Exploring Explanatory Techniques and Transparency of Popular Science Videos on YouTube

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Media Technology MSc Thesis
Leiden University
June 2021

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Abstract:

After a science video on YouTube with wrong or biased information becomes widespread, a simple retraction or removal of videos might not have the same impact or reach as the first one, as the ideas and misconceptions about the theme are already spread. The simplification or explanation techniques are ways of reducing the content, where variables related to education and entertainment need to be balanced. Our main objective is to avoid some pitfalls when communicating scientific-related subjects and understand if the content creators are open about their sources and their strategies for the simplification of the science-related topics. While the use of qualitative methods to interview YouTube content creators allowed us to include their perspectives in our study, by using quantitative methods, we analyzed explanatory strategies for simplification considering Video styles and Explanatory techniques measured by Category Points (CPs). In addition, we addressed the transparency about sources in the science landscape based on the source material's origin. As a result of the integration of both data sources, the outcomes showed that the great majority of video styles were Voice over Visuals and Vlogs, which define how most of the popular science videos are currently presented on YouTube. In addition, we identified some of the most recurrent explanatory strategies used by the content creators as Summarization, Use of graphs and images, and Use of examples or applications. We consider the CPs had an elevated median grade of 7 out of 10. It was also noted among the analyzed videos that 49% of them did not present a primary source of information, which raises concern about the transparency of sources of those videos. Therefore, both the qualitative and quantitative methods were complementary in presenting a more objective picture of the science video landscape.

1. Introduction

In March 2019, the YouTube channel 'Kurzgesagt – in a nutshell' removed 2 of their most popular explainer videos from the platform because of criticisms in the science community, accused of being biased and opinion-based (Kurzgesagt – In a Nutshell, 2019). After that, they decided to take the videos offline and created a framework to fact-check their scripts with specialists in two moments of the production, while also adding the source materials and papers used in the video description. This was a self-initiated measure to have a more scientifically accurate video, which demonstrates their critical view. At the same time, they still are their own judge and it depends on their own criticism to publish the videos. Moreover, after a video with wrong or biased information becomes widespread, a simple retraction or removal of videos might not have the same impact or reach, as the ideas and inaccuracies about the theme are already spread.

Our objective in this study is not to explore how to rectify information through science communication when it goes wrong, but rather to focus on how to avoid some pitfalls when communicating scientific-related subjects, and understand if the content creators are being transparent about their sources and their strategies for the simplification of the themes presented. Even though we are not trying to measure the video's popularity, choices made by the content creators are possibly affected by the audience and YouTube algorithms.

Science Videos on YouTube have a significant role in society today, much larger than pure entertainment. They are tools used by teachers, students and with astonishing audience numbers reaching millions of people. Science communication mistakes have a negative effect on the learning process, which can be harmful to society, affecting societal values and science in general. People with misunderstandings about scientific findings are prone to spread and reinforce misbeliefs and generating polarization. Likewise, it can affect people's lives and even the political sphere, hindering actions needed to prevent global warming or children's vaccination.

In the remainder of this work, we will first present and discuss related academic work which is framed and adapted from previous studies of Welbourne and Grant (2016) and Kulgemeyer & Peters (2016), with adaptations based on their methodology and classification system. This framework is guided by our research questions on how content creators tackle transparency of sources and explanatory strategies for the simplification of science-related topics. To answer these questions we use complementary approaches applying qualitative and quantitative methods. We entered into the YouTube world interviewing the content creators which allowed us to better understand their position. For the quantitative methods, we analyzed explanatory strategies for simplification considering *Video styles* and *Explanatory techniques* assessed by *Category Points* (CPs). The transparency on the source material used in science videos, we addressed it by examining the source material's origin. We integrate both methods to provide a more objective view of the analysis conducted. The discussion is centered around potential improvement on the methodology and the integration of the main conclusions.

2. Related work

One study that appears closely related to our topic was done by Kulgemeyer and Peters (2016). They analyzed the correlation between the quality of physics videos on YouTube with their popularity, only considering explainer videos and excluding the recording of lectures and speeches. The authors chose two main topics in physics, Kepler's laws on planetary motion (36 videos) and Newton's third law (15 videos), and analyzed the videos using a framework created earlier by Kulgemeyer and Tomczyszyn (2015). The method proposed a set of 45 categories, giving or removing a point if a variable was present in the video. The categories were also divided into groups about language code, graphic representation form, and mathematics code, and the use of analogies and examples.

Ultimately, Kulgemeyer and Peters did not find a direct correlation between video quality and popularity, showing that the popularity as expressed in the number of views/likes/number of comments is not always related to the quality of the video. Even though we are not trying to measure the video's popularity, it is a very important factor since the reach of the videos is dependent on them and it possibly affects the choices made by the content creators and how the video is presented by YouTube algorithms.

The landscape of science YouTube videos and factors that affect their popularity were researched by Welbourne and Grant (2016). Although this is not related to the quality of the expressed information, several choices made by the producers of the videos can be focused on achieving popularity growth. The model created by YouTube makes video popularity important to YouTubers via monetization. Web 2.0 changed the role from passive consumers to active participants, and where science communication is made by journalists, amateurs, and scientists directly to viewers instead of via corporations like the Discovery channel and British Broadcasting Corporation.

YouTube does not directly get involved in the content creation, but the algorithms created for the platform might affect and model how the creators make their choices. These content choices, from visual style, information characteristics, topic, duration, delivery style, and uploaded date and time are closely related to the popularity of each video and channel, as identified by Welbourne and Grant (2016). It is worth noting that YouTube recommends videos to its viewers based on factors that are not clear to the creators and are subject to change.

2.1 Simplification, oversimplification & misrepresentation

Because of the complexity and intricacy of details in scientific findings, to be understood by a layperson, science communication requires simplification in order to be effective. These simplifications are done not only by reducing the amount of content or translating it into a more accessible language, and by using visuals, examples, analogies, and metaphors among several other approaches.

When communicating scientific findings to the general public, it needs to be precise and clear to prevent both misunderstandings in laypersons and mischaracterizations of the results by the media. One example of this misrepresentation done by the media was the popular dissemination of a study about forecasting future global extinction as a result of climate change, which was presented with a more catastrophic outcome in a shorter timescale than the actual publication at Nature (Ladle, Jepson, & Whittaker, 2005 as cited by Lewandowsky et al. 2012).

If the information gets oversimplified it can create misunderstanding according to Lewandowsky *et al.* (2012). These misunderstandings can be transformed into misinformation, which can be spread and disseminated on purpose or inadvertently. The original intent of the publisher or the author of the video is almost impossible to uncover.

Simplification can be very hard to measure and even more difficult and imprecise to determine when a topic becomes oversimplified, which means the way of communicating should serve not only the message itself but the context of the medium where it is presented. The National Academies of Sciences, Engineering, and Medicine (2017) stated that also the way scientific research should be communicated may vary from place to place since each medium has its particularities.

Asymmetry also can be a problem when communicating science. The journalistic principle of "balance" or to present both sides of the story is a very common approach in the media, and, but it can be misleading and misrepresent the problem (Clarke, 2008 by Lewandowsky et al., 2012). As an example, more than 95% of scientists agree about man-made climate change on the globe, still, most of the television boards address the theme using 'experts' for debating the two sides.

Science has the societal role of not only informing and educating but it is also used for policymakers to make knowledge-based decisions and affects the beliefs and opinion of the general population. This makes the work of researchers difficult since they are not necessarily trained as science communicators as described by the Committee on the Science of Science Communication (2017).

2.2 When corrections are done wrong – Minimizing the impact of misinformation

Although it is not the focus of our study it is important to point out that correcting erroneous ideas constitutes a serious problem in education and learning. From the behavioral point of view, people have tendencies for rejection of authoritative retractions because they do not like to be told how and what to think (Brehm & Brehm, 1981). According to Lewandowsky *et al.* (2012), retracting alone will not stop the influence of misinformation, and can even reinforce the message. To increase the effectiveness of retractions the authors come with 3 methods, warnings at the time of the initial exposure of misinformation; repetition of the retraction; corrections that tell an alternative explanation that fills the coherence gap otherwise left by the retraction. Also, the authors refer to a phenomenon of selective exposure, in which people find sources related to their existing views and beliefs, and the internet is an enabler for this fractionalization of information, creating "echo chambers" in which views and opinions propagate, in which YouTube is included.

2.3 Studies about popular science videos

Several studies examined how the production value or visual quality of science videos affects engagement. Lo, Esser, & Gordon, (2010) compare the looks of amateur videos with those of professional videos, defining the use of lights, camera shakes, resolution, and quality of the camera and stage production as a factor to captivate viewers. Welbourne & Grant (2016) commented that financial resources could increase the production value, appeal, and volume of content.

This is interesting since we are focusing on content strategies and communication techniques. Content creators have a few constraints, they need to be informative about scientific findings, to consider the impact on the popularity, how to make it engaging for the audience to watch the whole video, how the YouTube algorithm is going to display them to their viewers, and limitations on the available time they have to produce each video and be profitable.

2.4 Key findings

Here we present the main findings from our concise review of related works. These outcomes will act as a base for our study design.

1. Explainer videos are different from lecture videos (Kulgemeyer & Peters, 2016). In this work, we focus on explainer videos only, because they are created to be presented on the platform they are in, other than for example lecture videos where a classroom is filmed.

2. There is a knowledge gap in the study of science communication videos (Welbourne & Grant 2016). Research on popular science videos is scarce and scattered through different scientific fields. One of the possible reasons for the lack of available knowledge relates to the difficulties when analyzing the videos, which requires manual work and cannot be automated.

3. YouTube is not merely a video hosting platform, but a participatory community (Welbourne & Grant 2016). This gives us an opportunity to include viewer responses into our study design.

4. Videos can not be replaced on YouTube, just the description, thumbnails and titles can be edited and the only way of altering a video is deleting it. This can be a good feature when the goal is to maintain what was published, and harmful in case it needs retraction or updates in the information (YouTube).

5. Retraction can be damaging and reinforce misleading information (Lewandowsky, S., Ecker, 2012).

6. The popularity of a science video is not related to the quality of information expressed therein (Welbourne & Grant 2016).

3. Research question

The main focus of our study can be formulated in two questions:

1. Which explanatory strategies are being used the most for the simplification of Science videos on YouTube?
2. Are popular science videos on YouTube being transparent about their sources and the science landscape when they present a specific topic?

Likewise, we have two additional questions that we would like to answer, although they are not our main focus on the research. We approach these questions by making some recommendations along the way:

3. How to avoid, but also how to minimize errors and address misconceptions in science videos?
4. Which explanatory strategies are being used for avoiding oversimplification?

4. Methods

To best answer our research questions we decided to divide the research into three main phases. For the first one, we analyzed YouTube videos focusing on the transparency of sources in the scientific landscape and measured the strategies for simplification. In the second phase, to better understand their explanatory strategies with a qualitative approach, we interviewed content creators from popular science videos. Also, it was a way of uncovering the choices made by content creators and validating the findings we had. Then in the third phase, we compared both findings, synthesized and clustered the information in different categories, with quotes and observations collected in order to answer our questions.

4.1 Video analyses

The main goal for this research phase is to help answer the first question on the explanatory strategies for simplification of science videos on YouTube. Similarly, it supports the second phase confirming that the outcomes of the interviews are reflected in the results of video analysis.

We collected data manually from each selected video and their respective YouTube pages. The benefit of applying manual techniques for data analysis instead of using an AI is that humans are better than AI at analyzing subjective variables and understanding the context of a certain topic, science education in this case. The limitation of using a manual approach instead of AI is the smaller sample of videos we were able to analyze for this study.

We use the six categories proposed by Welbourne and Grant in 2016, for video style to frame our analysis and support the criteria for video selection: Vlog, Hosted, Interview, Presentation, Voice-over visuals, and Text-over visuals.

Table 1. Classification of Video Styles by Welbourne and Grant (2016)

Styles	**Description**
Vlog	the presenter talking directly to the camera delivering content
Hosted	similar to the vlog, but other members as interviews or public are also part of the video content
Interview	the video creator is off-camera talking to a specialist who is delivering the content
Presentation	the information is presented to an audience and not directly to the camera
Voice over visuals	animated or static visuals are displayed with a voice over
Text over visuals	similar to the above, but instead of voice written text is displayed

4.1.1 Video selection

The videos were selected from channels from the internet ranking *Feedspot top 100 YouTube science channels* (Feedspot 2021), following the methodology from Welbourne and Grant (2016) who used YouTube channels chosen randomly from an external site in the category of education. Although the authors used a different ranking service, we believe Feedspot is a more accurate ranking system, considering the frequent updates and the combination of metrics based on videos relevancy, frequency of publishing, traffic, social metrics, and experts on the domain that curates the list.

We assessed 25 different channels, selecting and analyzing 2 videos from each channel, the one with the most views and the latest video published at the time of the research, making a total of 50 YouTube science videos. We only selected videos that were spoken in the English language.

We noticed that some of the channels diversify their content, in some instances performing a small experiment, a recorded vlog message to the audience, or communicating a philosophical idea, and occasionally these are their most viewed videos. Taking this into account, when the 5 most viewed videos were not relevant to the research, the channels were excluded. In the same way, the selected videos from the video style that belonged to the 'presentation' type (table 1) were not included due to the format, which resembles a filmed classroom, comparable to lecture videos. We also avoided videos containing extracts and excerpts from films or television shows, like the videos from Mythbusters jr. from the Science Channel prioritizing original content. Besides, videos with a scientific background but emphasizing life-hacking techniques also were eliminated, since they present experiments but do not follow with the explanation for the phenomena they are presenting.

Finally, channels that were advertised to be a combination of science and mysticism or religion were not considered for the analysis, because it is likely to be pseudoscientific, and it would be out of the scope of this research to differentiate between science and pseudoscience channels.

4.1.2 Data extraction

As mentioned previously, we selected and watched a set of 50 science videos from YouTube. Using the variables described in table 2, we checked and collected the data on video performance, comments, and engagement of the audience from the video page. Afterwards, we watched the video and checked the above-mentioned variables.

In order to classify the scope of the measured variables, we divided them into different categories: Metadata (01), Engagement (02), Sources (03), and Explanatory Techniques (04), as follows in Table 2.

Table 2. Variables for data analysis

Category	Variable	Type	Description	Example
01	Video title	text	title of the video	"The Coronavirus Explained & What You Should Do"
01	Channel name	text	title of the YouTube channel	Kurzgesagt – in a nutshell
01	Channel link	URL	link of the video	https://youtu.be/BtN-goy9VOY
01	Video length	numeric	total time of the video in seconds	514

01	Date of release of the video	date	date the video was uploaded on YouTube	Mar 19, 2020
01	Date of analysis of video	date	date the video was analyzed for the research	Mar 05, 2021
02	Video style	category	Reference to table 1 (Vlog, hosted, interview, presentation, voice-over visuals, and text-over visuals)	Voice over visuals
02	Video views	numeric	total number of views when the video was analyzed	29.432.032
02	Channel subscription	numeric	total number of subscriptions of the channel when the video was analyzed	14.200.000
02	Total likes	numeric	total number of likes of the channel when the video was analyzed	953.000
02	Total dislikes	numeric	total number of dislikes of the channel when the video was analyzed	14.000
02	Video relative appreciation	numeric	f_likes = n_likes / (n_likes + n_dislikes)	0,985522234
02	Video liked views fraction	numeric	f_likedviews = n_likes / n_views	0,032379688
02	Number of comments	numeric	total number of comments	60.503
02	Number of replies to the top of comments	numeric	On YouTube, users can reply to comments. We sorted the top 10 comments selected and counted the total number of replies.	913
02	Video relative engagement	numeric	n_comment / n_views	0,002055685
03 – 04	Shared source material	Y/N	There is a description of the source material for the creation of the video like papers, books, interviews, etc. in the video description or pinned comment?	Y
03	Where the material is displayed	category	Where the source material is displayed, in the video description or pinned comment.	pinned comment

03	Source material origin	category	It is from a primary source (science paper, book, interview with specialist), secondary (magazines, blogs, news media, etc.), both (primary +secondary) or Unknown?	Both
04	Highlight relevancy	Y/N	Is the importance and relevance of the knowledge explained highlighted to the audience?	N
04	Summarising	Y/N	Is there a summary of the concept or explanation?	Y
04	Experimentation	Y/N	Experiments are reproduced or presented to exemplify scientific concepts?	N
04	Use of analogy and metaphors	Y/N	Does it use analogies or metaphors to make complex concepts reachable to the audience?	Y
04	Use of examples or applications	Y/N	Does it use examples of real-world applications about the topic?	Y
04	Addressing misconceptions	Y/N	Misconceptions and incorrect ideas are identified and addressed in the video?	Y
04	Use of models, graphs or other visualization	Y/N	Does it use visual aids as support to the video?	Y
04	Addressing source material	Y/N	Are the source materials addressed in the video?	Y
04	Description or details of the research	Y/N	Does it have a discussion, critique or description about the research methodology to support the explanation?	N
	Category Points (CP)	numeric	The number of (Y) from the 04 categories that were used in the video, indicating the explanatory diversity.	7

4.1.3 Data analyses

After collecting the data we compared the metrics of the videos (metadata, engagement & sources) and the video content and relate the results to our hypothesis. Based on Kulgemeyer and Schecker (2013) and Kulgemeyer and Tomczyszyn (2015), we created a Category Point (CP) system to measure and compare the explaining quality of the videos based on the occurrence of an Explanatory technique item. That means if a video presents a variable it adds one CP, moreover if a variable is presented twice it is not counted again, since it doesn't imply it is a better explanation by repetition.

In the variables like *Addressing source material in the video,* we did not add a point when the presenter referred to the source as: “Scientists say” or “a study“ or similar phrasing without citing or pointing out the specific study or scientist name. Also, in the *Use of models, graphs, or other visualization* if the visuals were not used to support the explanation, but instead as an entertainment value, it was also disregarded.

After collecting the data from the videos we identified which videos had a high and low CP score, and by comparing the values we could identify which had a minimum, maximum and medium scores among all the video CPs. Moreover, we also counted and compared the incidences for each individual variable, which gave us an understanding of the landscape and frequency of the strategies that are most and least used in the science videos.

A correlation was measured between the video relative appreciation, liked view relation, and engagement with the CPs of the video, to understand the connection between the video success and the richness of the explanation.

4.2 Interviews

Following the research questions and our approach to deepen the understanding from the content’s creator perspective, we studied their explanatory strategies to validate our discoveries. The interviews provided additional information on the choices they made for the content and approach of the videos, ways of working, and challenges they faced. Each session was designed to last 30 minutes, however, the three interviews had a longer duration due to the engagement of the interviewees with the topic.

The interviews gave us a more human and tangible inside perspective of the science video arena. It enriched our knowledge and comprehension of the variables we measured for the video analysis, acknowledging the reasons and explanations for some of the strategies, approaches, and decisions made behind the scene. Both the qualitative and quantitative methods were complementaries in presenting a more objective picture of the science video landscape. Also, the interviews were very useful to answer the additional research questions 3 and 4 and also valuable for the discussion.

4.2.1 Selection of interviewees

The recruitment for the interviews was performed by contacting the creators via email and even searching for creators at the ResearchGate platform. In the end, only 4 persons agreed to participate, and one could not take part due to personal problems. Other 15 did not reply to the emails, 4 did not agree to participate for various reasons, and it was impossible to connect due to incomplete contact on their YouTube and webpage. Also, 2 of the channels had the same teams.

In our ideal research plan, we would have at least 5 interviews, however, it was difficult to reach and engage with content creators to participate. It is worth noting that some YouTube creators are celebrities with millions of subscribers, with a very busy agenda to produce a large amount of content for different platforms. We also understand that we are conducting this research during a time of a global pandemic (Spring 2021), which is a delicate and difficult moment for everyone. To not be biased towards the channels that agreed to participate in our interviews, we finished the data collection and video analysis before the sessions with the content creators.

By chance, our sample had channels that consisted of different structures and team sizes. We interviewed Dominic Walliman from Domains of Science, David Goldenberg from Minute Earth/Minute Physics and Victoria Barrios from Seeker. The channel Domains of Science (DoS) is operated by only one person, Minute Earth and Minute Physics have a team of around 15 people, and Seeker, previously named Dnews, is an independent media company with around 50 people and is part of Discovery (Wikipedia, 2021).

4.2.2 Interview method

Our interviews were conducted by video call (Zoom). Before the interview, we explained a bit about the project without disclosing our data. We started with an ice-breaker open question (**Table 3)** followed by a selection of closed questions that were asked to all the content creators and which serve for comparison purposes (1-6). Moreover, we prepared a set of supplementary questions to be answered depending on the available time and involvement of the interviewee (7-10).

We tried to include questions that appear naturally in the conversation and go deeper in some instances with follow-up questions. The open questions were focused on understanding the Interviewees' point of view about the landscape of Science education and difficulties faced, while closed questions mostly addressed their methods, and how they see their audience.

Table 3. Interview questions

Question topic	**Question**
About the author	1. How did you get involved in making science videos? (ice-breaker)
About science education	2. What do you feel is the impact of science videos on society and education?
About the knowledge acquisition	3. Do you have scientists, technical people involved in the making of the scripts, or specialists to review them?
About the video subject	4. What are your sources and how do you evaluate if your source is a serious publication?
About simplification	5. How do you avoid oversimplification?
	6. What are common mistakes you see from other makers?
About misconception	7. How do you address scientific misconceptions?
About representation	8. How do you choose and research a topic?
About other YouTube channels	9. Do you look for references on other videos about the same subject?
About the audience	10. Which is the level of education of your audience? How do you target that?

4.2.3 Interview analyses

The interviews were recorded and transcribed using AI software (Otter), and then manually added to a virtual canvas (Miro), highlighting the main quotes and findings for each question by clustering the findings and comparing the different answers between the interviewees (appendix 01). The outcomes were connected with the findings with the analysed data on the Results (section 5).

5. Results

5.1 - Explanatory strategies being used for the simplification

To best answer the research question with respect to explanatory strategies used for the simplification, we organized the results by first reviewing the video styles, then the explanatory techniques categorized and further the Category points (CP) and their relations with the Video styles.

5.1.1 Video styles

Based on the data collected from the analysed videos (*n*=50), we could draw insights from the occurrences of the Video styles. Concerning the explanatory strategies used for simplification, we observed that *Voice over visuals* is the video style with the highest incidence, showing 24 occurrences (48%), in the second place *Vlog* with 18 (36%), *Interviews* with 5 (10%) and *Hosted* with 3 (0.6%), as can be seen on Table 4.

Table 4. Video style proportion. (*n*=50)

Video styles	**Counts**	**Proportion**
Interview	5	0.100
Vlog	18	0.360
Voice over visuals	24	0.480
Hosted	3	0.060

We can assume that *Voice over visuals* is the most recurrent style used by the content creators because, although it requires post-production with video animations and image edits, it entails only desk work using the computer and relies on the skills of the team with no external variables that could cause delay or difficulties during the production phase of the video. The complexity level of this format goes from the use of stock footage and video, PowerPoint slides, or animated stick figures to complex illustrations and animations. This format is only required to edit the audio while the others need to edit audio and video combined.

Vlog also has a major occurrence, corresponding to the format which YouTube is known for. This layout requires filming, scenarios, or stages, which involves lights, audio and video edits of footage, etc. Although it takes a production effort, once it is established it is easier to perform a recurrent setup for filming.

Interviews and Hosted are not common video styles since they require external efforts for the production, needing people willing to participate, agreeing to be filmed, and as our research exposed (section 4.2.1), the difficulty in finding interviewees prone to participate in such effort. This kind of format usually entails more complicated logistics and a specialized production team to create, plan, arrange and film interviews with all the participants.

Another factor in the creators' decision for certain video styles can be also explained by aesthetic arguments and communication strategies made by the creators. This would require further investigation on why they chose the different categories.

5.1.2 Explanatory techniques categorized

From the explanatory techniques described in Table 2, we could compare the incidence of the categories most and least used for simplification by the content creators (Table 5).

Table 5. Occurrences of Explanatory techniques (*n*=50)

Variable	Occurrence	Counts	Proportion
Shared source material	No	17	0.340
	Yes	33	0.660
Highlight relevancy	No	13	0.260
	Yes	37	0.740
Summarizing	No	1	0.020
	Yes	49	0.980
Experimentation	No	25	0.500
	Yes	25	0.500
Use of analogy and metaphors	No	16	0.320
	Yes	34	0.680
Use of examples or applications	No	5	0.100
	Yes	45	0.900

Addressing misconceptions	No	24	0.480
	Yes	26	0.520
Use of models, graphs or other visualization	No	4	0.080
	Yes	46	0.920
Addressing source material	No	17	0.340
	Yes	33	0.660
Description or details of the research	No	30	0.600
	Yes	20	0.400

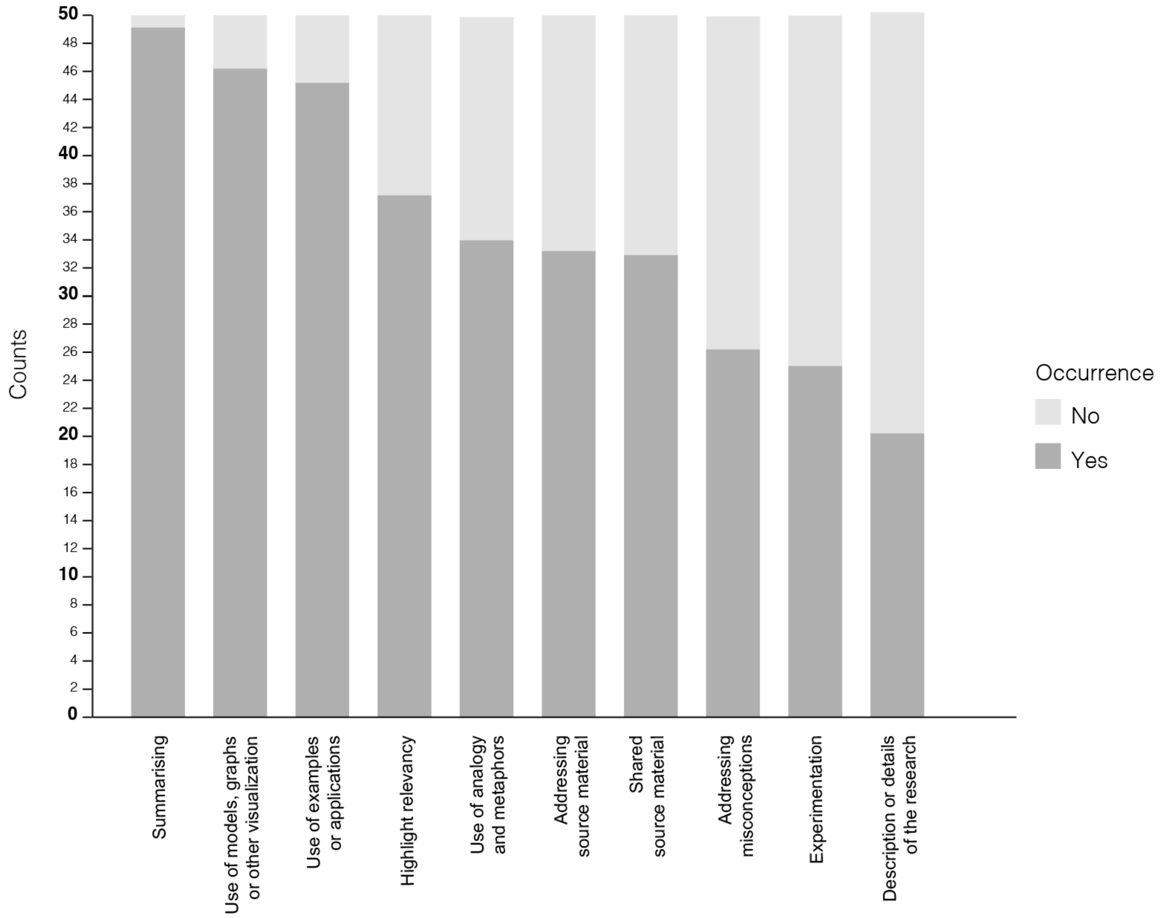


Figure. 1 Occurrences of Explanatory Techniques based on video analysis. (*n*=50)

From Table 5 and Figure 1, we noticed that the majority of videos handle their content through *Summarising*, which is observed in 98% of the analysed cases. This might be answered considering it is not only a good explanation strategy but also a very good storytelling technique. One of the interviewees commented on the theme: "*Sometimes I have no idea how to explain something. If I have good visual or animated infographics, it is really useful if you don't have to just describe things, you can actually show them in pictures. (...) That is very, very helpful.*"

Also, we can identify that the *Use of models, graphs, and other visuals* was employed in a high number of cases (92%). During the conversation with the interviewees, they pointed out the importance of using images to create visual analogies or how illustrations and animations help to convey the complexity of the video topics. This was mentioned frequently and in greater detail as a simplification technique, and relates directly with the finding being the second most measured variable of evaluation of the videos with 46 occurrences. The *Use of examples or applications* also had a high incidence of 90% of the analysed cases, where we can imagine this also is an effective way of conveying real-world applications to the audience to relate with the discussed topic. In the same way, *Highlight relevancy* was used in 74% of analysed cases and the use of *Analogy and metaphors* appeared in 68% of the cases analysed.

Shared source material only occurred in 66% of the cases, by saying that, we can mention that 34% of the cases do not add any reference to the sources, which raises questions on the transparency of some of the analysed science videos. This will be later described at length in chapter **5.2.**

We expected that *Experimentation* would indicate a low value, with 50% of studied cases, due to the complexity associated with this explanation technique, involving more production costs for building the test and, in some cases filming certain experiments can be a challenging process.

Address misconceptions had an incidence of 52%. The importance of addressing misconceptions explicitly when designing multimedia for science education is a critical explanation technique that aids learners to consider scientific conceptions to their prior knowledge, Muller, D. (2008). The author is also the creator of the YouTube channel Veritasium.

Addressing source material appeared 66% of the time in the analysis of the videos, mentioning the scientists or the study that generated the knowledge being presented. Although this variable showed the same value as the *Shared Source Material*, it was a coincidence, since both varied between the samples.

The variable *Description or details of research* was the least used simplification strategy and had a low score with only 40% (20 occurrences) in all videos analysed. This could be even considered a subcategory of Addressing Source material because if the creators do not mention the source material origin it is unlikely that they will mention the methodology of the research.

5.1.3 Category Points (CPs) results from explanatory techniques

We can observe in Figure 2 the distribution of the Category Points and their incidence, showing a slightly skewed distribution of the CPs values.

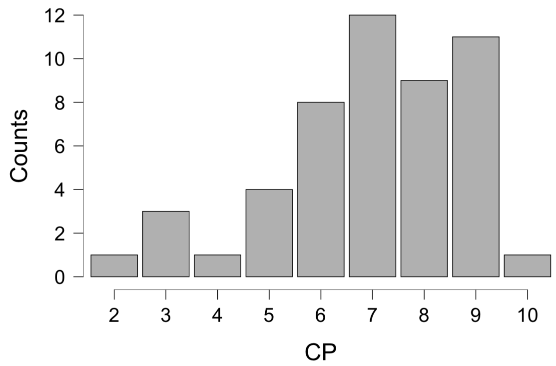


Figure 2 - CPs Histogram. (*n*=50)

As mentioned before, the sum of Explanatory Techniques in a video gives us the count of the Category Points (CPs) (Table 2). The CPs are indicators to measure and compare the diversity of explanation techniques on the videos, which can be linked to their quality. With the analysis of the 50 videos, we believe the CPs had a considerable high median grade of 7 out of 10, where the maximum was 10 and minimum 2 (Table 6). The lower expectations in terms of median value stem from the random selection of the channels and the assumption that content creators would have used fewer explanation strategies per video.

Table 6 CPs distribution over video selection

	50 videos (*n*=50)	**Most viewed (*n*=25)**	**Latest released (*n*=25)**
min	2	2	3
median	7	7	7

max	10	9	10

With this sample, we could not detect a significant difference between the latest videos and most viewed videos (Table 6). Although we could intuitively expect the latest videos to have a higher quality since creators go through a learning process, and with time channels become more professional, which influences how the landscape of science videos evolve on YouTube.

During the interviews, two of the respondents emphasized the transformations that channels experienced during the years. Some of the changes informed by one of the interviewees in relation to his channel are linked to the publishing frequency of the videos, improvements on fact-checking, and put more attention on the reliability of their communication processes. They informed us that today the processes to create a video takes longer than 5 years ago, the release of videos has a shorter frequency from 2 videos a day for individual creators to 2 videos a week using a larger team. About the production time, one interviewee stated: *“It is very hard to do this, especially because it takes a lot of time to produce, a 2 minute video takes roughly 250 hours.”*

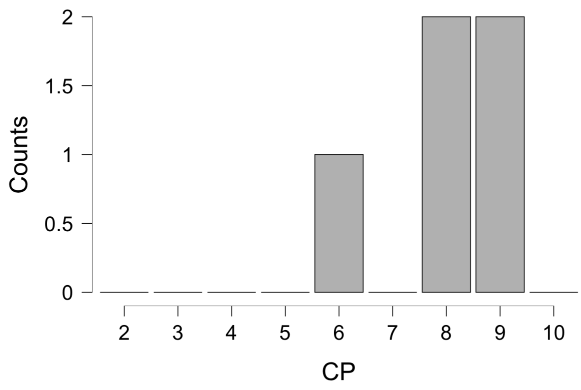
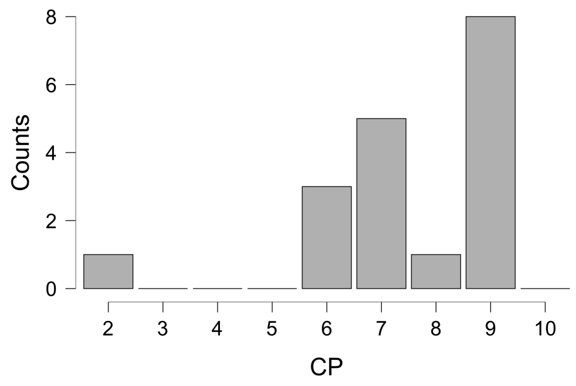
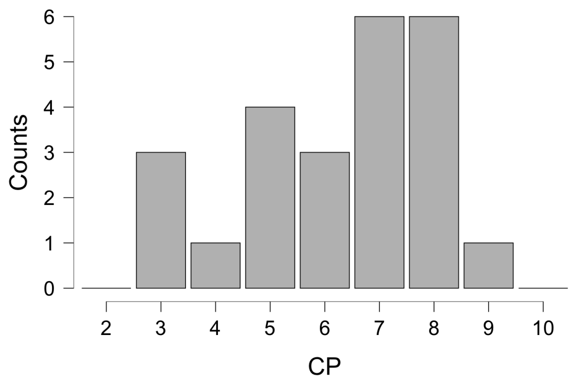
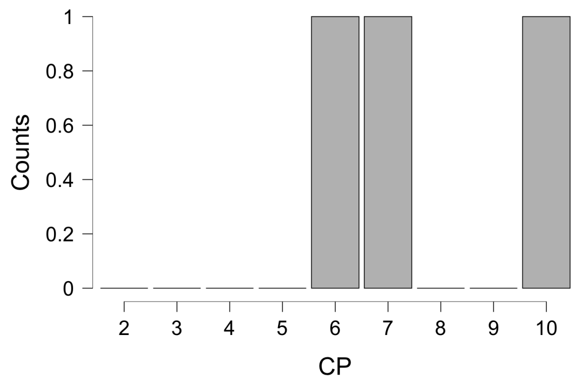
Interview x CP (a)	**Vlog x CP (b)**
	
Voice over visuals x CP (c)	**Hosted x CP (d)**
	

Figure 3 (a) CP distribution for the *Interview* video style. **(b)** same for the *Vlog* video style. **(c)** same for *Voice over visuals* video style. **(d)** same for the *Hosted* video style.(n = 50)

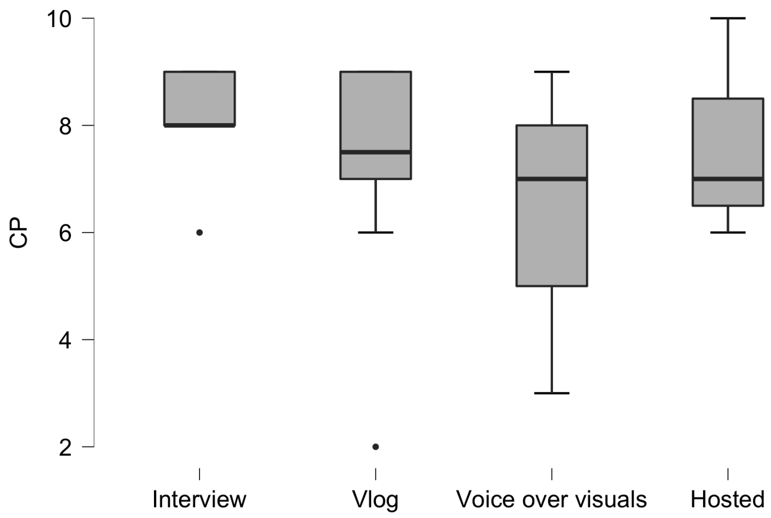


Figure 4 - Boxplots of CP distribution for each of the video styles. (n = 50)

Concerning the video styles (Figures 3 and 4) we can identify that *Interview* presented a concentration in the distribution with high values. The Median is 8, but with a limited number of observations (5). The Vlog video style presented a concentration in the high values, with a median of 7.5 (18 observations) and a very defined outlier. In the Voice over visuals category, values are better distributed, with a median of 7 (24 observations). Hosted also had a concentrated distribution, and presented the median of 7, however it had a limited number of observations (3). We comment briefly on the counting of video styles and their characteristics in section 5.1.1.

We performed a Chi-square test to detect if there is any dependency between the two variables *Explanatory techniques* and *Video Styles*. This test provides a p-value that determines the probability of both variables being independent. Typically, p-values below 0.05 indicate the variables are dependent (Cochran, 1952).

Table 9 - Chi-square test *p*-value between Video styles and Explanatory technique (n=50)

Explanatory technique	***p***
Experimentation	0.014
Highlight relevancy	0.067
Addressing misconceptions	0.123
Description or details of the research	0.131
Source material	0.208
Source material origin	0.371
Examples of application	0.604
Summarizing	0.776

Use of models, graphs or other visuals	0.817
Analogy and metaphors	0.957

Experimentation and *Video style* are dependable variables as shown by the Chi-square p-value smaller than 0.05 (0.014) as seen in Table 9. On Table 10 we can see the data for *Experimentation* across the *Video styles*. In the *Voice over visuals* style, there is a high number of *No* cases, which is logical since if a Content Creator is making a video entirely with imagery and animations, it is improbable that they make use of *experimentation*, which requires filming to be produced.

Table 10 - Video styles x Experimentation

Video style	No	Yes	Total
Interview	0	5	5
Vlog	9	9	18
Voice over visuals	16	8	24
Hosted	0	3	3
Total	25	25	50

Highlight relevancy has less clear dependence on Video Style. As can be seen in Table11 there is an uneven distribution of *No* cases*,* as the majority of cases observed are in the *Voice over visuals* style. The count for the other *Explanation techniques* is included in the *Appendix 03*.

Table 11 - Video styles x Highlight Relevancy

Video style	No	Yes	Total
Interview	1	4	5
Vlog	1	17	18
Voice over visuals	10	14	24
Hosted	1	2	3
Total	13	37	50

5 .2 - Transparency about sources and the science landscape

In order to answer research question 2, regarding transparency about sources, we analysed videos and interviewed content creators to better understand the landscape of science videos, best practices, and to acknowledge the scientific findings content creators communicate. They include the source material origin (*Primary, Secondary or Unknown*) and its placing in the video (comments, pinned comments or none), which directly relates with the importance given by the content's creator to the information displayed (Appendix 3).

5.2.1 - Source material origin

As we can see from Table 12, *Primary sources* were the most representative category from the sample reviewed (52%), where some of them also presented secondary sources in their description. The *Unknown* category was relatively recurrent (30%) in the analysed videos and *Secondary* sources also were frequent (18%). The feedback on this topic we had from the content creators indicates that all the interviewees are aware and understand how to verify scientific publications, the importance of fact-checking the sources, and review the content with specialists in the field.

Table 12 - Source Material Origin (*n*=50)

Source	Counts	Proportion
Primary	26	0.520
Secondary	9	0.180
Unknown	15	0.300

Only about half of the videos had a primary source of information. Reliability of the information is a crucial issue for science communication and unknown sources preclude the audience to know the origin of the knowledge and follow further on the subject. In our view, the use of secondary sources may be a barrier to the original source and compromise the quality of the information that is acquired second-hand.

5.2.2 - Placing of source material in the videos by the content creators

In 33 out of 34 videos that presented information about the source material, it was referenced in the video description. Only one shared the information as a link in the pinned comments. This was done in an old video, and the newest of the same channel had displayed in the description.

This shows consistency, and as mentioned before, YouTube was not built to present science videos specifically, but the creators had to shape the best practices including choosing the place where it was easier for the users to find the information. Some of the channels also had external links for a google sheets document with a more lengthy and detailed description of the sources, but that was not measured by the study.

From the 50 videos analyzed, 33 addressed in some way the source material in the video as an explanatory technique (Shared source material), and only 20 had a description or discussion around the research or the used methodology (*Description or details of the research*).

5.3 - Correlation between CP and YouTube engagement metrics

Although it was not related to a specific research question we compared the YouTube video metrics collected with the CPs. In the same way as the study from Kulgemeyer, & Peters (2016) we were not able to detect any correlation (Table 13). Also one of our interviewees stated: *"Good educational videos might not get the popularity they deserve because there isn't a correlation between how many views and how educationally valuable it is."* That means content creators are aware that the quality of the video and the number of views are not directly related, but it is considered by the audience an indicator of quality.

Table 13 - Pearson's correlations between CP and YouTube metric (n = 50).

YouTube metric	**Pearson's *r***	***p***
Video Views	-0.054	0.709
Channel Subscription	0.175	0.224
Video Relative Appreciation	0.219	0.127
Video Liked Views Fraction	0.085	0.558
Video Relative Engagement	0.015	0.919

5.4 - Avoiding and minimizing errors and misconceptions in science videos.

In order to answer the third research question regarding misconception, we looked into the explanation strategy used in each video. As a result, only 26 videos from the 50 addressed misconceptions as an explanation strategy **(**Table 5 and Figure 1).

We observed that one of the analysed videos had a pinned comment about an error, a number that was misspoken during an experiment but the calculations and all the data in the video were correct. Later on, we confirmed this practice during the interviews. We discussed with content creators their strategies for correcting the videos in case there are errors, and they described again the impossibility of replacing videos on YouTube in case of an issue. It seems that if it is a minor mistake they add a pinned comment, but in case it is a bigger problem such as a wrong image, a number in a formula, or something that can create confusion they need to re-upload the video. We were told that earlier it was easy to fix errors by adding annotations on the video so the audience could have the information in the exact moment, but this feature was removed by the platform.

All the interviewees said they avoid deleting and re-uploading the videos. As stated by one of our respondents: *"I don't like to re-upload it because it hurts the performance of the video*" but all of them said if there is a big problem they will delete it and re-upload with corrections, and also have done in the past.

Usually, the mistakes are called out in the comment section of the videos by their audiences. This plays an important role and engages the audience as active examiners of the content and data shared in the videos. A complementary approach used by the content creators to prevent misinformation is to reach out to experts to review their scripts or to gather additional information.

The way that YouTube is structured does not facilitate correcting issues of misinformation spread through the platform. One of the interviewees stated: *"a lot people talk about misinformation, but in reality it is disinformation, which people are actively trying to confuse people" "I also think it's just the lack of education and a lack of critical thinking"*

It is worth noting that two respondents commented on the moment of disinformation the world went through in the last years, which helped the channels to be alert on the quality of the information displayed and be a trustful source of knowledge.

5.4.1 - Research and fact check

All of the interviewees were quite open about their research process and understanding how scientific knowledge works, how to verify the quality of a paper, authors, journals, scientific performance indicators, the importance of using primary sources, etc. One of our respondents commented on this matter: *"I dropped the ball on two of my latest videos, I said that I had to take down and re-upload after I'd fixed the errors. You know, I didn't get those facts checked. So, that was the penalty for making errors."*

Upon the same subject an interviewee remarked: *"I've got fact-checked by some experts, and gonna try and make sure I do that for all of my big videos, where it's outside of my realm of expertise, then, I think that's just good practice."*

5.5 - Explanatory strategies are being used for avoiding oversimplification

To answer question 4 regarding the explanatory strategies we looked into the interview's feedback to understand the creator's point of view on the issue.

During the interviews, we learned that the creators have competing goals on informing, educating, and making the audience care about it and engage. If the storyline is too complicated it is hard to follow and generate this engagement. Some of the topics are very complex and would need more time for a detailed explanation than the average 544 seconds or 9:06 minutes (data collected from the analysed videos *n*=50). Thereby, YouTube is a platform mainly made for entertainment, and science communication and education became a niche for it. As observed by one of the interviewees: *"YouTube isn't built for science education. If you wanted to design an online video platform for science education, there are some big changes you'd make."*

One of the interviewees told us that they have a table read session of the scripts with different teams to determine if the information was coming across as not too simple or too complicated, recognising what parts need improvement.

One of the content creators pointed out that there are channels considered 'fake' science channels. They follow the style, structure, and communication type of science and educational channels, but they present very shallow knowledge without any fact-checking, research, or scientific value. They also ignore errors with the content, even when pointed out by other creators or the audience, and are only worried about the number of views.

The channels are constantly looking at how they can improve the performance of their videos to make them more enticing. The creators or specialized teams look at video metadata about the audience and can verify if they lose interest in certain moments of the video, discussing how the issue can be tackled. "*We spent, let's say a week on an animation that was able to tell the science perfectly, the audience development team is able to go in and see how long did the audience stay throughout the entire animation"*

5.6 YouTube problems and evolution

In relation to YouTube limitations and problems, the fact that the platform does not allow the creators to replace a video is a common problem for popular science video creators. For instance, if a replaced video has a small correction or minimal fixing, someone who already watched the video would not notice if there is a new section in the video or where the correction took place. This could cause confusion among the viewers and the impact of the rectification may not be effective in the end. This is a controversial problem with different opinions and points of view. On this matter one interviewee added:

"So I would like to be able to see if the science changes, or if we find out something new, I'd like to be able to go and update that video. But yeah, I understand why that's not possible."

Because YouTube is not built for education, as stated by one of our interviewees, we can safely say that decisions on where the reference material was placed or how today's videos look, were shaped by the early channels and the way they have co-evolved. The channels also change while interacting with other channels, based on their peers, not isolated but as a network. Moreover, YouTube as a platform changes, not only the visuals and the streaming technology but also the algorithm that recommends the videos to the audience and the rules on how the video will reach more audience. We heard from content creators they had to experiment and it was a trial and error process to learn about the balance between education, entertainment, transparency about science, and engaging for the audience.

"I've been doing that for the last five years, it's funny because we're considered old in the YouTube world (...). And it's fun to work with other channels that are on their way up and, and sort of telling them a little bit about the standards and practices that we've come up with over the years to make this work."

5.6.3 What can be considered an old video?

Another discussion that appeared during the interviews was about how few channels are around for so long that old videos might not be relevant anymore. Some channels are active for over 10 years. Quoting one of the interviewees: *"Should we take down these old videos? How do we know if they aren't relevant anymore?"* The question which seems to have an easy answer might not be that simple, since in some instances it also requires extra effort to fact-check if the information is still relevant or has become obsolete. *"When do we make the cut-off of videos that have old information? I feel like that's something that we brought up recently. What is too old?"* Moreover one can state that although the videos are old they also have historical value.

6. Discussion & conclusions

From the analysis, we conclude the great majority of video styles were *Voice over visuals* and *Vlog* that together had 84% of occurrences and define how most of the popular science videos look on YouTube. *Interview* and *Hosted* styles have combined only 16% of occurrences. The use of different styles could be explained by factors related to logistics, production of the video, channel style, or aesthetic choices made by the content creators

In this work, we could identify some of the most recurrent explanatory strategies used by the content creators in science videos such as *Summarization*, *Use of graphs and images*, and *Use of examples or applicatio*n (table 4, figure 1). This was also supported by all interviewees as good explanation techniques and simplification strategies. Strategies like *Description or details of research* (40%), *Experimentation* (50%), and *Addressing misconceptions* (52%) were the least used explanation categories. We have the assumption that the *Description or details of the research* (30%) can be a sub-category of *Addressing source material* (66%) since it is likely to mention the study or the authors before explaining the methods.

We believe the CPs on the analysed videos had a considerable high median grade of 7 out of 10. This indicator was used to measure and compare the explaining quality of the videos based on the occurrence of an item in the category. It is worth pointing out that the use of CPs is a solution to measure quality because it is highly complex to determine which are the best explanation techniques to specific knowledge. Additionally, it should be recalled that having all the explanation techniques in a video does not guarantee a better explanation, but a richer one. Therefore, it would be required to further understand which explanation techniques are more effective in general or in specific cases.

In Table 9 and Table 10 we can see the data for *Experimentation* across the *Video styles* and verify that the two categories present dependency. We interpreted that this is due to the fact of *Voice over visuals* style has a high number of *No* cases. We could suppose that if a Content Creator mainly have desk work using the computer it is unlikely that it will make use of *experimentation* since it requires filming.

In terms of the criteria used for video selection and the exclusion of lifehack videos, one of the interviewees noted this as a poor example of science videos. He remarked they are not grounded upon any scientific information and in some cases are completely fabricated and enable misinformation practices. Usually, they have a short duration, are easy to produce, and are consumed by viewers at a faster rate. In view of the fact that we excluded these videos as part of our selection criteria, might have improved the overall quality of our sample and could explain a high median value of 7 for the videos. Additionally, it would be interesting to have a comparison between the ‘fake’ science videos, underlined by the interviewees, with the videos that have a serious and careful approach towards science.

Likewise, it would be compelling to develop a methodology for video selection that does not use an internet ranking system, which provides a preselection of the best samples, but rather one with more heterogeneous content. Having said that, the analysis of a larger number of channels and videos would have supplied a more diversified sample.

Our outcomes also noted that among the videos analysed, 49% of them did not present a primary source of information related to their content. Whilst the interviewees declared that adding sources, do fact-checking, and present a high knowledge of the science domain was relevant to them, the results we collected on their practices showed this is not a widespread custom, and there is a high number of videos with unknown sources or where secondary sources are also a common tactic.

Nearly all videos presented the reference to the source material in the video description. Because YouTube was not specifically designed for science communication it was the content creators that shaped best practices, which also refers to sharing the source material.

Following the study from Kulgemeyer, & Peters (2016) we were not able to detect any correlation between the quality of the videos measured by the CPs and YouTube video metrics (Table 10). It would be interesting to have further investigation to uncover similarities in the results. These findings were supported by one of the interviewees that affirmed by his own experience this relation did not exist.

In terms of video retraction, we commented the only way to replace a video on YouTube is by deleting and re-uploading it. Because it hurts video performance the interviewees told us that they try to avoid this practice the most. The way to prevent errors and replacements should be done by having more intense fact-checks. We observed that when a video is published with minor mistakes, like a misspoken word, misspelling, or something that does not directly affect the information, a pinned comment with corrections is made. This was also observed by us in one of the analysed videos. The strategies for corrections like the use of pinned comments could be another measure for further analysis that was not investigated in our study.

As mentioned above, YouTube was not built for education purposes and the platform algorithm does not reward the best quality of explanation. In that case, content creators have competing goals on science communication, entertaining, and engaging throughout the whole video.

Overall our methodological approach could be used not only as an assessment tool for measuring video quality but also as a framework to define the structure of the storyline for communicating popular science videos. During the interviews, information about the explanatory techniques was a common question, creators make choices by envisioning the best way to give a certain explanation, and a framework with explanatory categories could help them to create diverse, entertaining, and transparent communication.

Some channels exist for a long time, in some cases for more than 10 years. Relevant questions also emerged during our interview sessions about the quality of information, relevance, and accuracy of old videos. It should also be the role of the content creators to review and remove this content in the context of misinformation? or the videos have historical value and should be kept for consultation? During our research, we had difficulties finding one of the videos Kurzgesagt removed because it has a unilateral view on a scientific topic mentioned in our introduction (section 1).

Usually, when creators remove a video it is for corrections instead of scrapping it like in this case with Kurzgesagt. At the same time, peer pressure from the audiences and scientific community can force and influence the practices of content creators in the platform. How to keep evolving best practices towards transparency and quality-wise is a combined effort from everybody, society, YouTube, the scientific community, and especially, creators.

References

Kurzgesagt – In a Nutshell (2019). Can You Trust Kurzgesagt Videos? *YouTube video,* Last accessed 08/10/2020. URL: youtu.be/JtUAAXe_0VI

Kulgemeyer, C., & Peters, C. H. (2016). Exploring the explaining quality of physics online explanatory videos. *European Journal of Physics*, *37*(6), 065705.

Kulgemeyer, C., & Tomczyszyn, E. (2015). Explain physics - measurement of the explanatory ability of prospective physics teachers in a simulated classroom setting. *Journal for Didactics of Natural Sciences*, *21* (1), 111-126.

Kulgemeyer, C., & Schecker, H. (2013). Students explaining science — assessment of science communication competence. Research in Science Education , 43 (6), 2235-2256.

Welbourne, D. J., & Grant, W. J. (2016). Science communication on YouTube: Factors that affect channel and video popularity. *Public understanding of science*, *25*(6), 706-718.

Lo, A. S., Esser, M. J., & Gordon, K. E. (2010). YouTube: a gauge of public perception and awareness surrounding epilepsy. *Epilepsy & Behavior*, *17*(4), 541-545.

National Academies of Sciences, Engineering, and Medicine. (2017). Communicating Science Effectively: A Research Agenda.

Lewandowsky, S., Ecker, U. K., Seifert, C. M., Schwarz, N., & Cook, J. (2012). Misinformation and its correction: Continued influence and successful debiasing. *Psychological science in the public interest*, *13*(3), 106-131.

Feedspot 100 educational YouTube videos: Last accessed 08/03/2021. URL: https://blog.feedspot.com/educational_YouTube_channels/

Clarke, C. E. (2008). A question of balance: The autism-vaccine controversy in the British and American elite press. *Science communication*, *30*(1), 77-107.

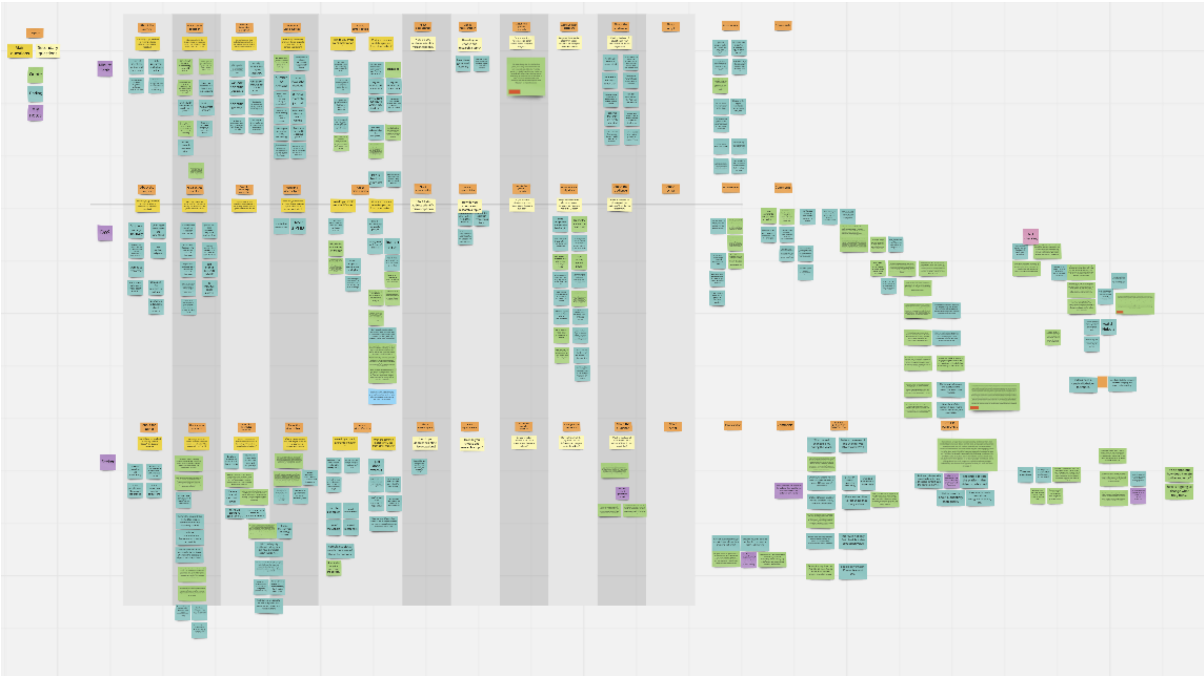
Brehm, S. S., & Brehm, J. W. (2013). *Psychological reactance: A theory of freedom and control*. Academic Press.

Seeker Wikipedia page. Last accessed 07/06/2021. URL: https://en.wikipedia.org/wiki/Seeker_(media_company)

Muller, D. A. (2008). *Designing effective multimedia for physics education*. Sydney: University of Sydney.

Cochran, W. G. (1952). The $\chi 2$ test of goodness of fit. The Annals of mathematical statistics, 315-345.

Appendix 01 – Miro



Miro board https://miro.com/app/board/o9J_lGr36Aw=/

Appendix 02 – Correlation Engagement metrics and CP

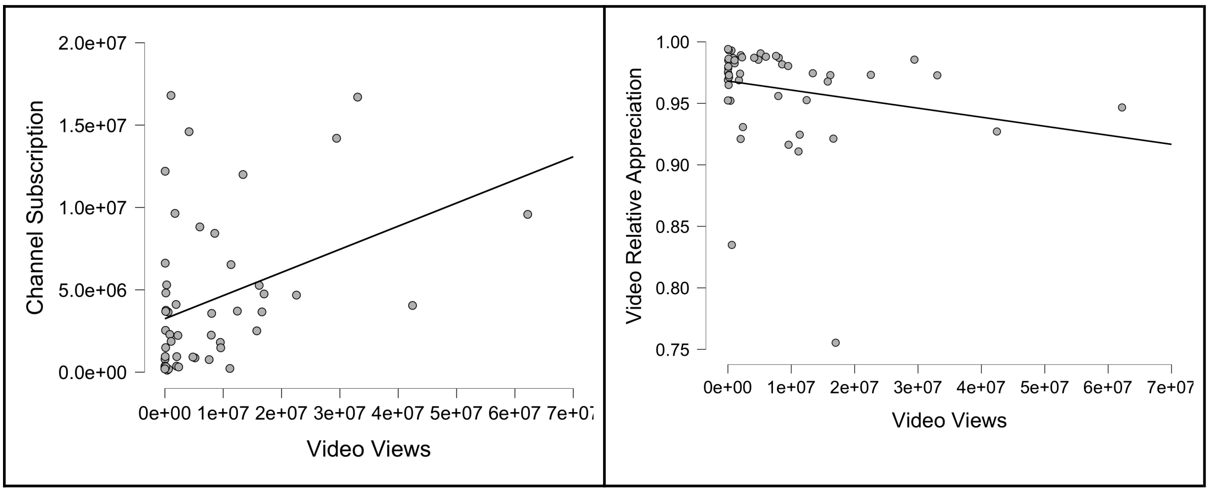
Pearson's Correlations

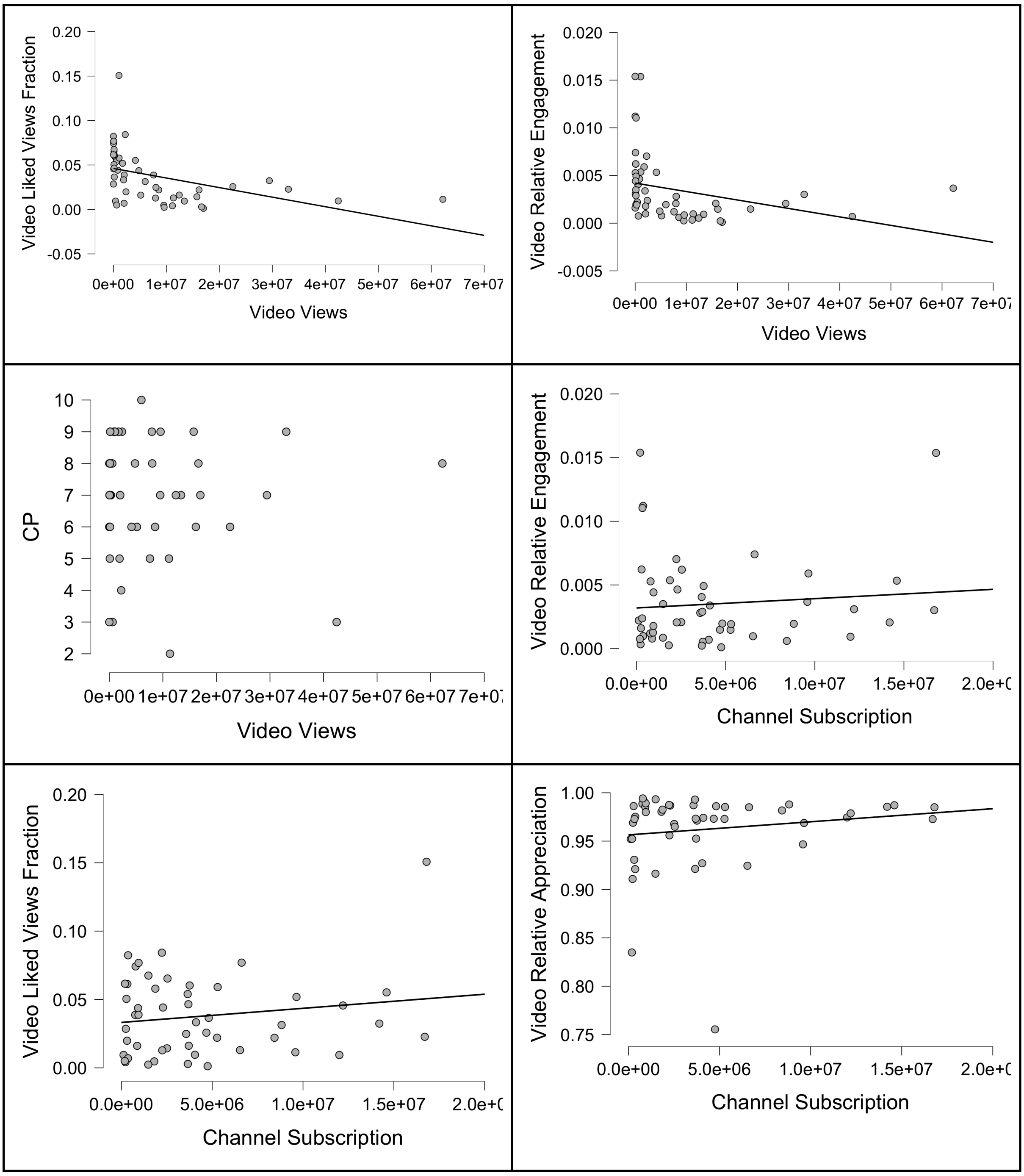
			Pearson's r		p
Video Views	-	Channel Subscription	0.374	**	0.007
Video Views	-	Video Relative Appreciation	-0.214		0.137
Video Views	-	Video Liked Views Fraction	-0.448	**	0.001
Video Views	-	Video Relative Engagement	-0.306	*	0.031
Video Views	-	CP	-0.054		0.709
Channel Subscription	-	Video Relative Appreciation	0.148		0.306

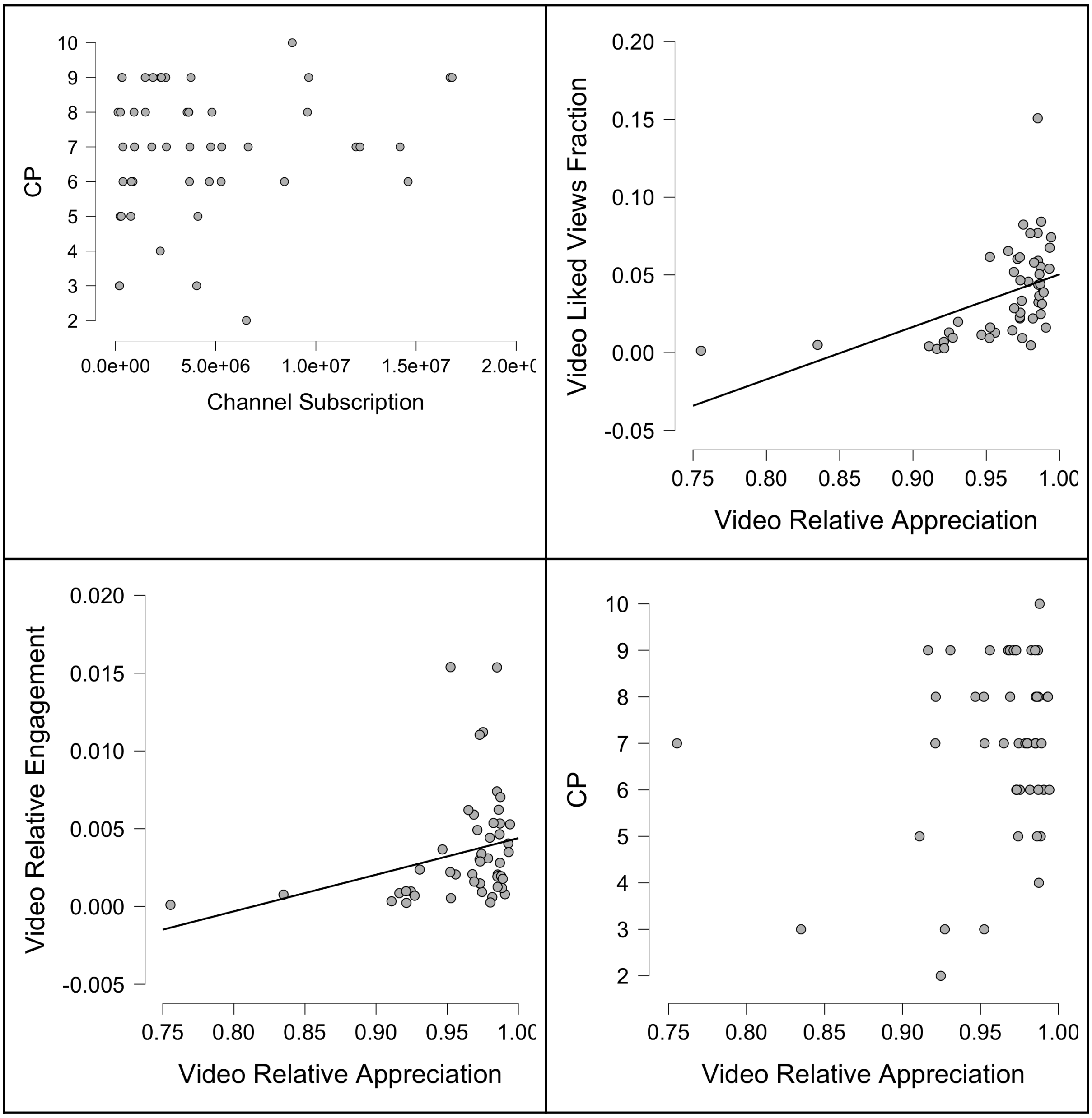
Channel Subscription	-	Video Liked Views Fraction	0.161		0.263
Channel Subscription	-	Video Relative Engagement	0.095		0.512
Channel Subscription	-	CP	0.175		0.224
Video Relative Appreciation	-	Video Liked Views Fraction	0.485	***	< .001
Video Relative Appreciation	-	Video Relative Engagement	0.279	*	0.049
Video Relative Appreciation	-	CP	0.219		0.127
Video Liked Views Fraction	-	Video Relative Engagement	0.807	***	< .001
Video Liked Views Fraction	-	CP	0.085		0.558
Video Relative Engagement	-	CP	0.015		0.919

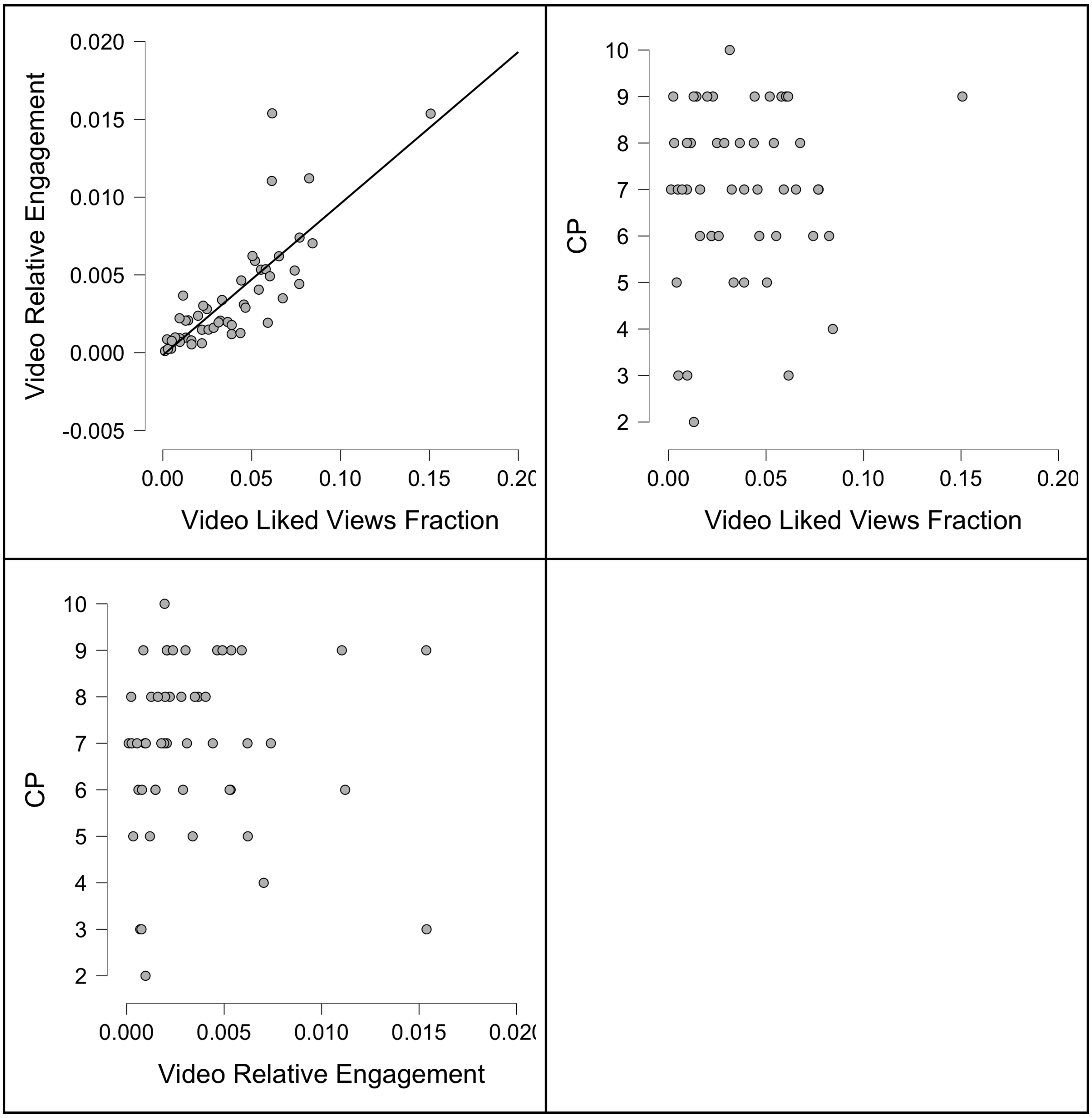
* p < .05, ** p < .01, *** p < .001 — N=50

Scatterplots




Video Liked Views Fraction
0.20
0.15
0.10
0.05
0.00
-0.05
0e+00 1e+07 2e+07 3e+07 4e+07 5e+07 6e+07 7e+07
Video Views
Video Relative Engagement
0.020
0.015
0.010
0.005
0.000
-0.005
0e+00 1e+07 2e+07 3e+07 4e+07 5e+07 6e+07
Video Views
CP
10
9
8
7
6
5
4
3
2
0e+00 1e+07 2e+07 3e+07 4e+07 5e+07 6e+07
Video Views
Video Relative Engagement
0.020
0.015
0.010
0.005
0.000
0.0e+00 5.0e+06 1.0e+07 1.5e+07
Channel Subscription
Video Liked Views Fraction
0.20
0.15
0.10
0.05
0.00
0.0e+00 5.0e+06 1.0e+07 1.5e+07
Channel Subscription
Video Relative Appreciation
1.00
0.95
0.90
0.85
0.80
0.75
0.0e+00 5.0e+06 1.0e+07 1.5e+07
Channel Subscription


CP
Channel Subscription
Video Liked Views Fraction
Video Relative Appreciation
Video Relative Engagement
Video Relative Appreciation
CP
Video Relative Appreciation



0.020
0.015
0.010
0.005
0.000
-0.005
Video Relative Engagement
0.00
0.05
0.10
0.15
0.20
Video Liked Views Fraction
10
9
8
7
6
5
4
3
2
CP
0.00
0.05
0.10
0.15
0.20
Video Liked Views Fraction
10
9
8
7
6
5
4
3
2
CP
0.000
0.005
0.010
0.015
0.020
Video Relative Engagement

Appendix 03 – Chi Test- Video Style x Explanatory techniques

	Highlight relevancy		
Video style	**No**	**Yes**	**Total**
Interview	**1**	**4**	**5**
Vlog	**1**	**17**	**18**
Voice over visuals	**10**	**14**	**24**
Hosted	**1**	**2**	**3**
Total	**13**	**37**	**50**

	Summarizing		
Video style	**No**	**Yes**	**Total**
Interview	**0**	**5**	**5**
Vlog	**0**	**18**	**18**
Voice over visuals	**1**	**23**	**24**
Hosted	**0**	**3**	**3**
Total	**1**	**49**	**50**

	Experimentation		
Video style	No	Yes	Total
Interview	0	5	5
Vlog	9	9	18
Voice over visuals	16	8	24
Hosted	0	3	3
Total	25	25	50

	Source material		
Video style	No	Yes	Total
Interview	2	3	5
Vlog	3	15	18
Voice over visuals	10	14	24
Hosted	2	1	3
Total	17	33	50

	Examples or applications		
Video style	**No**	**Yes**	**Total**
Interview	**0**	**5**	**5**
Vlog	**3**	**15**	**18**
Voice over visuals	**2**	**22**	**24**
Hosted	**0**	**3**	**3**
Total	**5**	**45**	**50**

	Analogy and metaphors		
Video style	**No**	**Yes**	**Total**
Interview	**2**	**3**	**5**
Vlog	**5**	**13**	**18**
Voice over visuals	**8**	**16**	**24**
Hosted	**1**	**2**	**3**
Total	**16**	**34**	**50**

	Examples or applications		
Video style	**No**	**Yes**	**Total**
Interview	**0**	**5**	**5**
Vlog	**3**	**15**	**18**
Voice over visuals	**2**	**22**	**24**
Hosted	**0**	**3**	**3**
Total	**5**	**45**	**50**

	Addressing misconceptions		
Video style	**No**	**Yes**	**Total**
Interview	**4**	**1**	**5**
Vlog	**5**	**13**	**18**
Voice over visuals	**13**	**11**	**24**
Hosted	**2**	**1**	**3**
Total	**24**	**26**	**50**

Video style	Use of models, graphs or other visualization: No	Yes	Total
Interview	0	5	5
Vlog	2	16	18
Voice over visuals	2	22	24
Hosted	0	3	3
Total	4	46	50

Video style	Addressing source material: No	Yes	Total
Interview	0	5	5
Vlog	6	12	18
Voice over visuals	11	13	24
Hosted	0	3	3
Total	17	33	50

	Description or details of the research		
Video style	**No**	**Yes**	**Total**
Interview	**1**	**4**	**5**
Vlog	**11**	**7**	**18**
Voice over visuals	**17**	**7**	**24**
Hosted	**1**	**2**	**3**
Total	**30**	**20**	**50**

Thank you, Sonia Mena, Domenico Astolfi, Igor Oliveira, Louise Bezerra, Roland Dierendonck, Lise Stork, Luca Baldini, Wagner Martins, Marteen Lamers, Christoph Kulgemeyer, Ruben Pater

https://science-education-research.com/EdResMethod/Theoretical_saturation.html

Christoph Kulgemeyer to Everyone (11:33 AM)

Spearman’s rho

Christoph Kulgemeyer to Everyone (11:43 AM)

ordinal scale

rank correlation

why median is better than mea