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Assessing users' perception on the current and potential Educational value of an Electrical Engineering YouTube channel

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ABSTRACT Full comprehension of abstract concepts present in engineering education has been usually considered challenging. Engaging multimedia resources have proven to be useful pedagogical aids to increase students' motivation. In fact, already existing dissemination videos might be suitable to fulfill this objective. This research aims to contribute assessing video implications in the enhancement of engineering education quality through the evaluation of the current pedagogical use of a specific electrical engineering YouTube channel. To meet this objective, we characterize the use of such channel through a quantitative methodology based on a 5-point Likert scale survey (Cronbach's alpha=0.76). Sample data were collected from 912 respondents, evaluating users' perception on the channel's content and format adequacy, their preferences, and their perceptions on video integration in educational contexts. Results show (3.98 over 5) that there is currently a far-reaching educational use of the channel, and a general perception that its contents and audiovisual format are adequate for such purpose. Most users agree (4.74 over 5) that this kind of pedagogical resource could enhance education quality. As limitations, an underrepresentation of teachers in the sample could be highlighted, though student community is well represented. Overall findings suggest that the format and cognitive load in scientific dissemination YouTube channels might be perceived as suitable for pedagogical use, as means to improve education experience. This complementary use unveils the need to implement technology integration models to facilitate their pedagogical insertion, which will be addressed as future works along with more evaluations of similar dissemination channels.

INDEX TERMS Electrical Engineering Education, Educational Activities, Videos, YouTube

I. INTRODUCTION

During 2020, UNESCO reported that educative centers' closure due to covid-19 pandemic affected an estimate of 1.5 billion students worldwide, which represents approximately 90% of global student population [1]. Several authors have highlighted lockdown implications in education, agreeing that technology unavailability and lack of previous experiences with online learning were relevant aspects increasing its impact [2]–[5]. In this situation, online learning had an essential role in ensuring the continuity of academic activity, but this new paradigm carries some challenges that might affect education quality, such as non-universal technological access or the possible lack of an adequate home environment, both key aspects when online education is involved [4], [5].

The current context, as clearly evidenced during covid-19 pandemic, is unfortunate for all students, [4], [5], but it is specially challenging in disciplines with wide presence of abstract concepts such as Science, Technology, Engineering and Mathematics (STEM) [6].

An additional challenge specifically found in engineering students is the ability to properly understand the connections

between subjects and being able to integrate them in the big picture of the degree and its professional applications [7]. In those regards, the integration of Information and Communications Technologies (ICT) in distance education plays a facilitating role that allows creating virtual communities that boost learning through search and interaction among pairs. Through the creation of these communities, students are involved in social, cognitive and lecturer's presence, which are the three main constructs for a successful constructivist interaction, as defined by the Community of Inquiry (CoI) paradigm [8], [9].

Engineering education quality could be enhanced by the improvement of abovementioned weaknesses, and the use of audiovisual materials might be a complementary solution. Research in pedagogical use of video material provides numerous references of its enhancement of parameters such as long-term retention of concepts [10], comprehension and deeper learning [11]. Descriptive images and animations, usually included in educational videos, are helpful for complex and abstract concepts understanding, as they provide complementary meaning to theoretical explanations, and they can also be reproduced by students when incorporated as a new problem-solving strategy [12]. These educational videos often focus on the creation of interest and show examples of practical applications, which also promote students' engagement and develop their critical thinking ability [13]. Such characteristics also make them suitable for the teaching of soft skills in engineering education [14], using them as key format in gamification strategies, as well as supportive resources in learning environments and content delivery resources in Massive Online Open Courses (MOOC).

Additionally, when referring to affective deficiencies, videos are also proven to be an effective support on students' motivation and on reducing academic stress, as well as anxiety levels [15], [16]. These aspects are highly related to dropout rates, which are specifically elevated in engineering disciplines [17]. Videos not only can be accessed anywhere and anytime, but also students are in control of their pace. Moreover, new free time in synchronous classes due to video integration, that would otherwise be used for topics introduction and the resolution of basic initial questions, can now be dedicated to other activities that promote active learning from those educational videos [18]. An example of such activities could be the implementation of problem based learning methodologies, as studied in previous research with positive results for teaching-learning processes [19]. Another successful example would be the use of instructional videos in engineering flipped classrooms, where they have proven to have an overall positive effect on student awareness of real-life applications [20]. Authors such as Shoufan [21] specifically highlight YouTube videos as key backup material in active learning strategies, highlighting its success in students' engagement and perception for purposes such as step-by-step learning procedures, as well as descriptive and conceptual explanations.

The development of such practical activities is crucial in online learning environments, as they are able to enhance online participation. As previously stated, CoI paradigm acknowledges this active component as vital to develop a successful and sustainable online learning experience [8]. Other models such as Technological Pedagogical Content Knowledge (TPACK) [22], [23], also describe the continuous knowledge improvement of lecturers as essential to design useful constructivist educational environments, through a successful integration of current technology.

Trying to continue studying the implications that audiovisual material might have in the described context, this article focuses on currently online available engineering communication videos, and the role they might play in higher engineering education environments. Our case study is based on *Sígueme la Corriente*, a Spanish channel specialized in electrical engineering [24]. This study is focused on the assessment of the channel's user preferences towards its educational integration. Therefore, the following research questions have been established: are YouTube dissemination videos being integrated in electrical engineering education? In that case, what are their most valued features for such pedagogical use?

Consequently, three specific objectives have been defined for this study:

(1) Detect if such channel, created with the purpose of entertaining the general public through technological dissemination, can be having a side use as educational resource.
(2) Evaluate the perception of its audience on key aspects for video adequacy to be integrated in educational environments (format and content adequacy).
(3) Evaluate the opinion of its audience on the integration of pedagogical videos in education.

Aligned with the aims of the study, results have shown an important pedagogical use of the channel mainly from pre-university teachers, university students and junior electrical engineers. Format and contents are highly rated as adequate for its integration in educational contexts. Additionally, the channel's users show a remarkable tendency to consider videos as a successful resource to enhance education quality. Overall, the findings of this study provide useful insight about the potential suitability of the channel for the creation of future sections specifically designed to be used as educational aid, in service of the needs detected in different Electrical Engineering degrees.

The paper is organized as follows: the currently available literature related to our research is presented in section II. The sample considered and the survey developed to characterize the audience is detailed in section III. Section IV introduces the main results, discussed in section V.

Conclusions are highlighted in section VI.

II. LITERATURE REVIEW

This study aims to contribute to the integration of audiovisual resources as means of improving online learning of STEM disciplines and dynamize constructive learning strategies. These resources might constitute a helpful pedagogical aid when used within the context of CoI model [8], enhancing the educational experience by the improvement of parameters such as content engagement, interaction with pairs through video-related activities, and self-regulated learning. The proactive use of video resources might create a self-motivational environment able to promote students' engagement and goal setting [16]. Furthermore, ICT-TPACK model is based on constructs that could also be benefited by the integration of videos as pedagogical aid [25], [26]. The ultimate goal of this educational model is the creation of new scenarios that could improve teaching-learning processes using ICT, through the analysis and enhancement of the interactions between technology with contents and pedagogical methods. Both CoI and TPACK models can benefit from each other fostering a constructivist perspective of knowledge, focused on the student [27].

Our research takes over the existing literature on social network and video integration in educational contexts. Audiovisual resources, and particularly those currently available in YouTube as the most used platform [28], [29], are showing several benefits as a pedagogical complementary tool, that we intend to explore in this section. Negativity towards new processes is acknowledged by Zachos et al. [30] when referring to online social networks integration in higher education, though they also provide wide evidence on their positive contributions as didactic complementary tools [31].

However, results from previous research [32] show that teachers did not present resistance when incorporating ICT into their lectures. A 5-point Likert scale survey was developed in this study, where teachers from Universidad de Las Palmas de Gran Canaria (ULPGC) expressed their opinion on ICT tools as supporting resource for attendance-based teaching, showing how parameters such as materials accessibility and communication were importantly enhanced. Increase of motivation and engagement are also key benefits from integrating ICT in higher education, as exposed by several authors [11], [21], [29], [33].

As pointed out by Lee and Lehto [34], YouTube didactic value might not be easily recognized by both students and teachers due to its focus towards entertainment instead of education. Yet, despite this is an extrinsic task goal for the platform, research driven by Černá and Borkovcová [35] also show that there is clear prevalence from YouTube when referring to video application in educational contexts. Moreover, Gil-Quintana et al. [33] studied some of the characteristics of the communicative model widely used by youtubers. Furthermore, they also considered the interaction with followers and high engagement rates. They concluded that these parameters might turn youtubers in a preferred academic reference for students. The connective nature of YouTube also makes it an interesting candidate to be increasingly integrated in educative contexts, as it contributes to increment social-skill building in students through interaction and discussions [31], [36].

All abovementioned benefits could merge in a resulting student performance increase. D'Aquila et al. [37] developed a case study confirming the improvement of the academic performance in a sample of 246 individuals assessed through a Likert scale questionnaire and analyzed by a multivariate regression test. These findings are also coherent with results from Expósito et al. [38], whose research show how instructional video integration in teaching activities resulted in a significant reduction of the probability of achieving low test scores.

As previously exposed, YouTube might constitute an ideal complementary tool for educational contents. However, the issue of pedagogical video integration in university STEM education is far to be completely solved. Several authors have pointed out the role of teachers as content facilitators more than content creators, acknowledging the real challenge of selecting adequate channels and videos [35], [39]. Therefore, the challenge focuses on teachers being able to select videos whose format and cognitive load is appropriate for students and course needs, which is not straightforward due to the excess of information and unregulated contents, that results in the appearance of the decision paradox.

Some strategies have proven to be significantly useful. Brame's research [18] suggests that it is crucial to correctly measure the cognitive load of recommended didactic videos, boosting active learning linked to those resources and maximizing student engagement by selecting easy-to-follow video formats. Tadbier and Shoufan [39] acknowledge the challenges associated with adequate channel and videos selection, and suggest the creation of trustworthy rankings that could be useful to aggregate didactic YouTube channels. Additionally, other authors [34], [40], [41] suggest the use of rubrics as guidelines for adequate video selection, highlighting aspects such as accessibility, production quality, explanation rhythm, accuracy, and completeness, narrator confidence and engaging communication style. In consonance with these parameters, Romero-Tena et al. [42] propose the use of a Likert scale questionnaire that helps identifying video suitability in terms of lecturer's perception on abovementioned metrics.

As a further contribution to the abovementioned challenges and proposals, this article focuses on exploring the perception on the educational value of an electrical

engineering dissemination YouTube channel applying the most representative metrics extracted from literature, as exposed in the Methodology section. This analysis is also intended to explore a potential full educational development of the channel, unveiling the benefits of implementing such educational videos in Electrical Engineering degrees with the main purpose of easing the motivation and understanding of complex abstract ideas and wicked problems surrounding engineering challenges as per the energy perspective [43].

III. METHODOLOGY

A. CASE STUDY

This paper presents an analysis of the current and potential pedagogical use of *Sígueme la Corriente* through a characterization of its audience and an evaluation of its users' preferences. *Sígueme la Corriente* was created in 2017 with the aim to contribute to Spanish-speaking public with more engineering dissemination contents. It has increasingly reached an audience particularly interested in energy, electricity, and sustainability topics.

The channel was not created with an educational purpose; however, comments and views sources suggest that the channel might be having a side use as a pedagogical resource. Hence, this study aims to confirm whether the channel is already being used for such applications, and what are its audience perception on key parameters that would make it adequate for educational use, in consonance with metrics highlighted in Literature Review. Additionally, this study evaluates the perception of the channel's audience on the implications of didactic videos integration in education. For those purposes, a questionnaire has been developed as data acquisition instrument.

B. DATA COLLECTION

The designed questionnaire has considered a quantitative research methodology. A descriptive study is provided using a five-point Likert scale, where scores correspond to the following perceptions: 1 as 'strongly disagree', 2 as 'disagree', 3 as 'neutral', 4 as 'agree', and 5 as 'strongly agree'. The descriptors adopted for the questionnaire have been selected as per the main metrics defined in Morain and Swarts's rubric [40], which are also in consonance with the Technology Acceptance Model (TAM) as implemented by Lee and Lehto for YouTube procedural learning user acceptance analysis [34]. Table I shows the designed questionnaire.

TABLE I
QUESTIONNAIRE

ID	Questions
Q1	I watch the channel's videos the same week they are published
Q2	I watch old channel's videos
Q3	I use the channel with educative purposes
Q4	I use the channel for entertainment purposes
Q5	I use the channel to stay updated on news in the sector
Q6	The selection of topics and contents matches my interests
Q7	The presenter's explanations are attractive and interesting
Q8	Rhythm of videos is adequate for concept comprehension
Q9	The technical level is adequate (I can follow the concepts and I also learn new things)
Q10	The channel's contents are rigorous
Q11	Its contents help me understand topics I'm interested in
Q12	Video's contents are up to date
Q13	Video's duration is adequate
Q14	Audiovisual resources used (images and music) are helpful to understand concepts
Q15	Didactic videos could help enhancing education quality
Q16	Classrooms are well equipped for the projection of didactic videos
Q17	Professors should be provided with competences for the creation of own didactic videos
Q18	Didactic videos can substitute assistance-based education

This instrument mainly focuses on characterizing *Sígueme la Corriente* users, to be able to determine if there is an existing pedagogical use of its contents. Additionally, a set of questions has been designed to evaluate the audience perception on key metrics related to contents and format adequacy, considering the main parameters mentioned in Literature Review. Finally, a last set of questions is included to assess the audience perception on didactic videos integration in education.

The developed questionnaire was provided to *Sígueme la Corriente* subscribers on July 14th, 2020, and answers were collected for 18 days, until July 31st. The population considered in this study has been 69,829 users, as it was the total amount of subscribers when the survey was closed.

The minimum representative sample is calculated through the Cochran equation [44] with finite population correction (1). It describes the sample size (n) given a targeted confidence level (which provides a score value (Z)), margin of error (ε), population proportion (p), and population size (N). For a confidence value of 95% (1.96 score), a margin of error of 5% and an assumed population proportion of 50%, the minimum sample needed to be representative would be of 383 participants.

$$n = \frac{\frac{Z^2 \cdot p(1-p)}{\varepsilon^2}}{1 + \frac{z^2 p(1-p)}{\varepsilon^2 N}} \quad (1)$$

The questionnaire developed for this study was shared with the channel's audience, achieving a maximum sample of 912 individuals, which exceeds by 529 the minimum required (383) for a 95% confidence level. Though not all questions were answered by the totality of the sample, the minimum sample size has been 849, which is still above the minimum sample size for 95% confidence level.

The collected information is available online through IEEE DataPort [45].

C. DATA ANALYSIS

As means to characterize the sample, and the total audience,

demographic questions were included as part of the survey. On the other hand, population data were extracted from YouTube statistics for the period from December 28th, 2016 (when the channel was opened) to July 31st, 2020 (when the survey was closed to the public). Table II represents a comparison between the sample and the whole population.

TABLE II
COMPARISON BETWEEN POPULATION AND SAMPLE INFORMATION

Parameter	Sample (95% CI)	Population
Individuals	912	69,829
Men	92.4 % (90.63 – 94.17 %)	96.1%
Women	7.6 % (5.83 – 9.63 %)	3.9%
Individuals age		
Between 13 and 17	9.21 % (7.28 – 11.14 %)	2.2%
Between 18 and 24	48.68 % (45.38 – 51.98 %)	42.7%
Between 25 and 34	24.56 % (21.71 – 27.41 %)	38.6%
Between 35 and 44	8.33 % (6.48 – 10.18 %)	11.6%
Between 45 and 54	6.80 % (5.11 – 8.49 %)	4.1%
Between 55 and 64	2.08 % (1.1 – 3.06 %)	0.5%
More than 65	0.33 % (0 – 0.76 %)	0.3%
Individuals Geo-location[1]		
Spain	31.25 % (28.19 – 34.31 %)	22.14%
Mexico	15.90 % (13.47 – 18.33 %)	21.46%
Argentina	9.54 % (7.58 – 11.5 %)	10.71%
Colombia	8.99 % (7.08 – 10.9 %)	9.42%
Chile	8.22 % (6.38 – 10.05 %)	7.84%
Peru	6.14 % (4.52 – 7.75 %)	8.74%
Ecuador	3.40 % (2.17 – 4.63 %)	4.39%
Venezuela	3.07 % (1.9 – 4.24 %)	1.58%
Bolivia	2.19 % (1.18 – 3.19 %)	2.49%
Guatemala	1.86 % (0.93 – 2.79 %)	1.33%
Others	9.44 % (7.49 – 11.39 %)	9.90%

[1] Geo-location data for views during July 2020 is shown at population column

In terms of sex distribution, it is noteworthy that only a 3.9% of the population are women. As per the sample proportion, it seems that women were more willing to answer the proposed survey, since there was a women participation of 7.6%. Moreover, according to Fig. 1, it is clear that the majority of women are in the group between 18-24 years, whereas men age distribution is wider. This is in consonance with the demographic statistics.

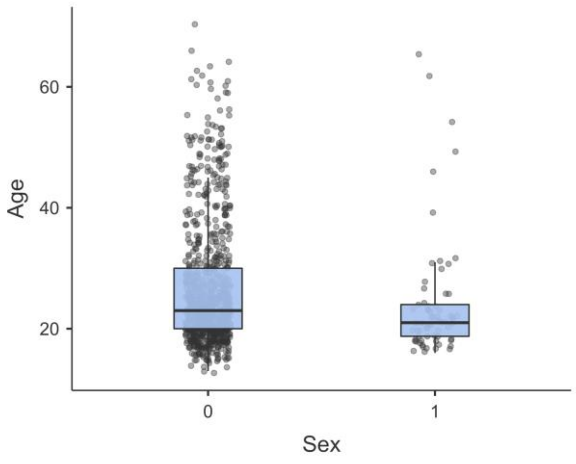

FIGURE 1. Sex VS Age boxplot (N=912).

Referring to age proportions, it is remarkable that the group between 25 and 34 years old is not correctly represented according to the defined confidence interval. However, the group between 18-24 years (most of them university students as can be seen in Fig. 2) is almost half of the sample (48.68 %), exceeding the upper limit of the confidence interval, which means that this group was clearly willing to participate. It is also interesting to highlight that most electrical engineers are within their early professional life.

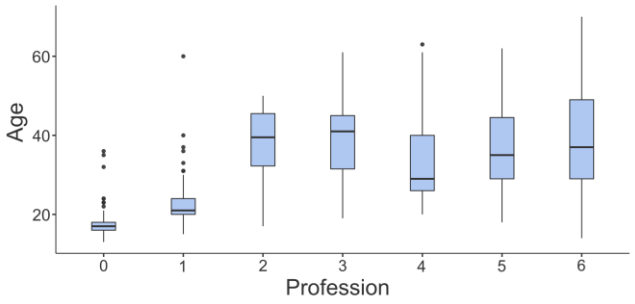

FIGURE 2. Profession VS Age boxplot (N = 912). 0: Pre-University Students; 1: University Students; 2: Pre-University Teachers; 3: University Teachers; 4: Professionals Electrical Engineering sector; 5: Professionals in other engineering sector (non-electrical); 6: Others.

Finally, considering individuals geo-location, most sample proportions are inside the defined confidence intervals excepting Spain, which is overrepresented, and Mexico, which is underrepresented. The reason for this could be that, when the survey was conducted, the channel was temporarily more devoted to the Spanish public considering the whole group of subscribers due to specific strategies to integrate new videos in Spanish universities. In any case, when a heat map of survey participants' geo-location is presented, as in Fig. 3, it is clear that the channel public is mainly Latin American.

FIGURE 3. Heat map of survey participants' geo-location

Statistical analysis shown in the Results section has been performed using the software Jamovi [46], considering a confidence level of 95% in all cases. To evaluate potential correlations between qualitative variables, chi-square tests have been used.

D. VALIDITY AND RELIABILITY

In order to validate the reliability of this questionnaire as a suitable data collecting instrument, Cronbach's alpha method was implemented obtaining a coefficient of 0.76. This score is considered as adequate according to authors such as Nunnally [47], who states that, for early stages of a research, a value of 0.5 or 0.6 would be sufficient. Other authors, such as Huh et al. [48] consider that reliability value in an exploratory research should be equal or higher than 0.6. Therefore, the survey used as instrument in this article counts on a high reliability rate.

After conducting and validating the questionnaire as our data acquisition instrument, Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were studied to allow the posterior performance of an exploratory factorial analysis. Results showed a χ^2 (153) = 2315.3 ($p<0.001$), and a KMO measure of .850, confirming the adequacy of our questionnaire for the performance of a factorial analysis.

Five factors have been identified to explain at least 50% of variance. Accordingly, questions are organized in those five main categories, presented hereafter sorted by their contribution to the objectives of this study:

(1) Assessment on channel use preferences.
   - Channel use for non-educative purpose (Q4, Q5, Q10 and Q12).
   - Fan phenomena (immediacy) (Q1).

(2) Assessment on channel contents and format adequacy.
   - Content adequacy to solve problems or satisfy topics of interest (Q2, Q3, Q6, Q9 and Q11).
   - Audiovisual format adequacy and communicative style (Q7, Q8, Q13, Q14 and Q15).

(3) Perception on educational video integration (Q16, Q17 and Q18).

E. CONFIDENTIALITY

All the answers to the questionnaire were completely anonymous. Additionally, all respondents gave informed consent for the scientific use of the data gathered.

IV. RESULTS

This section presents the results obtained through the conducted survey, organized by subsections as per the objectives of this study. A quantitative analysis of Likert scale in each question of the survey has been performed. Results can be found at Table III. Additionally, comparative analyses have been performed through chi-square tests, unveiling useful information about the descriptors defined in the questionnaire. Results from chi-squared evaluations can be found at Table IV.

A. ASSESSMENT ON CHANNEL USE PREFERENCES

As presented in Table III, descriptors for channel use in non-educative purposes (Q4, Q5, Q10 and Q12) show a high frequency of 'agree' and 'strongly agree' answers. The use related to stay updated in news on the sector has suffered of more 'neutral' answers than the other questions. On the other hand, the entertainment use of the channel shows a remarkable 87.2% positive answers, leading to a mean score of 4.46 within the Likert scale.

TABLE III
QUESTIONNAIRE IDENTIFIERS (ID), SAMPLE (N), AND LIKERT SCALE FREQUENCIES (%), MEAN SCORES AND STANDARD DEVIATIONS (SD)

ID	N	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean	SD
Q1	912	3.2	9.9	26.8	32.5	27.7	3.72	1.07
Q2	908	1.2	5.5	15.7	31.7	45.8	4.15	0.96
Q3	905	5.9	8.5	12.9	26.7	46.0	3.98	1.21
Q4	907	0.7	2.3	9.8	24.9	62.3	4.46	0.815
Q5	908	5.5	8.6	21.6	27.4	36.9	3.82	1.18
Q6	911	0.3	1.6	15.6	48.3	34.1	4.14	0.757
Q7	909	0.2	0.6	3.6	29.7	65.9	4.61	0.609
Q8	910	0.0	0.8	6.8	34.0	58.5	4.5	0.658
Q9	907	0.0	1.3	7.2	31.8	59.8	4.5	0.688
Q10	896	1.5	2.5	14.4	34.5	47.2	4.24	0.889
Q11	905	0.2	0.7	5.5	28.4	65.2	4.58	0.649
Q12	897	0.0	0.3	5.8	24.0	69.9	4.63	0.607
Q13	908	0.1	1.7	9.8	28.6	59.8	4.46	0.747
Q14	909	0.1	0.9	7.4	27.0	64.7	4.55	0.679
Q15	895	0.0	0.4	3.0	18.4	78.1	4.74	0.528
Q16	858	3.7	10.5	26.0	27.7	32.1	3.74	1.13
Q17	849	1.1	1.9	11.9	25.2	60.0	4.41	0.849
Q18	862	24.1	26.0	24.2	11.3	14.4	2.66	1.34

TABLE IV
COMPARATIVE X^2 TESTS BETWEEN KEY DESCRIPTORS OF THE QUESTIONNAIRE

	ID1 Q3 vs Q10	ID2 Q4 vs Q10	ID3 Q3 vs Q12	ID4 Q4 vs Q12	ID5 Q4 vs Q12
N	890	893	891	893	901
χ^2	24.1	64.4	41.9	60.1	83.1
p	0.087	<0.001	<0.001	<0.001	<0.001

	ID6 Prof. vs Q3	ID7 Q3 vs Q9	ID8 Q3 vs Q11	ID9 Q7 vs Q11	ID10 Q9 vs Q11
N	905	900	900	904	901
χ^2	36.8	56.8	97.8	218	256
p	0.046	<0.001	<0.001	<0.001	<0.001

	ID11 Q14 vs Q11	ID12 Q3 vs Q15	ID13 Prof. vs Q18
N	904	889	862
χ^2	134	74.9	39.4
p	<0.001	<0.001	0.025

Though pedagogical use of the channel seems to be less frequent than entertainment use, a high tendency to use the channel for educational purposes can still be found, as shown by the 72.7% positive answers. This finding confirms that the channel is also widely implemented with educational purpose, in consonance with our research question. When comparing users' profession with the frequency of educational use (ID6), chi-squared tests show significant correlation for a 95% confidence level ($p=0.046$), though evidence backing up this correlation is

not as strong as the ones found in previous descriptors comparisons shown in Table IV. The use of the channel in educative contexts is more associated with pre-university teachers, where 80.8% answered positively. Moreover, university students and professionals in electrical engineering sector tend to use the channel for learning purposes with respective values of 73.3% and 78.9%.

After chi-squared evaluations, shown in Table IV, no significant correlation ($p=0.087$) has been found between educational use of the channel and the opinion on rigor parameter (ID1). However, a strong correlation ($p<0.001$) is found for entertainment use and rigor (ID2). Regarding videos currentness, results show a significant correlation ($p<0.001$) with both educational (ID3) and entertainment use (ID4).

Another interesting behavior of non-educational use of the channel is the fan phenomena, which in certain sense could be evaluated through the immediacy of users' reaction to new contents on the channel (Q1). Most students reported watching both recently published videos (Q1) and old channel's videos (Q2). However, there are more quantity of users that tend to watch old videos with higher frequency than those published at the same week, with respective 'strongly agree' frequencies of 45.8% for old videos and 27.7% for new ones. These indicators might unveil the idea that *Sígueme la Corriente* covers more a utility need rather than a fan-based use, which may be also in consonance with educational applications.

B. ASSESSMENT ON CHANNEL CONTENTS AND FORMAT ADEQUACY

When evaluating content adequacy to solve problems or interests (Q2, Q3, Q6, Q9 and Q11), results show interesting information. As shown in Table III, there is a high quantity of users that resort to old videos, with a 77.5% of positive answers. Comparative results in Table IV show that there is strong evidence suggesting significant correlation ($p<0.001$) between entertainment use of the channel and a predominant use of old published videos (ID5), as means to satisfy specific topics that the user is searching for.

As per the capability of *Sígueme la Corriente* to generate interest in its audience, almost all participants agree that the selection of topics matches their interests, with an 82.4% of positive answers frequency. Additionally, almost all users (91.6%) believe that the technical level is adequate to ensure good concept comprehension, concluding with a mean 4.58 score that the channel's contents are helpful to understand concepts the audience is interested in.

Comparative analysis proves the dependance of didactic use of the channel with respect to the perception that the videos have a proper technical level (ID7), with significant results ($p<0.001$). Finally, there is also significant correlation ($p<0.001$) among the educative use of the channel and the opinion that the channels' contents are helpful to understand interesting topics for each individual (ID8).

As explained in Literature Review, audiovisual format adequacy and communicative style (Q7, Q8, Q13, Q14 and Q15) are also relevant descriptors when analyzing the suitability of videos for educational purposes. Referring to those descriptors, parameters such as engaging explanations, rhythm, video duration, and audiovisual resources used for the video creation, are of particular importance.

Results show general agreement in the perception that the presenter communication abilities are able to make contents both attractive and interesting, with a frequency of 95.6% of positive responses to the Likert scale. Additionally, there is a 92.5% positive response to the belief that the rhythm of videos is adequate to ensure good concept understanding. Concerning format adequacy, video's duration is considered adequate by most participants, with 88.4% positive responses, as well as the selection of images and animations to help concept comprehension, achieving 91.7% positive feedback.

Chi-squared tests ID9, ID10 and ID11 in Table IV also show significant correlation ($p<0.001$) between the successful educational use of videos and format aspects such as expressive abilities, technical level, and the artistic expression (defined in terms of audiovisual resources adequacy). These findings are in direct connection with our research question regarding the features that make *Sígueme la Corriente*'s videos to be perceived as suitable for educational use.

Because of users' perception on abovementioned descriptors, there is an extended belief that didactic videos could be useful to enhance education quality, with 96.5% positive responses and a mean score of 4.74. Additionally, comparative chi-squared test shows significant correlation ($p<0.001$) between those who use the channel for educational purpose and the perception that didactic videos could enhance education quality (ID12).

C. PERCEPTION ON VIDEOS INTEGRATION IN AN EDUCATIONAL CONTEXT

As per user opinion on the integration of videos as educational tool (Q16, Q17 and Q18), most users think that it would be useful to provide teachers with competences for the creation of their own videos, with 85.2% positive response. However, less users consider that classrooms are well equipped for the projection of videos, with 26% responses remaining neutral.

On the other hand, most answers remain negative or neutral in the perception that didactic videos could fully substitute assistance-based education. Chi-squared analysis shows correlation for a 95% confidence level ($p=0.025$) when considering if profession is significant on the perception that didactic videos could be a possible substitute for presence in education (ID13). On one hand,

university students showed tendency to disagree with the affirmation, with 50.3% answering 'disagree' or 'strongly disagree' versus the 24.3% that answered 'agree' or 'strongly agree'. On the other hand, results show that university teachers seem to think otherwise, as 60% answered 'agree' versus a 30% that answered 'disagree' or 'strongly disagree'. However, this finding might be affected by a small sample of university teachers, as stated in 'Limitations' subsection.

V. DISCUSSION, LIMITATIONS AND FUTURE WORKS

A. CHANNEL POTENTIAL EDUCATIONAL USE THROUGH ITS AUDIENCE CHARACTERIZATION

Findings support the initial hypothesis that a YouTube informal dissemination channel such as *Sígueme la Corriente*, which was created and developed for entertainment purposes, is also having a side use as an educational aid. Audience perception is very positive towards its educational value and adequacy.

The main channel use preferences are entertainment and education, with respective 87.2% and 72.7% positive use frequency. When evaluating profession distribution among users, the main groups that count on the channel for educational purposes are pre-university teachers, university students and junior electrical engineers.

Though didactic use of the channel was highly rated in questionnaire results, it is still under entertainment use (as shown in results), which can be explained by the fact that the channel's contents has not been developed to consider such pedagogical use. The fact that YouTube is mainly an entertainment platform was acknowledged by Lee and Lehto [34], addressing it as a challenge for a widely recognition of the educational value of the platform. However, educational use of *Sígueme la Corriente* can still be seen as high for a YouTube informal dissemination channel originated without the aim of covering didactic uses.

Regarding the perception on channel's contents rigorousness, a strong correlation has been detected between educational use and the perception of rigor as an important parameter. These results lead us to infer that, for the channel's audience, rigor is not as characteristic from the utility perspective as from the entertainment perspective. This is also coherent with results from the factorial analysis, exposed in 'Methodology' section.

Referring to channel users' characteristics, it is also interesting to remark the fact that, though gender distribution of the channel's user is remarkably asymmetrical, women are mostly young (as shown in Fig. 1). This appreciation is consistent with results shown by Saurabh and Gautam [49], in whose analysis of an information technology YouTube channel there was 20-30% women users, and they were mainly distributed through 13 and 24 years old. These data might back up the hypothesis that young women are becoming increasingly more interested in engineering and technology.

Besides channel use tendencies, there are also several aspects worth highlighting related to content and format adequacy. When evaluating the audience perception on such descriptors, a remarkably positive perception can be found from survey participants on production quality, video length, explanation rhythm, accuracy and completeness, narrator confidence, and engaging communication style. These are the main characteristics of evaluation rubrics suggested by several authors [40]–[42] to evaluate the suitability of certain videos as teaching aid for specific concepts that might need visual reinforcement. Those descriptors are also in consonance with the Lee and Lehto's proposal of extended TAM for user acceptance of YouTube procedural learning [34].

Additionally, results show correlation between those who use the channel for educational purposes and the perception that its technical level is adequate for their needs, which can be associated with the conclusion that the channel's contents are perceived as adequate for pedagogical integration.

When evaluating videos usefulness to satisfy the understanding of topics of interest, we found a remarkably positive reaction with a 4.58 score (in a scale from 1 to 5). This result is in consonance with the 4.15 score obtained by D'Aquila et al. [37] for the same question asked in accounting video-aided lessons. Also Wells et al. [15] asked their students about video tutorials usefulness to help learning their unit material, obtaining frequencies of 46% and 45% to 'always' and 'often', respectively. These results serve as practical demonstrations of video potential to facilitate comprehension of abstract complex concepts characteristically found in STEM education.

Furthermore, the perception on engagement as evaluating parameter for the presenter communication style is highly rated by participants, with a score of 4.61. This idea has also been highlighted by Gil-Quintana et al. [33], with results showing youtubers as the preferred academic reference for students due to their communicative skills. Moreover, Shoufan findings [21] also show that the main feedback from students when integrating videos as part of the learning experience are focused on an increase of interest and motivation, which directly results in an engagement enhancement. Results collected by Jackman and Roberts [11] also highlights illustrations, explanations, and examples as the main areas of recall when referring to long-term learning and better retention, metrics of which *Sígueme la Corriente* users tend to show a very positive perception (as reflected in answers to Q7, Q11 and Q14).

Additionally, drawings and animations are frequently used in the channels' videos to illustrate engineering concepts. These features might also be used by students when approaching such concepts. Aligned with this Wu et al. [12] described how drawing prompts, both driven by

classes and video, might constitute a useful tool to increase students' use of drawing as a problem-solving strategy. This practice, as quantified in their study case, can enhance cognitive engagement and performance in an engineering active learning environment.

Our results have also shown strong correlation in users' perception between video format aspects (defined by communicative abilities, technical level, and artistic integration to illustrate technical concepts) and pedagogical aspects. These findings confirm results from Romero-Tena et al. [42], where significant correlation was exposed for the same descriptors. The implication of this correlation is also consistent with previously detailed results, as it also describes how the content and format adequacy of videos is a relevant aspect for user's perception of their educational value.

Finally, when evaluating the audience opinion on the effects of pedagogical video integration in education, most users think that teachers should be provided with more competences on video creation for their lectures. This belief is also clearly related to UN's education quality Sustainable Development Goal (SDG) indicator 4.4.1, which goal is to substantially increase the number of young and adults with relevant ICT skills. The overall initiative in which *Sígueme la Corriente* is immersed aims to contribute to this goal by developing specific educational contents framed in technology integration models such as CoI and ICT-TPACK. Additionally, SDG 4.7.1. goal is implicitly included as part of our project contribution, as it relies on ensuring that all learners acquire the knowledge and skills needed to promote sustainable development. *Sígueme la Corriente* specifically addresses that sustainable development promotion in all its videos, as it is a channel particularly specialized in energy and sustainability.

In relation to possible future implementation of educational videos, there is no agreement regarding the idea that didactic videos could completely substitute assistance-based education. Instead, whereas there is only a 25.7% of positive answers, a frequency of 50.1% answered negatively to this descriptor. The remaining 24.2% maintained a neutral perspective. Results for university student perception show a divided opinion where 50.3% were inclined to reject this idea of fully substituting classroom teaching by media resources. It is a percentage accurately backing up previous findings by D'Aquila [37] where 54.14% of students prefer live classes than video format as complete substitution. These findings are also consistent with research from Muthuprasad et al. [4], where more than 70% of students answered negatively or neutrally to each one of the following statements: (1) Online courses were preferable than classroom learning, (2) Online classes were more helpful to comprehend course materials, and (3) Online environment makes communication with the instructor easier.

As shown by results from Gupta and Sengupta [50], students find desirable to integrate YouTube webinars as substitution of some presential lessons due to its greater accessibility and the option to attend from any location. However, factors such as technology availability or the need from face-to-face interaction are still valued.

This partial rejection to video format as full replacement on traditional assistance-based education, together with overall previous evaluation on user perception of videos benefits, suggests students' recognition and preference for videos as a complementary educational tool, which could not only help understanding exposed knowledge from specific subjects but also encourage an increase of motivation and interest in its contents. Previous research driven by Castro-Sánchez and Chirino-Alemán [32] also shows evidence that teachers consider ICT tools as helpful supporting resources for attendance-based lectures, instead of substitutes that would acquire the main role in the whole pedagogical process. As found by Pattier [29], three out of four teachers are satisfied with the use of video material as pedagogical aid, also stating that most of those that sowed rejection were based on the lack of appropriate technological resources in their educational centers. Research driven by Lo & Hew [20] show how the use of this kind of instructional videos in flipped classroom strategies has demonstrated to have a positive effect over traditional lecture-based learning, enabling students' self-paced learning and awareness of the practical applications of the studied concepts. On the other hand, Wells et al. [15] research has shown video tutorials as the most helpful resource for students, with a punctuation of 84%, over other resources such as lecture slides, assignments or even lectures themselves, suggesting that their students might not be opposed to the idea of video material use as substitute of classroom lectures. More research should be performed aiming to confirm the significance of these differences.

To conclude, there is an overall positive evaluation on the perception of *Sígueme la Corriente* users on its adequacy as an educational tool. Results show how the vast majority of the channel's users believe that didactic videos such as presented ones could help enhancing the quality of education, with 96.5% positive responses. Exposed findings back up the idea that informal scientific dissemination audiovisual resources might be serving both entertainment and educational purposes, and this conclusion unveils the need to implement on such dissemination channels formal strategies to successfully develop educational contents. This kind of resources could also contribute creating connections between technical subjects in electrical engineering that would otherwise be perceived as individual and unrelated, as pointed out by Maciejewski et al. [7]. Videos as the ones provided by *Sígueme la Corriente* could also be useful to provide pre-university students with more information about electrical engineering, as well as first-hand prospects about the professional application of the degree and job stability and promotion. Therefore, as described by Tayebi

et al. [17], such use of the channel would be directly influencing some of the main parameters affecting dropout rates in engineering studies.

However, more research is still needed on real case studios for the implementation of successful methodologies that could serve as guidelines for both creators and lecturers on how to integrate such audiovisual resources in educative contexts. This aspect is also highlighted by Pattier [29], concluding teachers difficulties on finding videos that adapt to their academic needs. Fyfield work [51] also concludes that the use of videos in classroom does not necessarily imply a change for traditional classroom interactions, as they are often used to replace the teacher's direct instruction or as static source like textbooks. In this sense, more innovative video integration strategies could potentially be developed for a more successful use of YouTube videos as pedagogical aid.

Such integration strategies should be based on technology integration models in educational environments such as previously mentioned CoI or ICT-TPACK. 'Future Works' subsection states the proposed objectives to continue developing this research line addressing those needs.

B. LIMITATIONS

There are several limitations in this study that should be highlighted. Though the channel audience is fairly well represented, there are certain groups that are not perfectly characterized (as exposed in 'Methodology' section), such as group age between 25 and 34. It is also noticeable the underrepresentation of university and pre-university teachers (as mentioned in 'Sample Description' subsection). Finally, the fact that this study is focused in a specific channel could affect extrapolating conclusions to the overall fitness of scientific dissemination YouTube channels. May this study serve as a first step to develop further evaluations in collaboration with other content creators from similar dissemination channels.

C. FUTURE WORKS

This study represents the beginning of a research line intended to contribute to the current literature in video integration as an educational aid in STEM disciplines, and how available scientific dissemination resources might be adequate for those means.

After analyzing the adequacy of *Sígueme la Corriente* to be used as a teaching aid resource, a new section will be developed in the channel where specific needs of Electrical Engineering degrees could be addressed. Concept maps [52], [53] are deemed as a potentially useful tool to detect those key areas that would need to be reinforced and, thus, they will be further developed. This approach would be designed with the objective of reinforcing conceptual connections between subjects which, according to Maciejewski et al. [7], is a current need in electrical engineering. Practical case studies should be performed to evaluate the effects of those videos' integration in a real classroom environment. Pursuing both objectives, CoI and ICT-TPACK models could serve as conceptual framework. Additionally, in an attempt to overcome one of the main limitations of this study, more evaluations will be performed in similar dissemination channels of other disciplines in order to further confirm the findings of this article and extrapolate them to other fields of study.

VI. CONCLUSIONS

Two main research questions have served as central guide for this study: are YouTube dissemination videos being integrated in electrical engineering education? In that case, what are their most valued features for such pedagogical use?

Sígueme la Corriente channel has been used as case study, and the following objectives have been set as methodology to answer the previous questions:

(1) To identify whether *Sígueme la Corriente* might be having a side-educational use (as inferred from received comments and source views statistics).
(2) To evaluate its audience perception on metrics considered in literature as essential for educational videos (format and content adequacy).
(3) To receive hints about the audience's perception on the effects of educational video integration as pedagogical aids.

As developed in 'Literature Review' section, there are several benefits from the use of videos as complementary pedagogical aids in higher education, though it is not always easy for lecturers to find time, knowledge, and resources to elaborate their own videos in an adequate format. For this purpose, YouTube can be a valuable source considering the high number of available videos on many specialized topics. The key challenge lies on lecturers being able to identify content and format adequacy of those videos. Additionally, from the creator's perspective, YouTube dissemination channels generally lack of specific pedagogical strategies backing up their content creation, and this might arise doubts on their actual educational suitability. If such unintentional educational use is correctly identified, it could serve as trigger for the implementation of educational models that could successfully lead the development strategy of subsequent videos.

Results obtained in our case study show how this is the case for *Sígueme la Corriente*, which already has a high rate of educational use that confirms our first research question. The main groups using the channel for this purpose are pre-university teachers, university students and junior electrical engineers. We detect slight differences with Lee and Lehto [34] perception that the educational value of YouTube is not appreciated due to its wide social recognition as an entertainment site. In this regard, *Sígueme la Corriente* users claim to take profit of the channel for

educational purposes with a positive frequency of 72.7% even though this is not one of the objectives to which its contents were conceived.

Audiovisual format used in this channel, together with its contents, are remarkably rated as positive by its audience. Users perceive that the channels' videos are useful for understanding topics of interest, as shown by a 93.6% frequency on positive responses. This is in consonance with results from both D'Aquila et al. [37] and Wells et al. [15]. In this regard, there is significant correlation between that belief and the educational use of the channel. Additionally, the presenter's communicative style is rated as attractive and interesting, which contributes to overall channel engagement rates. Our results for these parameters are aligned with the ones obtained Gil Quintana et al. [33]. Therefore, as a response to our second research question, the most valued features for the educational use of the channel are its engaging explanations, the rhythm and duration of its videos, their technical level, and their artistic expression.

Results suggest students' preference for videos as a complementary resource to enhance understanding of topics studied in lectures. In consonance with D'Aquila et al. [37] and Muthuprasad et al. [4], we find no clear tendency, among those who use the channel for didactic purpose, to believe that videos could be a potential full substitute for assistance-based education. We appreciate differences in this regard with Wells et al. [15], whose results show that video resources are perceived by their students as more helpful than lectures.

However, *Sígueme la Corriente* users recognize videos as a successful resource to enhance their overall education experience, that could be potentially considered as an adequate complementary tool both for distance and face to face education.

To sum up, the implications of previous findings are positive when considering the potential educational use of an existing YouTube dissemination channel. Such resources might also derive in a significant raise of students' interest in engineering jobs, as reported by Colston et al. [16]. *Sígueme la Corriente* directly approaches that objective, providing teachers and students with easy-to-follow engineering explanations from a professional in the electrical engineering field.

However, though parameters such as audiovisual format, communicative style, and technical level seem to be perceived as adequate, there is still need to continue developing tools that may serve as guidelines to enhance video integration as educational tool from the perspective of content creators, lecturers, and students. Those strategies should be backed up by state-of-the-art educational models such as CoI and ICT-TPACK, as previously cited in this article. Our future research will integrate specifically developed educational videos in a particular electrical engineering subject, to evaluate the perception of university students when such contents are presented as part of their study material.

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