfaction (SAT); usage (U); perceived usefulness (PU); the kind of video according to the creation method (TV) and the kind of content, theory or problems (ToP). The work also analyzes differences between physics courses in different studies and different environments (online and a face-to-face university). Finally, the study analyses the performance and results obtained in the analysed course when video is introduced.

This work is divided in the next sections: in the section LITERATURE REVIEW AND RESEARCH MODEL, a literature review is performed and the hypotheses of the current work are stated; the research method is introduced in the METHOD section, RESULTS AND DISCUSSION, the results are shown and discussed. CONCLUSIONS section, the main remarks are summarized.

LITERATURE REVIEW AND RESEARCH MODEL

Explanations given by teachers play a key role in Physics students learning “Such explanations may be given verbally—sometimes in a lecturing mode, but also in whole-class discussions—as well as including diagrams and calculations written on a whiteboard or screen” (Geelan, 2013). The video can facilitate the use, entry and access to information (BECTA ICT Research, 2003). In addition, the use of videos in schools has been very positive in some aspects, such as getting the desired effect on students (Bennett & Maniar, 2008; Reisslein, Seeling, & Reisslein, 2005; Takeda, Takeuchi, & Haruna, 2007) and facilitating the educator’s job (Einspruch et al., 2007).

Videos are widely-used in e-learning (Moran, Seaman, & Tinti-Kane, 2011) and are a very extended resource at university level for science subjects (Astrom, 2011; Chasteen, 2012; Lichter, 2012) because of its effectiveness (Claros Gómez & Pérez Cobos, 2013; Cofield, 2002; Eckert, Gröber, & Jodl, 2009; Green et al., 2003; Herron, Cole, Corrie, & Dubreil, 1999; Mayo, Sharma, & Muller, 2009; Mutlu Bayraktar & Altun, 2014; Pereira, Barros, de Rezende Filho, & Fauth, 2012; Shephard, 2003).

From the student’s point of view, it can be a crucial teaching tool of science subjects in general, and physics in particular, for several reasons:

- It helps acquire the abstraction capacity (Green et al., 2003; Weinrich & Sevian, 2017).
- It helps relate different scientific subjects (Carmichael, 2013; Santaliestra, Costa, & Ortín, n.d.).
- It reduces the difficulty (D.A. Muller, Bewes, Sharma, & Reimann, 2007; Derek Alexander Muller, 2008).

- It facilitates the acquisition of scientific language (Habraken, 2004) .

A key element is the non-verbal communication associated with the lesson (Stull, Fiorella, Gainer, & Mayer, 2018). Information entry to memory can be divided into three channels (Wray & Chong, 2007): verbal, visual (non-verbal), and the input-output information of the working memory. The dual coding theory (Paivio, 1986) points out that reading and writing involve activities in two independent cognitive subsystems of codification: verbal and non-verbal coding.

Among non-verbal information, several studies have shown the importance of iconic gestures (Kutas & Federmeier, 2000; Van Petten & Luka, 2006) that also have semantic information (Goldin-Meadow & Sandhofer, 1999; McNeill, Cassell, & McCullough, 1994; Yap, So, Melvin Yap, Tan, & Teoh, 2011) and are semantically processed (Özyürek, 2014) . Hand gestures in particular, can alter the interpretation of discourse, eliminate ambiguities, increase understanding and memory, and transmit information not explicitly integrated into the discourse (S. W. Cook, Yip, & Goldin-Meadow, 2012; Goldin-Meadow & Singer, 2003; Hubbard, Wilson, Callan, & Dapretto, 2009) . In the case of STEM, Stull (Stull et al., 2018) showed the importance of gesture in the case of chemistry. Some studies have pointed out the importance of showing the teacher's head and his/her gestures in distance learning (Khan & Réhman, 2015). However, there are extra elements that also play an important role in the non-verbal communication, like physical appearance (Westfall et al., 2016); and body language (Cassell, Nakano, Bickmore, Sidner, & Rich, 2001) but they can be decontextualized from the information to transmit (Van Cauwenberge, Schaap, & van Roy, 2014). On the contrary, *Videos with hands* can contribute to reduce the cognitive load by providing *non-verbal* communication (M. P. Cook, 2006; van der Meij & de Jong, 2006).

Recently, Nagy (Nagy, 2018) evaluated an application of the Technology Acceptance Model (TAM) to the usage of video by students, where it is shown that perceived usefulness, attitude, and internet self-efficacy has a direct effect on the video usage.

From the point of view of physics courses, problem solving is used as iinstructional model (Freitas, Jiménez, & Mellado, 2004; Hsu, Brewe, Foster, & Harper, 2004; Huffman, 1997; Van Heuvelen, 1991), which is common in many faculties(Dancy & Henderson, 2010).

hypotheses

Taking into account the aforementioned state of the art, we propose the following hypotheses:

H0: within a physics subject, satisfaction with videos is independent of the environment

This hypothesis can allow us to detect if the results are environment-independent (face-to-face, or virtual).

H1: Satisfaction of students increases when non-verbal information appears in the video.

H2: Perceived usefulness has a positive effect on learning satisfaction.

H2 corresponds to Nagy's proposed TAM to online video usage and learning satisfaction.

H3: The presence of videos of problems increases the perceived usefulness of videos

H4: Perceived usefulness has a positive effect on video usage

This hypothesis corresponds one of the Nagy's.

H5: Students prefer watching problem solving videos to theory videos

H6: Students see videos as complementary material instead of the main resource

The first proposed hypothesis (H0) analyzes the impact of the environment to student perception. The second hypothesis (H1) deals with the satisfaction of the students with the videos. The third hypothesis (H3) focus on the effect of the content of the videos. Hypotheses H2 and H4 assess the impact of perceived usefulness and will be tested by checking whether Nagy's results are hold in the proposed scenario. Finally, hypotheses H5 and H6 are related to the preferences of students and the relevance of the videos in the user learning experience, in a physics course.

METHOD

This section describes the methodology followed in the research that comprised the following stages: the creation of the videos, the definition of the population under study and the collection and analysis of data.

The creation of the videos

Two main kinds of video were created: screen capture (see Figure 1), created with a Wacom tablet; and videos with hands (see Figure 2) created with a camera that filmed the hands of the teacher while he was explaining. Both kinds of video correspond to the same topics and they follow the same structure and notation used within the text material provided to students. In some videos, the head of the teacher was included in a small box inside the video to allow students to see his face. Table 1 shows the number of videos created per topic and kind: 94 hands videos (nearly 10 hours); and 46 tablet videos (over 7 hours).

Videos are mp4 with codec H.264. Aspect ratio is 16:9 with 1280x720 pixels at 25 fps. Sound is in AAC LC, stereo with maximum bit rate of 128 kb/s and sampling rate of 48.0 kHz.

Table 1 Number of videos created with tablet and with hands. In brackets the number of videos of problems of every group is shown.

	Hands		Tablet	
	Number Theo/Prbl	Time Theo/Prbl	Number Theo/Prbl	Time Theo/Prbl
Mechanics	21/18	1:54:20/1:56:26	3/21	0:17:38/3:16:26
Circuits Theory	12/6	0:50:36/0:44:58	0/0	0/0
Electrostatics	7/10	0:34:23/1:23:14	5/7	0:52:24/0:58:45
Magnetostatics	9/11	0:48:54/1:25:46	4/6	0:36:55/1:06:50
TOTAL Theo/Prbl	49/45	4:08:13/5:39:24	12/34	1:45:57/5:22:01
TOTAL Hands and Tablet	94	9:47:37	46	7:08:58
TOTAL	142 videos		16:56:35	

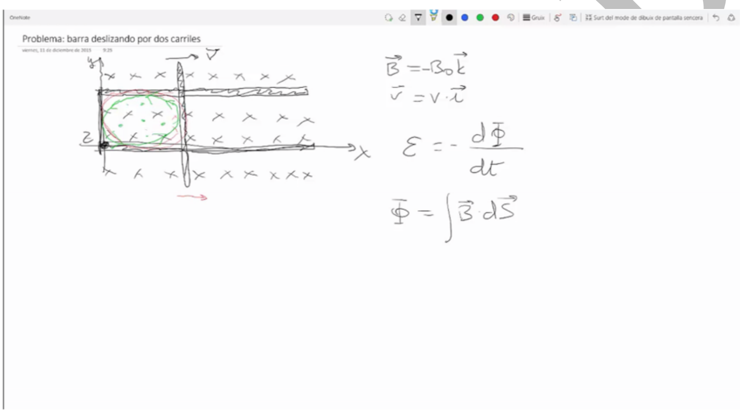

Figure 1 Example of video created with a digitalizing table.

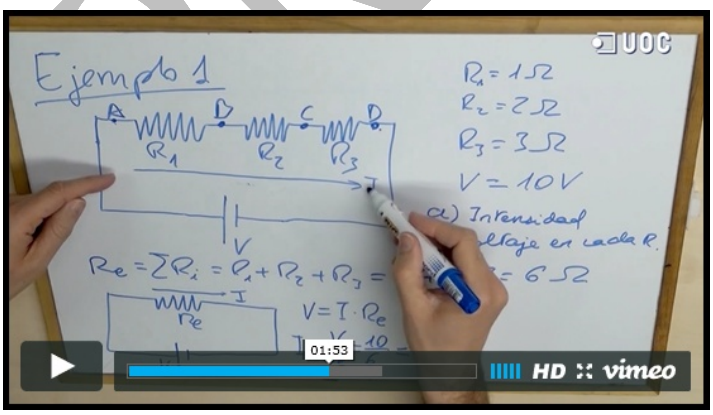

Figure 2 Example of video with hands.

The Population Under Examination

The experiment was performed at two different universities: EUSS, which is a face-to-face university; and UOC, which is a 100% online university. The courses chosen were: Physics of the degree of Industrial Engineering at EUSS ("EUSS"); Physics I of the degree of Telecommunication at UOC ("Tl") and Fundamentals of Physics of the degree of Computer Sciences at UOC ("Inf"). Table 2 shows the topics covered in every course. Within each topic, only the videos that correspond to the corpus of the course were given to the students.

Table 2 Contents of every subject involved in the experiment.

	Tl	*Inf*	*EUSS*
Mechanics	x		x
Circuits Theory		x	
Electrostatics	x	x	x
Magnetostatic	x	x	x

The teacher who recorded the videos is the same for all videos (but for 7 videos, that were created by another teacher and we think are too few to affect the results) and is the teacher of all courses, which is beneficial since students' engagement increases when the videos have been created by their own teacher (Guo et al., 2014).

Videos are given to students at the beginning of every lesson as a complementary material. Students have also access to all of the usual material: text material at UOC and summary and face-to-face classes at EUSS. UOC has a proprietary virtual campus, where students have all the materials corresponding to the subject, and the videos in a tool named Present@ (Bretones et al., 2014; Perez-Navarro, Conesa, Santanach, Garreta, & Valls, 2012; Perez-Navarro, Conesa, Santanach, & Valls, 2012) and communication tools. At EUSS, students have Moodle. Videos are available in Vimeo®, protected by a password to be accessible only to the students of the course.

Students received, every week, a guideline message from the teacher with links to the relevant videos for the week topic and the expected order to visualize them. Watching the videos was not mandatory in any case.

Data Collection

Data collection for the goal of the present paper was performed in two ways: through a questionnaire and through a semi-structured interview. Semi-structured interviews will be analyzed in a future work.

The questionnaire was compiled by using Google Forms and sent during the semesters between September 2016 and February 2018. That corresponds to one semester of EUSS, two semesters of Tl and three semesters of Inf. The number of students to whom the questionnaire has been sent is 62 of EUSS, 129 of Tl and 423 of Inf; and the number of answered questionnaires is 15 (24%) in EUSS, 25 (19,4%) in Tl and 85 (20%) in Inf (see table 3).

Table 3 Summary of the number of students and subjects in the research.

Subject	*Number of semesters*	*Total students*	*Students that answer n*
PhTl	3	129	25 (19,4%)
PhInf	3	423	85 (20%)
PhEUSS	1	62	15 (24%)

Questionnaire Development, Content Validity

The questionnaire was adapted from the one proposed by Nagy. Table 4 shows the Nagy's questionnaire (column 2) compared with the one proposed in this paper (column 3). Since most of the students were in an online environment, with a very well-defined pedagogical model[1], the questions needed to be adapted to fit the environment as well as the online model characteristics, while taking into account also the context of the other face-to-face students. On the other hand, it is important to take into account that in this paper we focus in more specific elements than Nagy's regarding the use of videos, since we would like also to see the effect of the kind of video and its content. The table also shows the name of the variable for every question and for every course. To identify whose course a variable belongs, we add "_Tl" for Telecommunication at UOC, "_Inf" for Computer Sciences (Informatics) at UOC and "_EUSS" for Industrial Engineering at EUSS. In those variables where we need to distinguish between topics, the following identifiers appear: "Mec" is for "Mechanics", "Elc" is for "Electrostatics", "Mgn" is for "Magnetism" and "Cir" is for "Circuits". Finally, the capital letter "T" is for Theory videos and "P" is for Problems videos. Thus, for example, "SNV_MgnP_Tl" corresponds to the variable SNV regarding to Magnetism ("Mgn") in Problem videos ("P") in the course of Telecommunications at UOC ("Tl"). At the end of the questionnaire students had the opportunity to add any comment.

[1] https://www.uoc.edu/portal/en/universitat/model-educatiu/index.html

Table 4 Questions and variable names of the proposed questionnaire compared with Nagy's.

Constructs and Their Indicators Construct	**Indicators (Items) (Nagy's, 2018)**	**Indicators (Items) Proposed/Questions**	**Name of the variables for Physics in Telecommunication (UOC) PhTl**	**Name of the variables for Physics in Computer Sciences (UOC) PhInf**	**Name of the variables for Physics at Industrial Engineering (EUSS) PhEUSS**
Perceived usefulness **PU**	PU1: Using videos makes my learning easier. PU2: Videos support critical aspects of the learning material. PU3: Using videos enhances my effectiveness of learning.	**PU**: "What do you think about the usefulness of videos?" Answers go from 1 to 5; where the higher the number, the higher the usefulness.	PU_Tl	PU_Inf	PU_EUSS
Learning satisfaction **SAT**	SAT1: I am satisfied with my learning from the videos. SAT2: I find the videos to be effective in meeting the learning objectives. SAT3: The videos have contributed greatly to my acquisition of relevant skills. SAT4: The videos make me spend more time studying.	**SAT**: To what extent did the videos help you understand the subject? Possible answers ranged from "not at all" (1) to "daily or more often" (5).	SAT_Tl	SAT_Inf	SAT_EUSS
Video usage **U**	U: How often did you use the videos? Possible answers ranged from "not at all" (1) to	**U**: How often did you watch the videos? Possible answers are: 1) Daily; 2) Weekly, 3)	U_Tl	U_Inf	U_EUSS

	“daily or more often” (5).	Monthly and 4) Never.			
Kind of video regarding the way it has been created. **TV**		**TV**: Which kind of video do you prefer? There are three possible answers: 1) only the voice of the teacher; 2) the voice and the hands of the teacher; 3) the head and part of the body of teacher.	TV_Tl	TV_Inf	TV_EUSS
Content of the video, theory or problems **ToP**		**ToP**: Which kind of video do you prefer? There are three possible answers: 1) theory; 2) problems; 3) theory and problems.	ToP_Tl	ToP_Inf	ToP_EUSS
Number of times a video is watched **NV**		**NV_MecT**: How many times did you watch the videos of Mechanics. Theory?	NV_MecT_Tl		NV_MecT_EUSS
		NV_MecP: How many times did you watch the videos of Mechanics. Problems?	NV_MecP_Tl		NV_MecP_EUSS
		NV_CirT: How many times did you watch the videos of Circuits. Theory?		NV_CirT_Inf	
		NV_CirP: How many times did you		NV_CirP_Inf	

		watch the videos of Circuits. Problems?			
		NV_ElcT: How many times did you watch the videos of Electrostatics. Theory?	NV_ElcT_Tl	NV_ElcT_Inf	NV_ElcT_EUSS
		NV_ElcP: How many times did you watch the videos of Electrostatics. Problems?	NV_ElcP_Tl	NV_ElcP_Inf	NV_ElcP_EUSS
		NV_MgnT: How many times did you watch the videos of Magnetostatics. Theory?	NV_MgnT_Tl	NV_MgnT_Inf	NV_MgnT_EUSS
		NV_MgnP: How many times did you watch the videos of Magnetostatics. Problems?	NV_MgnP_Tl	NV_MgnP_Inf	NV_MgnP_EUSS
Preferred role played by videos **RV**		**RV**: Which role play videos in the subject? There are four possible answers: 1) They are expendable; 2) They are a complement to the text documents; 3) They are the principal resource and the text documents are the complement; and 4) They are the only necessary	RV_Tl	RV_Inf	RV_EUSS

		resource and text documents are expandables.			
Satisfaction with the number of videos **SNV**		**SNV_MecT**: Are you satisfied with the number of videos of Mechanics. Theory? Possible answers are: 1) There were too many videos; 2) I had enough videos; 3) I would have preferred some more videos; 4) I would have like to have many more videos.	SNV_MecT_Tl		SNV_MecT_EUSS
		SNV_MecP: Are you satisfied with the number of videos of Mechanics. Problems? Same possible answers.	SNV_MecP_Tl		SNV_MecP_EUSS
		SNV_CirT: Are you satisfied with the number of videos of Circuits. Theory? Possible answers are: 1) There were too many videos; 2) I had enough videos; 3) I would have preferred some more videos; 4) I would have like to have		SNV_CirT_Inf	

		many more videos.			
		SNV_MecP: Are you satisfied with the number of videos of Circuits. Problems? Same possible answers.		SNV_CirP_Inf	
		SNV_ElcT: Are you satisfied with the number of videos of Electrostatics. Theory? Same possible answers.	SNV_ElcT_Tl	SNV_ElcT_Inf	SNV_ElcT_EUSS
		SNV_ElcP: Are you satisfied with the number of videos of Electrostatics. Problems? Same possible answers.	SNV_ElcP_Tl	SNV_ElcP_Inf	SNV_ElcP_EUSS
		SNV_MgnT: Are you satisfied with the number of videos of Magnetostatics. Theory? Same possible answers.	SNV_MgnT_Tl	SNV_MgnT_Inf	SNV_MgnT_EUSS
		SNV_MgnP: Are you satisfied with the number of videos of Magnetostatics. Problems? Same possible answers.	SNV_MgnP_Tl	SNV_MgnP_Inf	SNV_MgnP_EUSS
α=0.7					

1

Data Analysis

The construct reliability of the questionnaire was examined by using a Cronbach's alpha with 0,7 limit.

To validate hypothesis H0, *Satisfaction with videos in a physics subject is independent of the environment*, we analyzed differences regarding the environment. In particular, we compared the answers to every single question given by *Tl* course students and given by *Inf* and *EUSS* students. Quantitative questions were compared using t-test with $\alpha = 0{,}05$, whose results are in Table 5. Columns *t* and *p* correspond to these values of t-test. Qualitative questions were compared using a χ^2 analysis. Its results can be seen in Table 6, where columns χ^2 and *p* show the corresponding values of χ^2 analysis. The usual limit to reject the null hypothesis are p values lower than 0.05, therefore, since values obtained are above this limit in nearly all cases, null hypothesis cannot be rejected (Lynch, 2013) and this confirms that satisfaction is independent of the environment (H0 is validated). Therefore, results of one course can be taken as representative of all courses and results can be generalizable to any environment. In this paper we will take course *Tl* as representative.

Table 5 Comparison between Telecommunication variables and variables from Computer Sciences and Industrial Engineering through a t of Student.

Telecommunication	Computer Sciences	t	p	Telecommunication	Industrial Engineering	t	p
PU_Tl	PU_Inf	-0,16	0,88	PU_Tl	EUSS_PU	-1,43	0,17
SAT_Tl	SAT_Inf	-0,26	0,80	SAT_Tl	SAT_EUSS	1,29	0,22
NV_MecT_Tl	NV_CirT_Inf			NV_MecT_Tl	NV_MecT_EUSS	1,07	0,30
NV_MecP_Tl	NV_CirP_Inf			NV_MecP_Tl	NV_MecP_EUSS	3,15	0,01

NV_ElcT_Tl	NV_ElcT_Inf	1,37	0,18	NV_ElcT_Tl	NV_ElcT_EUSS	0,60	0,56
NV_ElcP_Tl	NV_ElcP_Inf	1,41	0,17	NV_ElcP_Tl	NV_ElcP_EUSS	0,98	0,34
NV_MgnT_Tl	NV_MgnT_Inf	0,42	0,68	NV_MgnT_Tl	NV_MgnT_EUSS	1,16	0,26
NV_MgnP_Tl	NV_MgnP_Inf	1,18	0,25	NV_MgnP_Tl	NV_MgnP_EUSS	1,55	0,14
RV_Tl	RV_Inf	0,00	1,00	RV_Tl	RV_EUSS	0,37	0,72
SNV_ElcT_Tl	SNV_ElcT_Inf	-1,13	0,27	SNV_MecT_Tl	EUSSNCirT	-0,27	0,79
SNV_ElcP_Tl	SNV_ElcP_Inf	-0,82	0,42	SNV_MecP_Tl	EUSSNCirP	0,25	0,81
SNV_MgnT_Tl	SNV_MgnT_Inf	-0,13	0,90	SNV_ElcT_Tl	SNV_ElcT_EUSS	-0,21	0,84
SNV_MgnP_Tl	SNV_MgnP_Inf	0,27	0,79	SNV_ElcP_Tl	SNV_ElcP_EUSS	0,00	1,00
SNV_MecT_Tl	SNV_CirT_Inf			SNV_MgnT_Tl	SNV_MgnT_EUSS	0,21	0,84
SNV_MecP_Tl	SNV_CirP_Inf			SNV_MgnP_Tl	SNV_MgnP_EUSS	0,21	0,84

Table 6 Comparison between Telecommunication variables and variables from Computer Sciences and Industrial Engineering through a χ^2.

Telecom munication	Computer Sciences	χ^2	p	Telecom munication	Industrial Engineering	χ^2	p

TV_Tl	TV_Inf	3.89	0.14	TV_Tl	TV_EUSS	1.96	0.38
ToP_Tl	ToP_Inf	3.49	0.17	ToP_Tl	ToP_EUSS	1.16	0.56

To verify that there is no effect in the results, regarding the topic, due to different perception of the number of videos for every topic (mechanics, electrostatics, magnetism or circuits), two analyses were performed: an ANOVA and a principal component analysis. The results of the ANOVA (see Table 7) show (with an F=0.546 and an α=0.05) that we cannot reject the null hypothesis. Therefore, the satisfaction with the number of videos is the same, regardless the content or the topic of the video. Table 8 shows the results of the principal component analysis. As can be seen, one single factor explains 83.7% of the variance, which is compatible with the ANOVA conclusion that the satisfaction with the number of videos is the same for all the videos, regardless the topic. Therefore, students do not have different perceptions regarding the number of videos in different topics.

Table 7 ANOVA analysis of the variables SNV_ElcT_Tl, SNV_ElcP_Tl, SNV_MgnT_Tl, SNV_MgnP_Tl, SNV_MecT_Tl andSNV_MecP_Tl to analyze potencital differences between the perception of the number of videos per topic.

	Df	*Sum Sq*	*Mean Sq*	*F*	*Pr(>F)*
Topic of the video	5	2.05	0.4107	0.546	0.741
Residuals	144	108.24	0.7517		

Table 8 Principal component analysis of the satisfaction with the number of videos of every topic.

		Alfa de Cronbach	Principal components
Number of videos of telecommunication	SNV_ElcT_Tl SNV_ElcP_Tl SNV_MgnT_Tl SNV_MgnP_Tl SNV_MecT_Tl SNV_MecP_Tl	0.9688	1 Factor Proportion Var 0.837 Test of the hypothesis that 1 factor is sufficient. p-value is 2.56e-10

The previous steps helped us to verify that neither the number of videos nor the environment affect the results, regarding the kind of the video, the content or the topic. These results allow us to generalize our results to any topic.

The next steps of the methodology are to verify hypotheses H1 to H4: Hypothesis H1, *Perceived usefulness has a significant positive effect on learning satisfaction*, looks for a relation between variables SAT and PU of Table 4; hypothesis H2, *Perceived usefulness has a significant positive effect on video usage*, looks for a relation between variables PU and U of Table 4; hypothesis H3, *satisfaction of students increases when non-verbal information appears in the video*, looks for a relation between variables SAT and TV of Table 4; and hypothesis H4, *the presence of videos of problems increases the perceived usefulness of videos*, which is an element specific of physics courses, looks for a relation between variables ToP and PU of Table 4. These four hypotheses are verified through the structural model proposed in Figure 3. Figure 3a) shows Nagy's structured model (Nagy, 2018) corresponding to the bubbles SAT, PU and U, and Figure 3b) shows the model proposed in this paper. The model is built with the results of *Tl* course, variables SAT_Tl, TV_Tl, PU_Tl, ToP_Tl and U_Tl, because thanks to the validation of hypothesis H0 we can take one single course as representative. A multivariate regression and three linear regressions have been performed as shown in Table 9.

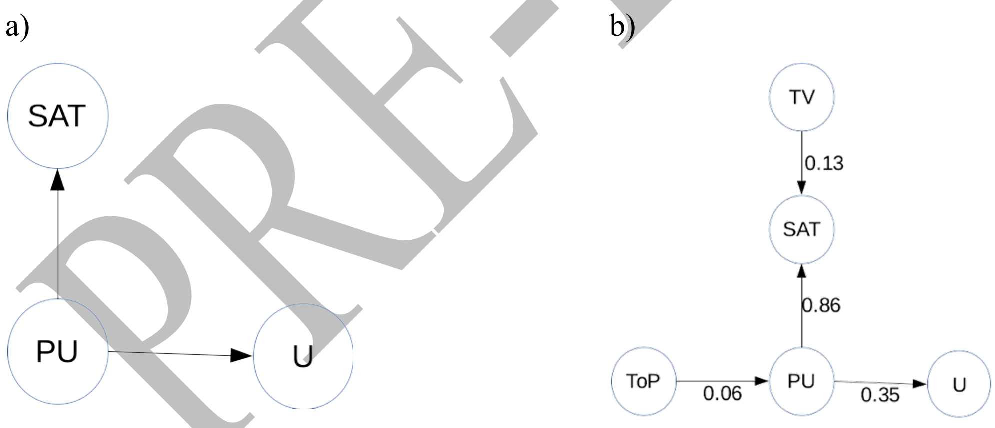

Figure 3 Structural model of the hypotheses presented: SAT is Satisfaction, and corresponds to variable SAT_Tl; TV is the making of the video, and corresponds to variable TV_Tl: without any part of the teacher, with the hands of the teacher, with the body of head of the teacher; PU is perceived usefulness and corresponds to the variable PU_Tl; ToP is "theory or problems" and corresponds to the variable ToP_Tl; and U is for Usage and corresponds to the variable U_Tl.

Table 9 Linear regression between: SAT_Tl and PU_Tl, TV_Tl; RV_Tl and TV_Tl; PU_Tl and ToP_Tl ; and U_Tl and PU_Tl. The first column represent the independent variable and the second the dependent variable; the column "Estimate" gives the values for the intercept and the coefficient for the dependent variable; "Std Error" gives the standard error of the estimate *value; "t value" and "Pr(>t)" gives the t value and the probability that the result could be obtained randomly instead of because correlation.*

Independent variable	*Dependent variables*	*Estimate*	*Std. Error*	*t value*	*Pr(>|t|)*
SAT_TI	(Intercept)	0,75	0,61	1,24	0,23
	PU_TI	0,88	0,09	9,72	0,00
	TV_TI	-0,22	0,14	-1,52	0,14
PU_TI	(Intercept)	4,08	1,00	4,08	0,00
	ToP_TI	0,13	0,38	0,33	0,74
U_TI	(Intercept)	30923,00	0,46	6749,00	0,00
	PU_TI	0,18	0,10	-1820,00	0,08

The program R, with the extension R commander has been used to perform the calculations.

Finally, results of students in the subject have been analyzed to see the true impact of videos in their performance.

The main limitations of the analysis are: 1) it was not possible to analyze the same number of semesters in all the analyzed courses because of uncontrolled external changes; 2) it was not possible to analyze whether different kinds of video had different effects since students had available all kind of videos and, therefore, we can only know which kinds of video (with hands, with tablets, etc.) were best perceived by students; and 3) we analyzed perception from students, but not the data about the videos they consumed and how they were consumed (what videos have been seen, when, for how long, etc.), which will be analyzed in a future work.

RESULTS AND DISCUSSION

The alpha of Cronbach for the questionnaire is 0.7 (see Table 4). From the t-test and Chi-square analysis we can see that the answer from students in the three subjects satisfy the null hypothesis that all the answers correspond to the same population and, therefore, results obtained can be considered independent of the environment or the degree. This satisfies the hypothesis *H0: Satisfaction with videos in a physics subject is independent of the environment.*
The ANOVA analysis confirms that the satisfaction with the number of videos is independent of the topic or the environment. The mean of the satisfaction with the number of videos is between 2.64 (theory of mechanics videos) and 2.96 (theory of electrostatics video) and the

standard deviation is between 0.84 and 0.9, what means that students are not satisfied nor dissatisfied with the number of videos.

The satisfaction with videos (variable SAT) is of 4.16 over 5, with a standard deviation of 1.1, which means that students are satisfied or very satisfied with the videos. Regarding the perceived usefulness (variable PU), the qualification is 4.4 over 5 with a standard deviation of 1, which means that students perceive the videos as very useful. The mean of the frequency of visualization of videos is 2.28 with a standard deviation of 0.54. That means that students watched videos mainly weekly (75%).

When the results regarding the content of the video are analyzed (variable ToP), the mean of the variable that shows the content of video preferred by students is 2.5 with a standard deviation of 0.58, what means that 64% videos of theory and problems, equally, i.e. students prefer having both kinds of videos.

Finally, when asked about the way in which videos have been created (variable TV), the mean is 2.24 with a standard deviation of 0.66, what means that 52% of students prefer videos with hands, and 88% of online students prefer videos in which the teacher appear and, if they can choose, they prefer videos with hands.

If we analyze the satisfaction, in the structured model presented in Figure 3, the making of the video (variable TV) explains only the 13% of the satisfaction of students. However, we cannot reject the null hypothesis (the kind of video does not affect the satisfaction of student) since Table 9) we obtain p=0.142 s. Therefore, we cannot prove hypothesis *H3, satisfaction of students (SAT) increases when non-verbal information appears in the video (TV)*. However, the same multivariate regression shows that our results are compatible with *H1, Perceived usefulness (PU) has a significant positive effect on learning satisfaction (SAT)*, which agrees with Nagy's paper.

Regarding the hypothesis H2, *Perceived usefulness (PU) has a significant positive effect on video usage (U)*, with $\alpha=0.05$, we cannot reject the null hypothesis that there is no relation between PU and U. This is a different result than that obtained by Nagy's. However, in this research videos were not the only resource available and students have always different ways to access the same content: the teacher or text material with the same explanations than videos. Therefore, students do not need to go back to the video to review the concepts.

Finally, regarding the hypothesis *H4, the presence of videos of problems (ToP) increases the perceived usefulness (PU) of videos*, we see from Table 9 that there is a linear relation between both parameters. However, with a typical value of $\alpha=0.05$ we cannot reject the null hypothesis that the preference for one kind of video or other affects the perceived usefulness.

The performance results of two subjects of Physics where videos have been introduced are shown in Table 10 (for *Inf*) and Table 11 (for *Tl*). Only the semesters when videos were introduced are presented. The addition of videos was the only change within these semesters. Physics at EUSS is not analysed here because in the period when videos were introduced, there were many other changes in the subject that affected the results.

Both tables show the percentage of students that fail or do not take the exam; and the rate that pass vs. those who take the subject, or vs. the total number of students. The cells in bold correspond to the semesters when the video was introduced. The percentage of students that pass the subject vs. the total that takes the exam, changes when video is introduced. In the case of *Inf*, the semesters before introducing the video the mean of pass over those that take the exam is around 75% and, when videos were introduced, it increased until nearly 92%. It is important to note, also that for the first semester of 2015-2016 not all the parts of the subject had videos available. This happened in the first semester of 2016-2017 and the percentage increased until nearly 97%.

In the case of *Tl*, the videos were introduced later. However, the mean of students that pass the subject over those who take the exam is 79% before introducing the videos, and raises until 92% after adding the videos. Nevertheless, data from previous semesters fluctuate around the mean value and in semester 20121 we find the same percentage. Maybe the reason for this fluctuation is that in the first semesters of Tl there was a lower number of students. As the number of students increased, the percentages are closer to Inf.

From these data we could conclude that for those students who follow the subject, videos can help them improve their chances to pass the exam, and therefore, the subject.

Table 10 Results of performance of several semesters in Physics in Computer Sciences. Results in bold correspond to semesters when the video was introduced. Every column corresponds to a single semester: 20mnp corresponds to the semester p of the academic year 20mn-20m(n+1), thus 20161 corresponds to the first semester of the academic year 2016-2017.

Results of Physics of Computer Science (Inf)

Qualif.	**20131**	**20132**	**20141**	**20151**	**20152**	**20161**	**20162**
Fail	14,74%	14,58%	17,00%	8,42%	**7,14%**	**0,90%**	**3,55%**
Not taken	40,00%	32,29%	39,00%	40,00%	**40,48%**	**40,54%**	**31,21%**
Pass/Total	45,26%	53,13%	44,00%	51,58%	**52,38%**	**58,56%**	**65,25%**
Pass / Taken	75,44%	78,46%	72,13%	85,96%	**88,00%**	**98,48%**	**94,85%**

Total students	95	96	100	95	126	111	141

Table 11 Results of performance of several semesters in Physics in Telecommunication. Results in bold correspond to the semester when the video was introduced. ery column corresponds to a single semester: 20mnp corresponds to the semester p of the academic year 20mn-20m(n+1), thus 20161 corresponds to the first semester of the academic year 2016-2017.

Results of Physics of Telecommunication (Tl)

Qualif.	**20121**	**20131**	**20141**	**20151**	**20161**
Fail	6,12%	8,00%	17,65%	33,85%	**5,71%**
Not taken	20,41%	22,00%	13,24%	24,62%	**25,71%**
Pass/Total	73,47%	70,00%	69,12%	41,54%	**68,57%**
Pass / Taken	92,31%	89,74%	79,66%	55,10%	**92,31%**
Total students	49	50	68	65	**70**

CONCLUSIONS

In this paper we analyze the perceived satisfaction and usage of videos considering the environment (online or face-to-face), the kind of video (tablet or recorded with hands) and the content of the video (topic, theory or problems). The experiment has been performed in three equivalent Physics courses of three different degrees (Industrial Engineering, Telecommunication and Computer Sciences) of two different universities, one face-to-face (Escola Universitària Salesiana de Sarrià, EUSS) and one 100% online (Universitat Oberta de Catalunya, UOC). All the subjects had the same teacher, who was the one who created the videos. To avoid a possible effect of the number of videos with the satisfaction, it has been checked that students were equally satisfied with the number of videos, regardless the topic or if they were of theory or problems.

The first conclusion found is that answers of students are independent of the course taken and the environment used (face-to-face or fully virtual). Students are very satisfied with videos and perceive them as very useful. Although they manifest to prefer problem videos, this preference neither affects the perceived usefulness, nor the number of times they watch every video.

We did not find a clear relation between the perceived usefulness and the number of videos, contrary to previous research (Nagy, 2018). This may be because in this experiment videos are not the main material and, therefore, students have also access to textual materials or face-to-face classes with the same content than in the videos.

Finally, students prefer videos in which they can see the teacher (hands, face or half body). This preference is a little more important in virtual students than in face-to-face students. However, there is not a conclusive effect with the satisfaction, what means that it is much more important for students having the video than the kind of video. On the other hand, results show that including videos in a physics subject increases the probability of passing the course.

Therefore, as a conclusion, students perceive the video in Physics as a very useful element and are very satisfied with it, although they perceive it as complementary material to textual material. This perception is confirmed by the results of the subjects that improve when video is introduced.

As a future work, we plan to analyze the behavior of students when watching the video to study the effects of topic and the kind of video, from the true usage point of video, instead of the perception of students. We will deep also in how students perceive the fact that the head and the body of the teacher appear in the video.

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