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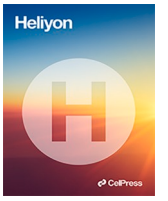

Research article

Comparing educational and dissemination videos in a STEM YouTube channel: A six-year data analysis

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ABSTRACT

Didactic videos have proven to be particularly beneficial for Science, Technology, Engineering and Mathematics (STEM) education challenges. This is due to their contribution to the reduction of the intrinsic cognitive load, as well as fostering connections among subjects to promote generative processing. This fact, together with the wide presence of STEM dissemination videos on YouTube, creates an opportunity both for teachers to focus on dissemination channels to acquire quality materials, and for content creators to develop specific videos aiming to serve as pedagogical aid. Aligned with such reasoning, this paper intends to evaluate the use and performance of a STEM YouTube channel that already publishes didactic videos categorized by intentionality into dissemination or educational. Using owners' data, the channel has been analyzed, considering a six-year extension period, from 2017 to 2022, and distinguishing between the two categories of contents. This dual intention of the channel allows to evaluate the educational use of dissemination channels, compared to their use for curiosity satisfaction. Through Mann-Whitney *U* and correlation analyses, the main channels' metrics have been analyzed in terms of awareness (i.e., impressions, views, or subscribers), use (view duration) and interaction (comments, shares, likes or dislikes). Significant differences have been found in the performance of educational and dissemination contents, such as in views ($p < 0.001$), average view duration ($p = 0.044$) and likes ($p < 0.001$). Additionally, video length optimization has been found as a determining parameter influencing video performance, being educational videos more sensitive to this metric than dissemination videos. This study has shown that a STEM YouTube channel of these characteristics can benefit from publishing videos aiming to a pedagogical purpose, increasing its use compared with other STEM dissemination channels only aiming to an entertainment purpose. Additionally, this study supports previous findings that video length optimization is a determinant characteristic for audience retention rate.

1. Introduction

Informal educational videos in social media provides an alternative world-reaching method to disseminate information, delivering

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additional resources that might enrich formal and informal education. YouTube is currently the main platform for such use [1–3], and particularly the role of edututubers (educational content creators in YouTube) is impacting education in a context where audiovisual content is highly demanded by the new generations of students [4].

The Cognitive Theory of Multimedia Learning (CTML), based on the Cognitive Load Theory (CTL), explains how multimedia material can positively impact processing capacity based on two main aspects: the reduction of extraneous cognitive load and the fostering of generative processing [5,6]. However, as highlighted by Shoufan and Mohamed [7], we still don't know how these principles could be applied to the selection of YouTube videos for students nor the optimal integration strategy into the teaching and learning process. Several authors highlight the need of new replication and comparative studies to understand the impact of YouTube in learning [7–9].

1.1. What aspects define adequate didactic videos? Format, user preferences and integration challenges

There is consensus among the main parameters that make didactic videos be perceived of good quality for pedagogical aid in STEM disciplines. Such parameters highlight audiovisual format aspects such as production quality and visualization of contents, video length optimization, explanation rhythm, technical accuracy and completeness, the use of examples and linking contents to prior knowledge, and an engaging communication style [10–13].

Particularly for the case of video length, several authors highlight its importance for videos to be considered engaging. This is directly related to the retention rate, which measures the average percentage of the video that has been effectively watched by the audience. Doolittle et al. [14] found, as part of their study on 212 undergraduate students, that shorter instructional tutorials promote engagement and, therefore, videos use for learning. This is also aligned with findings by Guo et al. [15] for Massive Online Open Courses (MOOC) environments. Furthermore, Pi and Hong [16] performed an eye-tracking analysis to reveal when mental fatigue appears while watching educational video podcasts. They concluded that mental fatigue started at 10 min and reached a peak at 22 min, recommending keeping videos shorter than 10 min whenever possible. Altman and Jiménez [17] also relate video length with retention rate, concluding that videos with low retention rate could potentially increase their audience engagement by shortening their length. However, it is important to consider that the possibility to shorten an educational video should be strictly conditioned by such video's contents. In this regard, Shoufan [18] appeals to the concept of efficiency in explanations, by addressing the videos' topics in a direct and concise way, rather than just shortening videos to meet a numerical video length target. Additionally, regarding other YouTube video metrics such as likes or dislikes, Shoufan & Mohamed [19] concluded that video length does not present a significant correlation.

Previous works have researched which parameters do motivate students to like or dislike educational videos, which are mainly related to the explanation quality, audiovisual presentation and interest generated [4,18]. Additionally, other authors have detailed a series of pedagogical benefits of YouTube videos, such as the enhancement of academic performance [20–23], the acquisition of new transversal and specific competencies [24], and the increasement of student motivation and satisfaction [25–27]. The following characteristics of YouTube videos are highlighted in such literature as useful for educational environments: providing a summary of the subject's contents, being able to clarify complex phenomena and abstract ideas through visual support, and providing models of professional skills and behaviors. In this context, the fact that other students or professionals create videos also reinforces specialized jargon learning and helps fostering virtual and collaborative learning [28].

The challenge relies on the creation of videos that are more adapted to pedagogical needs, as well as in providing adequate tools and competencies to the teaching community for the appropriate selection of educational videos [29–31]. This would avoid the potential negative effects of resorting to YouTube videos for educational purposes, such as the attention reduction or the lack of scientific rigor [32,33].

The suitable search of YouTube videos for education is complex, not only because of the huge number of videos published in the platform [34], but also due to the popularity-driven search and recommendation algorithm of YouTube [35,36]. According to a recent review on the educational use of YouTube, almost 81 % of analyzed videos for potential educational use fall into "poor quality' category [7]. Furthermore, learners tend to select their reference videos from the top of the searching list [37], which increases the challenge of appropriately delivering adequate videos to students as pedagogical aid.

However, the platform also hosts a large quantity of high-quality videos in a wide variety of knowledge domains [1]. Current evidence points out that the optimal strategy would be using YouTube for guided learning, where teachers assume the role of creating or selecting the most suitable videos within a defined pedagogical context. Evidence from previous research shows that teachers did not present resistance to incorporate Information and Communication Technologies (ICT) into their lectures, though their satisfaction in the use of ICT such as videos is associated with their level of digital competence [38,39]. Therefore, it is fundamental that they adequately develop their digital and pedagogical knowledge, according to the Digital Competence Framework for Educators (DigCompEdu) or Technological Pedagogical Content Knowledge (TPACK) [40,41].

In this context, both teachers and content creators could benefit each other from the specific consideration of the pedagogical use from the very beginning of the content creation phase in STEM YouTube channels. Teachers, on the one hand, would benefit from content creators contemplating the creation of educational videos because of the increase of available good quality and suitable didactic videos to be integrated in their teaching dynamics. Content creators, on the other hand, would benefit from targeting these needs by accessing to a new population segment and use purpose that, while maintaining the social dissemination purpose of the channel, adds another dimension to the channel and contributes boosting its use and popularity.

Such consideration towards pedagogical purposes should include the curricular alignment of created contents so that their introduction as pedagogical aid is facilitated. Additionally, previously mentioned aspects related to video content and format adequacy

should be specifically considered and maximized to ensure the perception of such videos as of good quality for educational purposes. Such aspects include an adequate production quality and visualization of contents, video length optimization, adequate explanation rhythm, technical accuracy and completeness, using examples and linking contents to prior knowledge and ensuring an engaging communication style. Didactic videos created with a pedagogical intention, and considering these characteristics, will be referenced in this article as educational videos. Whereas other videos that are created with the solely purpose of satisfying curiosity and entertaining, not necessarily considering abovementioned characteristics, will be referenced as dissemination videos.

This rationale motivates the present study, where the dual use of YouTube channels for social dissemination and education purposes is comparatively analyzed. Among the investigations that use public data to evaluate educational YouTube channels, validated instruments have been developed such as the one proposed by Pattier [42] for this matter. It is based on a 41-item evaluation that relies on the foundations of current literature for the evaluation of parameters such as dependent variables (gender, educational stage and topic), statistics applied to YouTube channels, video structure, video recording and editing, personality of the content creator, use of the YouTube platform and use of other social media. However, according to Bärtl [36], not using owner's data might present some limitations, as social media data (and, particularly, YouTube data) can differ depending on the data collection method that is used. This also highlights the importance of using owner data whenever possible, so that the information collected is precise.

Few articles have been developed with information from the perspective of channel's owners, which could provide useful insights on how to produce better educational videos and how to enhance their integration in the classroom. The cases described by Saurabh and Gautam [9], Bello-Bravo et al. [43] and Yang et al. [3] are some of the very few available. Moreover, as far as authors are concerned, there are no previous analyses in literature comparing the performance of educational and dissemination contents in a STEM YouTube channel. This motivates the reasoning behind understanding how are both types of videos performing in the context of a STEM channel, and which kind of video is more demanded (depending on whether there is a more curiosity-driven or educational-driven interest).

1.2. *Sígueme la Corriente: combining educational and dissemination purposes*

Sígueme la Corriente[1] is a popular Spanish-speaking STEM YouTube channel, focused mainly on energy, electricity and sustainability (see Fig. 1). It was created in January 2017, and, since then, three main stages have taken place in its evolution: presentation, consolidation and reconceptualization.

Initially, the presentation stage took place during approximately the first two years of the channel, until April 2019. During this time, *Sígueme la Corriente* was devoted to creating interest and awareness about energy, electricity and sustainability topics and, therefore, specialized contents were interleaved between other general STEM topics to catch the public's attention. Additionally, during this period the channel's author also visited some TV and radio programs and participated in different national and regional events aiming to present the channel's activity to a wider audience.

The consolidation stage covered from April 2019 to August 2020. During this time, with a regular audience in the channel, *Sígueme la Corriente* focused all its new contents in energy, electricity and sustainability topics but always maintaining a dissemination purpose and voice. The main purpose was still to contribute to curiosity-satisfaction, public awareness, and the entertainment aim usually associated to YouTube. The channel's subscribers and views grew considerably, proving that the interest in such topics became increasingly more evident. Additionally, both teachers and students started asking for complementary contents that could be used in class or as a study material, also coinciding temporarily with the irruption of the Emergency Remote Learning (ERL) due to covid-19 pandemic. This is coherent with Elareshi et al. [44] analysis about YouTube's implications as an educational platform for higher education institutions during ERL, who emphasized that the adoption of this platform is highly recommended.

Pre-experimental academic assessments were set in place to help adequately answering those requests, aiming to verify the involuntary pedagogical use and potential value of the channel as per its audience perception [45,46]. As a conclusion, the reconceptualization stage began in August 2020 with the creation of a specific series of videos dedicated to serve as pedagogical aid, aiming to be integrated both in technological branches of secondary education and in energy, electricity or sustainability related university degrees. The remarkable growth in views, subscribers and use of the channel has been noticeable since then, though still a comprehensive analysis of these trends was missing.

Since *Sígueme la Corriente*'s inauguration on January 1st, 2017, up to December 31st, 2022, the channel has published a total of 147 videos, reaching 146,772 subscribers and 4,268,071 views. All videos have been categorized by a functional criterion, discretizing between "dissemination videos", "educational videos", and "others" for announcements, shorts or non-energy-related videos. The total number of videos published during this six-year time frame in each category is: 29 in education, 62 in dissemination and 56 in others.

These categories were set by intentionality. On the one hand, "dissemination videos" are those that aim to satisfy an entertainment use and curiosity, as well as contributing to the public's awareness on energy, electricity and sustainability. This type of videos has been created since the channel started operating and have continued being published during its six years of operation within the various thematic sections of the channel. In its creation, no specific constraints are considered in terms of topic selection nor format definition, other than presenting interesting and engaging topics to a broad audience. Some examples of videos' titles within this category would be: "How can you understand your electricity bill?", "How is Energy produced in the Matrix movies?", or "Could you be saved if a lightning strikes you?".

[1] https://youtube.com/SiguemeLaCorriente (Accessed 15/10/2023).

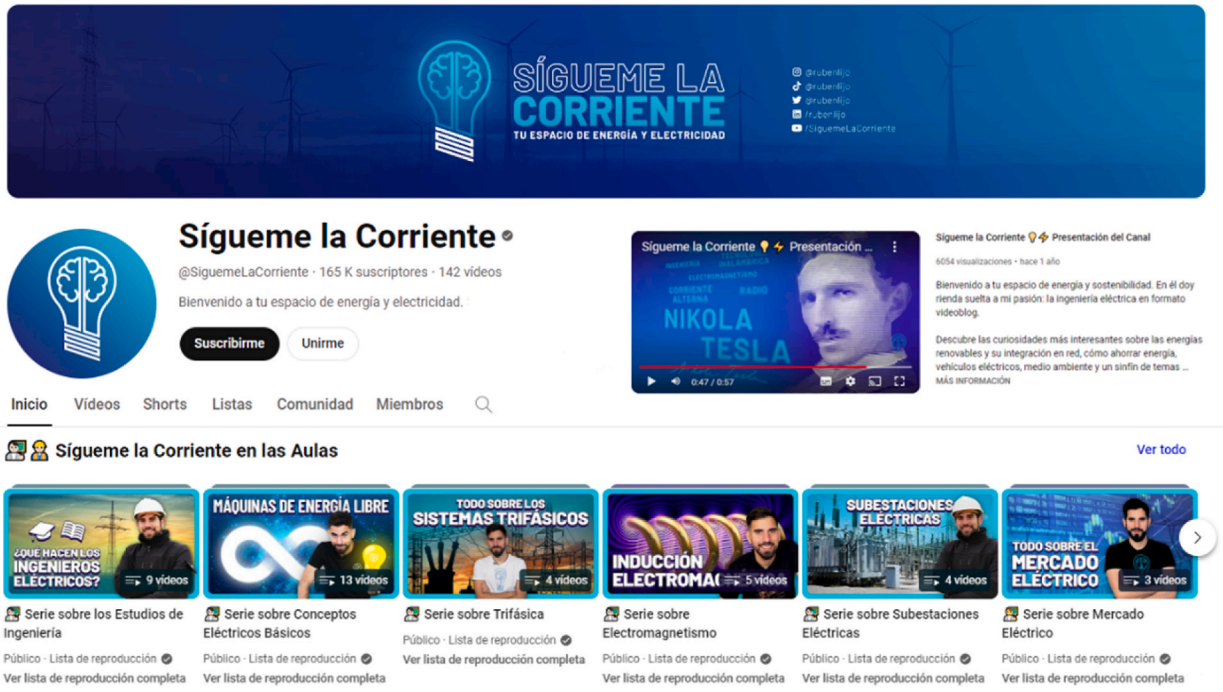

Fig. 1. Illustrative image of *Sígueme la Corriente* YouTube channel.

On the other hand, "educational videos" started to be created as such during the reconceptualization phase in August 2020. However, it is worth noticing that some previous contents were detected to also be compliant with the established criteria to fall under this category. From the presentation and consolidation stages, only a share of 24 % could be considered as educational, whereas during reconceptualization stage such share was set at 50 % (excluding "others" category from consideration in both cases). Educational contents in the channel respond to specific pedagogical requests from the audience (both students and teachers) and have been integrated in educational environments (either in secondary or university education). As opposed to dissemination contents, education contents in the channel are differentiated by the following specific features:

- They are specifically created to respond to a pedagogical demand from either teachers or students. Therefore, are aligned to specific subjects' contents of degrees in STEM formal education.
- They count on a deeper focus and more efficient explanations when compared to dissemination videos, and the communicative voice avoids the distractions that otherwise would aim for entertainment.
- The type of animations and visualizations used in educational videos are specifically designed to support learning of complex abstracts concepts.
- The mathematical explanations of explained ideas are explicitly included and explained as part of educational videos.
- They are often part of a wider series, allowing to link new contents to prior knowledge and creating a structured sequence of videos that increase in complexity.

With the development of the educational video category in the channel, also agreements with universities have taken place to produce specific videos or video series. A successful example would be the curricular integration strategy created together with *Universitat Politècnica de Catalunya* to reinforce Electromagnetism and 3-Phase Circuits concepts in "Electrical Machines I" subject within the Electrical Engineering BSc. Such initiative constituted a real classroom experience covering ERL and post-ERL stages, and the impact of videos was evaluated as a mitigating measure for such an unprecedented learning environment [47].

After more than two years since reconceptualization stage, *Sígueme la Corriente* has become a singular case of a STEM YouTube channel with dual purpose towards dissemination and education. This presents the opportunity of comparatively analyzing the performance of both types of videos and understanding the factors driving their use.

1.3. Objectives and research questions

This study is aiming to provide an analysis on how a YouTube channel might evolve to satisfy the dual needs from the dissemination and education perspective in STEM disciplines, as well as the comparative performance of both types of contents. *Sígueme la Corriente* channel is the object of study, continuing from previous analyses about its potential educational value, as well as its integration in real classroom scenarios. These assessments motivated the creation of specific contents addressing pedagogical purposes, which have been

complementary to the dissemination contents regularly published in the channel.

Therefore, this research's main objective relies on deeply understanding the comparative performance of dissemination videos versus educational videos in the context of a STEM YouTube channel, as well as the factors influencing it. The whole operating lifetime of *Sígueme la Corriente* has been analyzed, covering a total timeframe of six years (from 2017 to 2022). As channel owners, authors counted on advantaged data that could not otherwise be mined by any third party, which allowed deeper data acquisition and analysis.

On the one hand, it would be interesting to evaluate to which extent is the channel being used for educational or dissemination purposes, in order to confirm if the educational use (initially assumed as secondary use of the channel) might have become its predominant use due to the new education-focused strategy. On the other hand, the detailed owner's information for this channel is considered valuable in further providing data-based evidence about video length relevance for both educational-aimed and entertainment-aimed contents, based on the retention rate. Analyzing this parameter, together with other influencing metrics for video popularity, this study intends to provide further empirical evidence complementing the previous analyses on the channel's audience perception about the main parameters to define a good quality video for education.

Therefore, this research intends to answer the following research questions:

- RQ1: Is the educational use of a STEM YouTube channel higher than the entertainment use?
- RQ2: Is video length determinant for video performance in both education and dissemination purposes?

After this initial introduction to relevant literature on video integration as pedagogical aid in STEM disciplines, Section 2 defines the methodology followed in this study. Section 3 presents the most relevant results from the channel's statistics gathered for its six years of activity, and Section 4 is intended to deeply analyze the implications of this study, how these results are related with literature and their main contributions. Section 5 highlights the main conclusions of this article and, finally, Section 6 presents the main limitations and future works of this study.

2. Materials and methods

The YouTube channel object of study is *Sígueme la Corriente*: a STEM channel focused on energy, electricity and sustainability. It has been operating since January 1st, 2017, up to December 31st, 2022, and a total of 147 videos have been published in it, reaching 146,772 subscribers and 4,268,071 views. An extended description of the channel, its scope and the characteristics of its videos is included in the Introduction.

The following subsections are aimed at deeply explaining the methodology of this study, in order that both reproducibility and replicability are ensured.

2.1. Data collection

The data for this study has been collected through a six-year period, during the whole operating lifetime of the channel (from 2017 until 2022). Data has been extracted from YouTube Analytics, accessible through *Sígueme la Corriente*'s YouTube Studio for owners [48]. This tool allows to extract all the relevant metrics for videos published in the channel throughout its whole lifetime. However, even though YouTube Analytics is limited to videos as subjects of study, gathered data is representing the global use of the channel across its more than 4 million accumulated views. Moreover, counting on owner's data of the channel has allowed to perform a deeper and more accurate analysis than it would have been possible with publicly available data or through data mining. Additionally, it allows to obtain a more focused and detailed analysis of correlations between the most relevant video metrics, to understand which are the variables most influencing user engagement.

These data are available in any YouTube channel to their respective owners, and can be extracted from YouTube's content management system through YouTube Studio, under the section statistics. Within such section, any owner can select specific information on any video's performance, as well as on the channel. Moreover, advanced statistics are also available for several variables, allowing the owner to set up the time period for which the statistics will be extracted and also exporting them to an.csv file that will serve as raw data for analysis.

The sample considered for this study consisted of 147 videos, which represents the total number of videos published in the channel under the three categories pre-established due to intentionality: educational, dissemination and others (please, refer to the Introduction for more information). All the videos considered in this study were originally created by *Sígueme la Corriente* and published in the channel, excluding any content from third parties that might be present in certain playlists (e.g., interviews in tv programs or collaborations in other channels). The information collected for all videos has allowed to obtain a contextual understanding of the main metrics' evolution through time.

Particularly for the case of demographic information, whereas the geographic distribution of users in countries has been available for the whole period covered in this study, in the case of cities it has only been available since August 19th, 2021. Therefore, results for this parameter will only be shown as additional contextual information only for a fraction of the studied period. This fact has been addressed in the Limitations section.

Regarding the comparative study, the two video categories considered as object for comparison were educational and dissemination. Whether "others" category contributed to the overall statistic analysis of the channel, for comparisons between generic dissemination contents and contents designed for educational purposes, a subset of 91 videos has been considered, excluding in these cases the 56 videos categorized as "others".

Finally, comments received in the channel have not been collected for their assessment through qualitative methods. This could be an interesting complementary research analysis to be developed as continuation of this study and is, therefore, declared in Limitations and Future Works.

The collected information is available online through Mendeley Data, where it can be accessed and downloaded (Appendix A).

2.2. Available and analyzed variables

When accessing to the advanced mode of the Analytics section of YouTube Studio for owners, a series of parameters are made available that are useful to evaluate the performance and use of a channel. These metrics are grouped in several concepts, as shown in the following list:

- Overview: watch time (hours), views, average view duration, average percentage viewed, subscribers, videos added, videos published.
- Reach: impressions, impressions click-through rate, shown in feed, viewed (vs. swiped away), unique viewers, average views per viewer, new viewers and returning viewers.
- Interactions: subscribers gained, subscribers lost, likes, dislikes, likes (vs. dislikes), shares and comments added.
- Playlists: playlist watch time (hours), views from playlist, playlist average view duration, playlist average percentage viewed, playlist starts, playlist exits, playlist exit rate, average time in playlist, views per playlist start and playlist saves.

Moreover, additional metrics are available referred to concepts that are not deemed relevant in this study, such as revenue, members, posts, cards, clips, end screens, live contents, remixes, shopping and YouTube premium.

From all available metrics, this research focuses mainly on a selection of the most relevant parameters for the study's scope. They are grouped in Results section as those referring to reach and awareness (i.e., impressions, views and subscribers), use (average view duration) and interaction (comments, shares, likes and dislikes). Additionally, video length and video categories set up by intentionality are also considered as pre-defined parameters not depending on the channel's use. And, finally, contextual variables are considered such as the demographic information of users (gender, age, countries and cities) and the device type used when consuming the channel's contents.

2.3. Data analysis

Statistical analyses shown in Results section have been performed using Jamovi [49,50], with a confidence level of 95 % in all cases. Normality Shapiro-Wilk test concludes that the distribution of the data gathered is non-normal and, therefore, non-parametric statistics should be considered.

A quantitative approach has been developed for this non-experimental research, distributed between two main stages: observational and correlational. On the one hand, the observational stage is aimed to understand the general evolution of the channel, focusing on metrics such as views distribution, demographic characteristics, and consumption habits. Descriptive statistics have been useful to analyze and represent relevant explanatory information about the channel's users (demographic characteristics and device type used), as well as the overall channel's performance on the targeted metrics. Moreover, considering the non-normal distribution of variables for observational analysis, Mann-Whitney *U* has been used to detect significant differences in the studied variables among education and dissemination categories. Finally, the geographical distribution of visits has been analyzed using QGIS [51], which has also allowed to create countries and cities maps for their representation. On the other hand, the correlational stage aims to detect clear links between the different variables that measure videos' performance, to detect which patterns are definitory for video consumption, and also potential differences between dissemination and educational contents. Due to the non-normal distribution of most variables, Spearman's correlation analyses were used aiming to find significant relations among relevant metrics defining videos' performance, as well as different consumption behaviors between both types of contents, which might be useful when extrapolating those results to the broader picture of educational YouTube channels for STEM disciplines. Additionally, particularly for the parameter of average view duration (%) normality has been confirmed, which allows to perform linear regression analyses in such case.

In terms of data curation, the only manipulation that has been performed in the raw data file prior to the data analysis is the incorporation of videos' category and duration as an additional pre-set variable that allows grouping videos by their intentionality (educational, dissemination or others). The rest of the information has been directly extracted from the raw data file provided by YouTube Studio Analytics. All the information used in this study is available online through Mendeley Data (Appendix A).

3. Results

In this section, results are presented as per the previously stated stages of the study: observational and correlational. This information is intended to provide a complete mapping of the use of a STEM YouTube channel with both educational and dissemination contents. These analyses are also aimed to enhance the specific knowledge about the performance of education-focused videos in the context of STEM dissemination channels, intending to provide teachers and professors with valuable information to foster videos' pedagogical integration.

3.1. Observational analysis

Within the observational stage, the information is presented on key metrics for the performance analysis of any YouTube channel, such as views distribution, demographic characteristics, interaction with videos, or consumption habits. From those metrics, one of the most relevant parameters for the evaluation of a YouTube channel's performance is "views", as it is representative of the number of times that a video has been played. Fig. 2 represents the distribution of views throughout the whole lifetime of the channel. Additionally, a representation of the aggregate views is incorporated so that the channel's growth on popularity could be easily appreciated. In the six years lifetime of the channel, it has achieved a total of 4,268,071 views. In addition to these metrics representing the overall use evolution of the channel through time, subscribers' evolution can be seen in Fig. 3.

The channel's performance in terms of views and subscribers is also showing the effects of the three different stages presented at the Introduction section: presentation, consolidation, and reconceptualization. These stages correspond to a clear evolution in the management and content strategies of the channel, and their effect can be appreciated in the dotted trend lines included in Fig. 2. The channel has experienced a remarkable increase in views, subscriptions, and use since the reconceptualization stage began in August 2020. From such date, the specific series of educational videos started to be considered as half of the proportion of videos published, counting with optimized features for their use as pedagogical aid.

Views and average percentage of view duration are presented in Table 1, distributed per age range. The use of *Sígueme la Corriente* is mainly centered in people between 18 and 34 years old, covering 57.37 % of views. Additionally, referring to gender distribution, 84.12 % of views have come from men and 15.88 % from women. But besides views count, the percentage of video that is reproduced is also a very interesting parameter to understand audience retention through the channel contents. The average view duration on the channel is very similar for all age ranges, covering from 34.95 % to 41.29 %. When considering all video views during the whole lifetime of the channel, the view duration is in average 49.87 % of the total length of videos.

In terms of geographical distribution, most visits come from Spain, Mexico, and Argentina, with respective 24.50 %, 22.14 % and 11.48 % of total views. Furthermore, when analyzing views per cities, the main sources are Lima (Perú), Madrid (Spain) and Santiago (Chile) with respective 34.45 %, 17.14 % and 8.69 %. Data for cities has recently been implemented in YouTube Studio and, therefore, it is limited to the period between September 2021 to December 2022. Maps shown in Fig. 4 represent the whole geographical distribution of visits, highlighting the 10 countries and cities that are most relevant when it comes to views share. Additionally, further information for top 10 countries and cities is included in Table 2.

When deeply analyzing the sources of views, interesting information arises. First, 78.78 % of total visits comes from non-subscribers, which shows a wide sporadic use of the channel that might be associated with queries or occasional support. Additionally, the main device type from which the channel is consumed is the mobile phone, covering 53.92 % of views. Table 3 shows how views are distributed by device type, as well as the average view duration in each kind of device. While computer represents 19.04 % less views than mobile, it is noteworthy that viewers stay an 8.1 % longer watching the channel's videos. The highest retention rate is found in television, with a 57.4 % of average view duration.

Furthermore, an analysis of view sources can also bring interesting information on how *Sígueme la Corriente* is used. Up to a 41.64 % of the channel's traffic comes from specific searches, with values of 24.32 % and 17.32 % respectively coming from YouTube search and exploration function. Another 28.22 % of the traffic comes from suggested videos section, and 13.03 % of views comes from external sources. In terms of internal traffic, a 5.59 % of views comes from the channel pages, and 1.27 % and 1.11 % comes respectively from playlists and notifications.

While previous results consider the bulk statistics of all the channel's contents as contextualization, this paper mainly intends to compare the performance of educational videos versus dissemination videos. Table 4 summarizes the mean values for key metrics in both types of contents throughout the whole channel's lifetime. Additionally, Mann-Whitney *U* tests have been performed through all

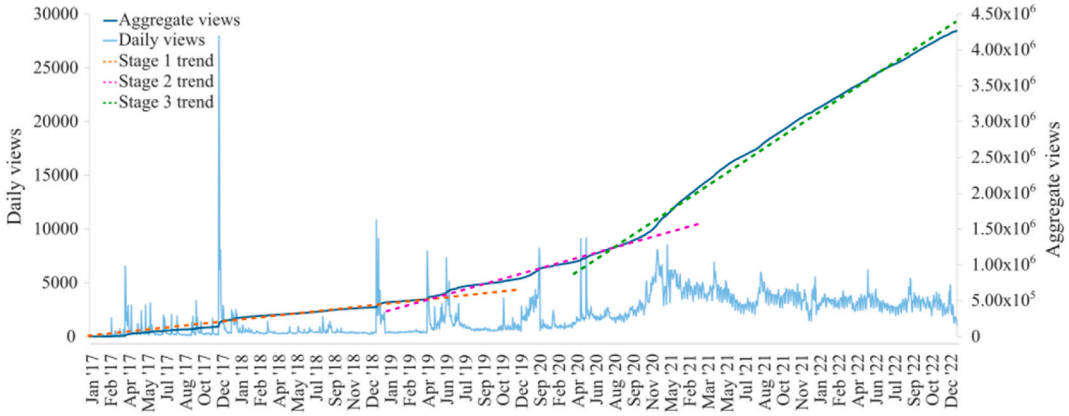

Fig. 2. Daily and aggregate views during the whole channel's life, showing in dotted lines its three definitory stages: presentation (orange), consolidation (pink), and reconceptualization (green). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

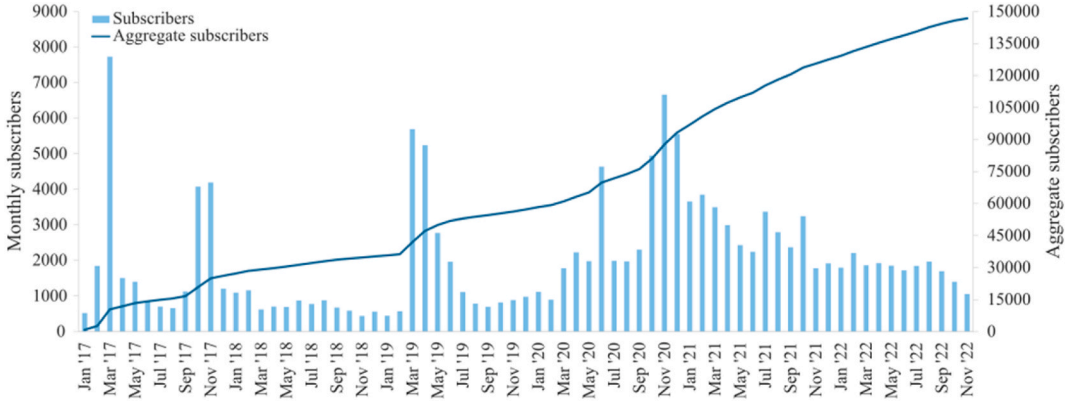

Fig. 3. Monthly and aggregate subscribers during the whole channel's life.

Table 1
Views distribution and average view duration per age.

Age of viewer	Views (%)	Average view duration (%)
Between 13 and 17 years old	2.61	34.95
Between 18 and 24 years old	28.76	38.73
Between 25 and 34 years old	28.61	41.29
Between 35 and 44 years old	17.66	40.33
Between 45 and 54 years old	12.05	40.36
Between 55 and 64 years old	6.81	39.7
More than 65 years old	3.5	39.1
Total	100	39.21

Fig. 4. Geographical distribution of views. Left: views per countries from January 1st, 2017, to December 31st, 2022. Right: views per cities from September 1st, 2021, to December 31st, 2022.

metrics, considering as null hypothesis that there is no significant difference between the mean values of education and dissemination video categories.

As shown in Table 4, there is no significant difference in average video length between educational and dissemination videos published in the channel, which is between 5 and 15 min for 69 % of the educational videos and 63 % of the dissemination videos.

Regarding the number of views, there is indeed significant difference between both categories. Those contents that are created aiming at educational use achieve in average 2.78 times more visits than dissemination contents. Additionally, view duration reveals respective average retention rates of 47 % and 42.3 % of videos' length for education versus dissemination. Similarly, educational videos receive in average 2.89 times more comments compared to dissemination contents. The sharing rate is also a very useful parameter to identify the use of the channel. There are significant differences in the number of shares when comparing both categories,

Table 2
Geographical distribution of views for the top 10 countries and cities.

Views per country		Visits per city	
Country	Views	City	Views
Spain	973,204	Lima (Peru)	22,656
Mexico	879,599	Madrid (Spain)	11,272
Argentina	456,186	Santiago (Chile)	5717
Peru	346,910	Bogotá (Colombia)	4945
Colombia	345,147	Ciudad de México (Mexico)	4857
Chile	271,014	Barcelona (Spain)	2811
Ecuador	132,744	San Salvador (El Salvador)	919
United States of America	96,190	Sevilla (Spain)	825
Bolivia	89,125	Buenos Aires (Argentina)	817
Venezuela	75,901	Valencia (Spain)	634

* Views per countries cover from Jan 1st, 2017, to Dec 31st, 2022. Views per cities cover from Sep 1st, 2021, to Dec 31st, 2022.

Table 3
Views distribution and average view duration per device type.

Device type	Views (%)	Average view duration (%)
Mobile phone	53.92 %	36.20
Computer	34.88 %	44.30
Television	7.06 %	57.40
Tablet	4.13 %	46.10

Table 4
Channel metrics mean values per content category, and comparison between Education and Dissemination categories.

Metric	Education		Dissemination		Education *vs* Dissemination[a]	
	Mean	SD	Mean	SD	*U*	*p* value
Video length (s)	723	442	818	344	692	0.079
Views	72,934	63,782	26,337	29,703	352	< **0.001**
Average view duration (%)	47	13.5	42.3	10.5	662	**0.044**
Comments	180	356	62.2	57.2	518	**0.001**
Shared	1234	1151	329	393	292	< **0.001**
Like	3788	3376	1181	1066	315	< **0.001**
Dislike	45.1	41	36	54.7	609	**0.014**
Subscribers	2007	2358	425	721	307	< **0.001**

Bold values: $p < 0.05$.
[a] Mann-Whitney *U* test.

where education contents are shared 3.75 times more. Similarly, educational videos achieve 3.2 times more likes than dissemination videos. A difference in dislikes is also found, where educational videos receive 1.25 times more dislikes than dissemination videos. Additionally, educational videos achieve 4.72 times more subscribers for the channel than dissemination videos.

As per the whole channel's collected data, Fig. 5 represents the relative video views and playlists starts distribution considering the total number of videos in each category. The views associated with educational contents in *Sígueme la Corriente* represent a 67 % of the total 4,268,071 views of the channel. Additionally, the contents are distributed through playlists that help users find the type of videos that they are seeking. These playlists are distributed both thematically and by purpose, facilitating their categorization also into education and dissemination. As shown in Fig. 5, from all playlists started in the channel, education playlists represent a 73 %.

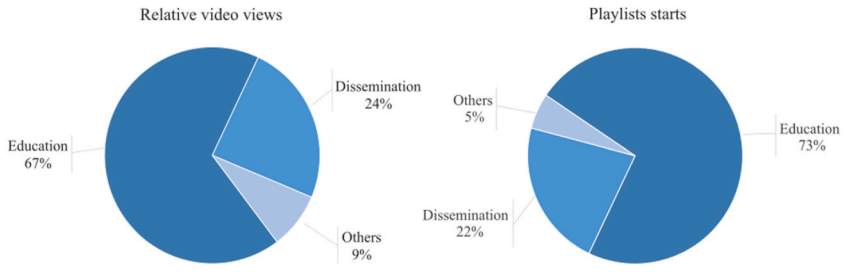

Fig. 5. Relative video views and playlists starts distribution per content category.

3.2. Correlational analysis

Intending to find deeper links among the analyzed variables for both contents' categories, non-parametric Spearman's correlation tests have been performed. This analysis aims to detect whether there are significant correlations between key metrics, and whether those correlations are valid for both education and dissemination categories. The results of the tests are presented in Table 5, from where interesting information can be extracted.

First, as evidenced through these results, views are not related with video length nor view duration achieved by the channel's contents. However, this metric is deeply related with impressions, which is the number of times that YouTube shows the content to potential users (after searching for similar topics, in the side bar of related videos, or at YouTube's main page). The more visible a content is, the more visits it gets. Additionally, interaction parameters as comments, sharing, likes and dislikes, are correlated with visits equally both for education and dissemination contents. This is also coherent with the fact that all the interaction parameters are correlated with each other, as they rely on the number of views and are representative of a coherent behavior: when the channel's contents are more viewed, interaction increases in the form of comments, sharing and likes or dislikes. As subscriptions to a channel is the maximum representation of loyalty and fan-phenomena, we can also appreciate how the number of subscribers is related not only to views, but also to other interaction metrics as the last stage of the user's attachment to the channel's activity.

Video length is one of the most relevant parameters when defining the characteristics of a video. When performing an optimized explanation, it is the result of how complex a topic is, together with the depth of the explanation provided. As mentioned earlier, most of *Sígueme la Corriente*'s videos are framed between 5 and 15 min long, representing 65 % of videos under both education and dissemination categories. Video length, as a parameter, is correlated with view duration for both categories, following an inverse relation as shown in Fig. 6: the more a video lasts, the less percentage of the video is viewed. Regression lines represented are defined by equations (1) and (2) respectively for education and dissemination. Both lines' intersecting point is the video length for which the mean retention rate is the same in both categories, resulting in 16 min and 29 s for a 40.21 % of video length viewed in average. As can be easily appreciated in the slopes, dissemination videos are less dependent on length, compared to educational videos. Educational videos' regression line shows a more aggressive slope, providing a clear idea on how, in this category, audience retention is more susceptible towards video length. It is also noticeable how dispersion is lower in educational videos, potentially responding to a more

Table 5
Values of Spearman's correlation rho among the main variables of interest, per content category.

	Video length	Views	View duration (%)	Impressions	Comments	Shared	Like	Dislike	Subscribers
Video length	–								
	–								
Views	0.285	–							
	0.095	–							
View duration (%)	-0.852**	-0.055	–						
	-0.551**	-0.098	–						
Impressions	0.481*	0.949**	-0.221	–					
	0.180	0.910**	-0.039	–					
Comments	0.533*	0.885**	-0.215	0.920**	–				
	0.203	0.830**	0.098	0.861**	–				
Shared	0.089	0.921**	0.140	0.849**	0.763**	–			
	0.203	0.920**	-0.081	0.911**	0.825**	–			
Like	0.380*	0.957**	-0.074	0.975**	0.917**	0.894**	–		
	0.112	0.905**	0.132	0.912**	0.915**	0.923**	–		
Dislike	0.230	0.965**	0.005	0.904**	0.865**	0.903**	0.912**	–	
	0.174	0.875**	-0.110	0.856**	0.817**	0.809**	0.809**	–	
Subscribers	0.362	0.974**	-0.078	0.963**	0.918**	0.881**	0.969**	0.949**	–
	0.111	0.957**	0.047	0.922**	0.870**	0.926**	0.947**	0.848**	–

Dark blue: education category. Light blue: dissemination category.
*p<0.05; **p<0.001

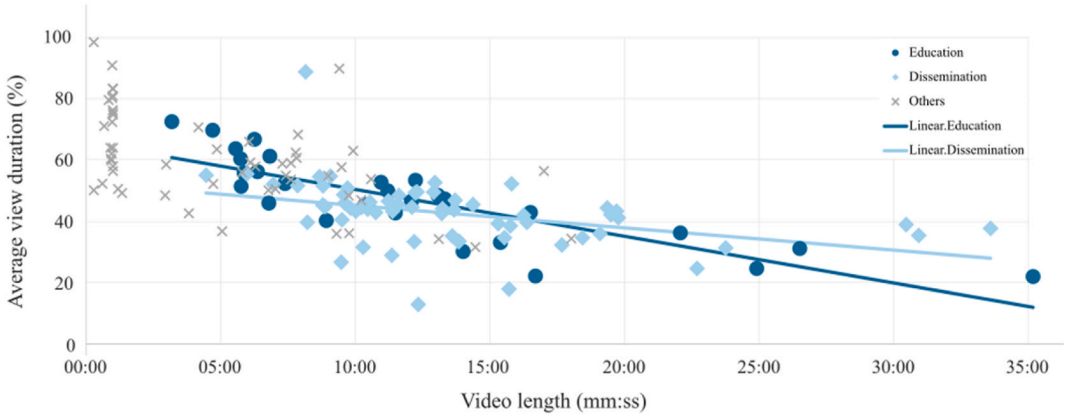

Fig. 6. Linear regression between video length and view duration per content category.

consistent user behavior due to such contents' specific common characteristics to optimize their potential pedagogical use.

$$y = 65.255 - 0.0253x \tag{1}$$

$$y = 52.190 - 0.0121x \tag{2}$$

However, there are additional interesting differences in user behavior for both categories when considering video length. There is a significant positive correlation between video length and impressions, comments and likes for educational videos, and this fact is not verified for dissemination videos as shown in Table 5. This means that longer educational videos published in the channel tend to have more impressions and more interaction in the form of comments and likes. Therefore, even though longer educational videos are watched in average through a shorter percentage of their duration, potentially because they are for a narrower target audience, they are greatly appreciated and interacted with.

4. Discussion

Over the last decade, YouTube has asserted its dominance as the main video-based social network and, therefore, as the most used network in university education for video-aided learning [1,7]. However, there are still some challenges mainly related to the adequate selection of quality videos as pedagogical aid due to the massive quantity of videos uploaded to the platform and the popularity-driven search criteria [35,36]. This article intends to comparatively evaluate the performance of education-focused contents and videos designed for social dissemination that might be introduced in learning activities without a specific focus for such use. For this purpose, owner's data have been used from a popular STEM YouTube channel called *Sígueme la Corriente*.

First, an observational analysis has provided useful contextual information from the overall channel characterization. Both the channel's presentation and consolidation stages described at the Introduction, and characterized in Fig. 2, had allowed the achievement of a total quantity of 69,829 subscribers and 1,180,848 views by July 31st, 2020, after three years and seven months of activity. The reconceptualization stage proposed the creation of different series of videos specifically aimed for pedagogical use in tertiary education, which brought the channel to a whole other level during the following two years and five months. This additional format, together with the dissemination videos that continued being published, contributed to the channel's acquisition of new 76,943 subscribers and 3,087,223 views leading to the total 146,772 subscribers and 4,268,071 views quantified in this study. This means that 52 % of subscribers and 72 % of views were gained during reconceptualization phase, which lasted 32.5 % less time than both presentation and consolidation phases.

Overall, the average number of views per video in *Sígueme la Corriente* is 28,965, and the median is 10,202. Considering the context, the median views count achieved by a YouTube video is 89, and average YouTube videos tagged as Science and Technology achieve a mean count of around 6638 views [3]. Moreover, YouTube channels achieve in average 199 subscribers and 43,000 views. This information allows us to comparatively consider *Sígueme la Corriente* as a popular Science and Technology YouTube channel.

During these years an increment of women presence in the channel's audience has also been quantified. During the first year of the channel's activity, only 6 %–9 % of the audience were women. This percentage has increased during reconceptualization stage, to the 15.88 % of women viewers that was quantified until December 31st, 2022. This is a positive result, also in consonance with the findings from Saurabh and Gautam [9] whose channel's audience is composed by a female share within the range of 20–30 %. They highlight the fact that female distribution on their case is between 13 and 24 years old, which might imply that young women are progressively getting more involved in STEM education. Yang et al. [3] also highlight a similar situation in their study, concluding that the 18–44 age group and males were the most active and engaged demographic group. This is in consonance with other research concluding that males are more active audiences in online science social media [52]. At this point it is also relevant to highlight that there is a clear gender gap among edutubers that implies fewer presence of role models for women, which might influence their interest in this platform as source of information for STEM education [3,53,54].

Geographically speaking, the channel's language is determinant for its audience to be mainly based in Spanish-speaking countries. The main countries reproducing its contents are Spain, Mexico and Argentina, representing respectively 22.8 %, 20.61 % and 10.69 % of total views. Additionally, up to 57.37 % of the channel's viewers are between 18 and 34 years old, aligned with the cases described by Bello-Bravo et al. [43], Reina et al. [55] and Yang et al. [3]. The average retention rate in terms of video duration percentage is very similar among all age ranges, reaching 41.29 % in the better case.

Referring to the device types where the channel's contents are consumed, *Sígueme la Corriente* is mainly used in mobile phones and computers, with a respective representation of 53.92 % and 34.88 % of total views. In terms of retention rate, phone and computer views achieved respectively in this channel a 36.20 % and 44.30 %. The case described by Saurabh and Gautam [9] represents the opposite situation, where computers represent an 81 % of their audience preferred device, and mobile phones only achieved a 16 %. Yang et al. [3] also received 81.32 % of their visits from computers and mobile phones with respective 64.01 % and 59.88 % retention rate.

Views from searches, external sources and suggested videos cover up to 82.89 % of the traffic, which is also aligned with the fact that 78.78 % of views comes from non-subscribers. The main view sources in the channel are represented by suggested videos and YouTube search covering respectively 28.22 % and 24,32 % of the channel's traffic. The exploration function and the external sources are covering 17.32 % and 13.03 % of the channel's traffic. This is supported by Cheng et al. [56] explanation that external sources are highly important in videos' early stage, where social referral during the first week creates awareness and provides the initial views boost. Our results are also aligned with Saurabh and Gautam's [9], whose channel's main view sources also were YouTube search and suggested videos with 39 % and 18 % of views. In their case, also 13 % of visits came from external links. Also, Yang et al. [3] reported that the majority of their scientific communication channel's users were non-subscribers, with a 92 % of representation. Evidence points out that STEM dissemination channels tend to engage mainly with external audience, which implies that the use of these channels is mainly sporadic and might be associated with queries or occasional support.

However, though these metrics are interesting to know the overall performance of the channel and the main characteristics of its audience, it is not easy to know whether such use is related to satisfy educational needs or whether it is related to entertainment and curiosity-satisfaction purposes. Reconceptualization stage in *Sígueme la Corriente* has also led to an increase in other interaction parameters, such as comments, shares, likes and dislikes, which might provide interesting information in user behavior and use of the educational and dissemination contents provided by the channel. The following subsections intend to dig deeper into this issue, by presenting a direct comparison of education and dissemination contents' performance, aligned with the two research questions presented in this article.

4.1. RQ1: is the educational use of a STEM YouTube channel higher than the entertainment use?

As means to answer this research question, we will consider that the use of a YouTube channel is mainly described by views, average view duration, subscribers count and interaction parameters (comments, shares, likes and dislikes). In this regard, in the case of *Sígueme la Corriente*, educational contents are by far more viewed and interacted with. Additionally, this study confirms the significant correlation between awareness metrics and interaction metrics, meaning that impressions, views, and subscribers metrics are correlated with comments, shares, likes and dislikes. This is consistent with the common consensus in literature [43,57–59].

Both the significant difference in the average view duration of educational videos compared with dissemination videos, and the number of views that each category has achieved, are representing a predominant educational use of the channel. Up to a 67 % of the video views achieved, in relation to the total number of videos published under each category, are related to educational contents. Moreover, a 73 % of playlists starts in the channel refer to playlists created for educational use.

The interaction parameters (comments, shares, likes or dislikes) have also experienced a trend change after August 2020, which might be related to the effects of the reconceptualization strategy followed in the channel. This stage included the creation of a specific series of educational videos considering pre-defined criteria to enhance videos use for pedagogical purposes. Such criteria are explained in more detail at the Introduction section. There are also significant differences in these interaction metrics between both education and dissemination categories.

Regarding comments, the channel has received an average of 4.95 comments per day, but there is a clear tendency change from August 2020 on, where a mean value of 7 comments per day was achieved, compared to presentation and consolidation stages (average value of 3.49 comments per day). The peak of comments received was 149 on December 3rd, 2020. There are 2.89 times more comments in educational videos than in dissemination videos (average of 180 *vs* 62.2 comments per video), which might represent a greater willing of asking questions or sharing perceptions with the video creator and with pairs in the case of the pedagogical use.

Shares show a similar pattern, with a mean value of 6.8 video shares per day during presentation and consolidation stages, and an average of 54.67 shares per day during reconceptualization stage. In the case of shares, the peak value was 232 on November 25th, 2020. Educational videos are shared in average 3.75 times more than dissemination videos (1234 *vs* 329 shares in average), which not only represents a higher use of educational videos, but also a greater willing to share them with others (e.g., colleagues, students, teachers, etc.).

Likes and dislikes are also confirming the higher use of the educational videos published in the channel. During the presentation and consolidation phases, the channel received respective averages of 58.03 and 1.27 likes and dislikes per day, where the reconceptualization stage changed the tendency to respective mean values of 160.15 and 2.77. Education contents received 3.2 times more likes than dissemination videos. Additionally, they have also received a mean of 45.1 dislikes per video, which is higher than the average of 36 dislikes per video quantified for dissemination contents. The reason behind this apparent contradiction is the high exposure of educational videos, which are more visited and consumed. Even though educational contents are visited 2.78 times the

number of visits achieved by dissemination contents, they only get 1.25 times more dislikes. Therefore, in proportion, educational contents receive fewer dislikes-per-visit.

Unlike other parameters such as comments or visits, likes are directly representing a positive evaluation of the audience about the videos' contents and format [60]. Videos with more likes use to receive more visits, and these tend to have longer average view duration, as has been demonstrated in this article. These results are also coherent with the findings of Yang et al. [3]. Previous research also highlights that, in social media environments, contents with higher number of likes are watched earlier by users and during more time [61]. Moreover, an interesting analysis of the reasons to like or dislike a video was developed by Shoufan [18], who performed a qualitative analysis on 51 students' responses about 54 videos. He found that those reasons correspond to the videos' performance on the following 7 main clusters or parameters (presented in order of impact): explanation and understanding, technical presentation, content, efficiency (worthiness of time spent watching the video), language and voice, interest, or others. This is coherent with the high rate of likes achieved in *Sígueme la Corriente*, whose users' perception on similar metrics has been previously quantified [45]. With a sample of 912 users, it was concluded that the channels' contents are helpful to understand topics of interest (4.58 score over 5), the images and animations used to understand concepts were considered adequate (91.7 % positive responses), the technical level of the videos was considered adequate (91.6 % positive answers), the rhythm of the videos was adequate for concept comprehension (92.5 % positive answers), the presenter's communication abilities were found attractive and interesting (95.6 % positive responses), and the topics and contents selected were considered interesting (82.4 % positive answers).

Regarding subscribers, the channel receives an average of 67.14 per day. Educational contents are responsible in average for 4.72 more people subscribing to the channel than dissemination contents. This means that a mean value of 2007 subscribers have been achieved from each educational video, versus 425 from each dissemination video.

As presented, there is a clear preference towards the use of educational contents from *Sígueme la Corriente* over the use of regular dissemination contents. This implies that the perceptions quantified from the channel's users in previous exploratory analyses was pointing in the right direction. Covering both presentation and conceptualization phases, the initially involuntary use of the channel's dissemination contents for educational purposes was evidenced, as well as an overall positive perception of such contents [45]. Additionally, a qualitative analysis with 524 participants was conducted in the same time frame [46], where *Sígueme la Corriente*'s audience highlighted the channel's value for understanding and learning complex concepts in electrical engineering, claiming that it also enhanced their motivation and interest towards such discipline. Responding to such demands, reconceptualization phase has addressed the unveiled educational needs of the audience, and the contents resulting from such considerations have performed much better than the classic dissemination format offered by the channel.

This preference for contents designed to be compatible with an educational use could be of relevance for other content creators, as they show how STEM YouTube channels might be perceived as suitable for educational use. Moreover, it also highlights how fostering contents specifically designed for educational use could boost the channel's growth, considering their curricular alignment and their format adaptation to be consumed as pedagogical aid.

4.2. RQ2: is video length determinant for video performance in both education and dissemination purposes?

Video length is a key parameter when planning to create and consume a YouTube video. In the early stages of YouTube, regular users were only authorized to upload videos up to 10 min length [62]. And even though nowadays there is no length limit imposed by the platform, results suggest that the longer an educational video is the more impressions it gets. Which is to say that such video is shown by YouTube to a wider potential audience in the search for similar topics, in the side bar of related videos, or at YouTube's main page. This is aligned with previous research stating that longer videos are more likely to be recommended by YouTube [3].

However, even though results point to an increment in impressions for longer videos, no correlation has been found in *Sígueme la Corriente* between video length and views count. In contrast with these results, there are some authors that claim that video length is a parameter influencing video views. This is indeed expressed by Cheng et al. [62] and Yang et al. [3], finding significant correlations between those parameters. Saurabh and Gautam [9] also highlight as a result that video length influences views count, but in their case no correlation analysis is presented. As a hypothesis, a possible explanation is that the type of videos analyzed in *Sígueme la Corriente* are mainly used for a utility purpose (either being educational or for curiosity satisfaction), and while videos might be recommended from YouTube they will only be accessed when there is a specific utility behind. Moreover, most authors agree that shorter videos are often preferred by the audience over longer ones. This might also be a factor influencing the decision of not reproducing *Sígueme la Corriente*'s longer videos recommended by the platform. Hence, video length would increase YouTube's recommendations and, therefore, impressions, but this does not necessarily mean that users decide to watch the videos.

The reasoning behind user preference over shorter videos includes that they are found more engaging, they are associated to an increasement of learning outcomes, and they are also influencing students to use them more than once for educational purposes [14–17,63–65]. But this is not only a matter of shortening a video, rather than also considering an adequate efficiency in explanations [18]. However, it is important to understand how short a video should be to take advantage of these positive effects in educational environments. This implies the consideration that an optimal target of video length should be flexible within certain margins, as it needs to adapt to the complexity and extent of explained concepts.

In terms of video length, the majority of *Sígueme la Corriente* videos are between 5 and 15 min, depending on the contents' requirements for a complete and clear explanation. This is real for 69 % of the educational videos and 63 % of the dissemination videos. During their creation process, particularly for educational videos, content delivery optimization is a target criterion. In fact, previous analyses in the channel suggest that its users perceive the channel's videos' duration as adequate, with a frequency of 88.4 % of positive responses [45].

Even though no correlation has been found between video length and the number of views in this channel, there is significant correlation between video length and the average duration of views. This implies that, in our case, video length influences how long does the audience stay in a video and, therefore, the potential success of its educational purpose. As described by the inverse correlation, the less a video lasts, the more percentage of the video is watched in both educational and dissemination contents. This is also true for Yang et al. [3] research, where correlation was found between video length and average view duration. Moreover, Bello-Bravo et al. [43] highlight this parameter of retention rate as a rather literal measure of viewer engagement. Regarding this metric, Fig. 6 shows that the average view duration in the channel for most educational videos between 5 and 15 min long is still above 50 % of video length.

It is important to mention that the educational contents are more sensitive to video length than dissemination contents. This fact can be appreciated in the regression lines defined by equations (1) and (2) respectively for education and dissemination. A possible explanation could be that educational videos are directed to a more specific use to explain concrete concepts or provide concise descriptions. In this line, it is also worth mentioning that educational contents show less dispersion in the linear regression model than dissemination contents. This is potentially due to the specific common characteristics present in all the educational contents of the channel, as opposed to the dissemination contents. In this last case, the format of the videos might change between each other as means of serving curiosity-satisfaction and entertainment purpose (as well as optimizing videos' reach in each particular topic). In opposition, educational videos in the channel prioritize a common format, pursuing curricular alignment, deeper focus, efficient explanations, enhanced quality of animations and visualizations, and back up mathematical explanations.

This is aligned with empirical results from Abu-Taieh et al. [23], which through structural equation modeling showed how the academic achievement through YouTube videos is influenced by the information adoption from YouTube as learning tool. Subsequently, the information adoption is influenced by the information usefulness, which might be linked with the utility perspective being satisfied through efficient explanations, as previously discussed. They also describe how the information usefulness is influenced directly from information quality, whereas the information language has not been evidenced as an influencing factor.

However, careful considerations should be taken when examining the inverse correlation between the video length and the retention rate. Even though regression lines appear to point to the reasoning that the shorter the better, video length should not be shortened to an extent that the contents presented are not adequately explained. This is also linked to the previously mentioned factor of the information quality. Therefore, video performance in terms of retention rate becomes a matter of the efficiency of the explanations, and this is a parameter highly valued for the educational use of videos. This fact has also been highlighted by Shoufan [18]. These results are aligned with DelSignore et al. [65] appreciations after an analysis of 179 videos in a pediatrics YouTube channel, where most videos lasted between 6 to 10 min. Shorter videos possessed the higher view durations (36 %–54 %), while videos exceeding 11 min achieved only a 15 %–28 % view duration.

Guo et al. [15] findings are also consistent with this evidence. Their study was based on data from an online MOOC with 6.9 million video watching sessions in STEM subjects, where the median engagement time was at most 6 min regardless of video length. Videos of 9–12 min were watched less than 50 %, and videos from 12 to 40 min were watched less than 25 %. Opposed to such findings, Lagerstrom et al. [66] argues that the "6-min rule" presented by Guo et al., despite it might be useful in MOOC environments, does not capture video viewing behavior of students in standard college courses. However, they also appeal to the creation of shorter materials than the traditional 50- or 75-min lectures, referring to an optimal range of 12–20 min-length videos as a "rule of thumb".

These comparisons between YouTube and MOOC are illustrative due to the similarities of both environments and formats. In fact, some classic MOOC platforms such as the Khan Academy or edX have also hosted their videos on YouTube for their consumption as MOOC enabling material [15,67]. However, it should be noted that the engagement behaviors in MOOC videos should not be literally generalized to other openly available online videos. MOOC students, as pointed out by Guo et al. [15] are more likely to find self-motivation and, therefore, retention rate is expected to be higher. This might be related to the fact that MOOC contents are presented in a structured environment, as opposed to open YouTube videos, and they often require voluntary registration. Linked to this idea, Shoufan [68] also pointed out that YouTube videos are more likely to be interrupted due to the different watching behavior of students. Unlike MOOC students, who follow a predefined video curriculum, YouTube users are actively seeking out the most suitable videos for their needs.

According to our results, and contrasted with literature, video length is clearly influencing video performance in terms of retention rate, which is a definitory measure of video engagement. This is particularly noticeable in educational contents, where optimal video length appears to be approximately between 5 and 15 min long. And it is highly recommended that this target margin for video length is considering an adequate time dedication to clearly and efficiently present the topics set as objective for each video. While dissemination contents also show a similar pattern, retention rate in their case is not so sensitive to video length.

5. Conclusions

STEM dissemination videos published on YouTube present an opportunity for teachers to use quality material as educational resources. However, the successful search and integration of "good quality" videos for education is challenging and not always easy. This research is considering the incorporation of a specific educational focus to already available STEM YouTube channels, which might benefit both teachers and content creators. In the first case, teachers can be benefitted by the increase of quality materials available, already optimized for their pedagogical integration. In the second, content creators can reap benefits from catering to this need by expanding their reach to a new audience segment and diversifying their channel's purpose (while maintaining its core social dissemination purpose). This diversification might bolster the channel's appeal and use.

A six-year data-driven analysis has been presented in this study for *Sígueme la Corriente* STEM YouTube channel based on owners'

data. Through this time frame, the channel has evolved from a purely STEM dissemination purpose to a dual purpose towards both dissemination and education. The objective of this research has been focused on analyzing such evolution to understand the implications of this dual use, focusing on the comparative performance of both types of contents, and the factors influencing it.

Results have revealed how the educational purpose of the channel has boosted its performance. The use of the channel has widely increased due to the creation of contents specifically designed for their integration as pedagogical aid. Comparatively, this study shows how the educational use of a YouTube channel of these characteristics is significantly higher than the entertainment or curiosity-satisfaction uses commonly associated to YouTube as social media. Additionally, it can be concluded that video length is a relevant aspect in video engagement, where significant correlations have been found between video length and retention rate. In this context, educational contents have shown to be more sensitive to this aspect than dissemination contents.

These results support the suitability of incorporating a focused strategy on education to STEM dissemination YouTube channels. Under adequate creation criteria to optimize their adequacy for pedagogical integration, as well as their curricular alignment, this potential new workstream presents an interesting opportunity. Moreover, from the educational perspective, it may positively influence the selection of more suitable videos to be integrated as part of a defined pedagogical context. The development of digital competences and pedagogical knowledge is crucial for teachers' acceptance and integration of these resources, for which DigCompEdu and TPACK frameworks are of relevance.

6. Limitations and future works

Though this study has presented interesting results after the analysis of the detailed data collected through six years, it also has some limitations that should be addressed. First, within the analyzed period there were different ERL scenarios imposed by the lockdowns due to covid-19 pandemic in the various regions where the channel's audience is based on. This implied a global increase in the demand for online resources and, therefore, during such period the consumption pattern of the channel might have been affected. However, this limitation is also partially mitigated by the fact that the analyzed period covers from January 1st, 2017, to December 31st, 2022, which implies that pre-ERL during-ERL and post-ERL scenarios are being considered in this study. Other authors are encouraged to perform similar replication studies that allow to extract conclusions from other STEM channels. Moreover, additional real classroom interventions will be performed for the integration of *Sígueme la Corriente* in a context where no ERL is taking place. Therefore, the focus of the study could be placed on videos' impact itself on a normal scenario rather than the videos' ability to mitigate an unprecedented situation.

Second, no objective metrics or parameters have been collected to measure content and format adequacy. Data collected is useful to measure videos' performance and use, and previous studies are providing complementary information in users' perception on content and format adequacy of the channel's videos for potential educational purposes [45,46]. As mentioned, further integration of the channel in real classroom scenarios will be implemented, also considering placing objective measures such as visual fatigue to evaluate the effect of videos on students. Moreover, a longitudinal analysis will be put in place to adequately measure the impact of such videos in their conceptual learning and academic performance.

Other limitation refers to videos being compared in a period where they have had different life cycles. Not all videos were published at the same time and, therefore, the data gathered is covering different time ranges for each video. A minor limitation is also declared regarding the geographic distribution of users in cities, which information has only been available in YouTube since August 19th, 2021, and, therefore, is not covering the entire period of study for this research. However, this information is provided as a contextual complementary description, and no conclusions of the study are affected or biased by this limitation.

Additionally, the classification on educational and dissemination contents was set by intentionality, as expressed in Introduction and Methodology sections, and this might imply a limitation that should be considered in the interpretation of results. Also, comments included by users have not been analyzed through qualitative methods, which represents a clear research opportunity for future works. Comments are expected to provide additional explanations to the different uses of educational videos versus dissemination videos, as well as the specific user experience of an important fraction of the channel's audience.

Finally, as this article is based on a study case, all data collected and provided refers to only one STEM YouTube channel, which might not represent the global behavior of YouTube audience. We encourage other authors to develop replication studies with channel owners' data to confirm whether these results could be extrapolated to the whole situation of STEM dissemination videos on YouTube.

CRediT authorship contribution statement

Ruben Lijo: Writing – original draft, Visualization, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **José Juan Castro:** Writing – review & editing, Validation, Supervision, Methodology, Formal analysis, Conceptualization. **Eduardo Quevedo:** Writing – review & editing, Validation, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: The corresponding author is the creator of Sígueme la Corriente YouTube channel analyzed in the research, and this is what could enable the possibility of counting with owner's data as described in the article.

Other authors declare that they have no known competing financial interests or personal relationships that could have appeared to

influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e24856.

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