Video features predicting engagement in climate change education

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Abstract. Climate change is a substantial threat. Awareness-raising and education are key goals. Social media provide an opportune context for the delivery of science education content. However, little research has examined which video features elicit engagement on climate change. This project focused on YouTube and aimed to identify the most predictive factors of video engagement on the topic of climate change. Video engagement was defined as an algorithmic composite of outcomes derived through YouTube API such as the number of views and number of comments, among other measures. A search of YouTube videos revealed an original list of 183 videos on climate change. A random selection of 90 videos was manually coded on engagement predictor variables (i.e., video type, presenter type, audio-visual elements, video content, and other features). Results indicated that most YouTube videos are consistent with a widely accepted scientific viewpoint on the topic although their scientific quality and video argumentation content do not appear to affect video engagement. Rather, presenter and video characteristics associated with entertainment emerge as more specific predictors influencing video engagement. Social media can be used as a fruitful avenue for imparting education on pertinent issues such as climate change although it is important to consider ways of balancing quality education with entertainment features.

1 Introduction

Climate change is an important threat to our environment and the sustainability of life on planet Earth. According to the Intergovernmental Panel on Climate Change 2023 report [1], global warming has been the result of human utilisation of greenhouse gases, negatively affecting the atmosphere and the weather. It has been predicted that this phenomenon will continue to grow if humans do not act [2]. Despite the importance of grand-scale policy changes, it has also been suggested that an increase in public interest and engagement on climate change will be beneficial to support green policies and elicit a green shift in human behaviour [3]. Increasing awareness and knowledge on the topic could support engagement with environmental and green practices. For example, previous psychological research has shown that effective communication of the science and impact of climate change can increase public engagement and alter human behaviour [4]. Even though some environmental groups try to raise public environmental sustainability awareness via social media sites, such as YouTube [5], freely available, accurate, and attractive educational content on the topic appears to be limited on social media [6]. This is despite the rise in online educational content and the significant role that social media sites can have in its wide dissemination.

1.1 YouTube and video-based learning

Social media sites have emerged as a fertile ground for the promotion of science education in a way that is interesting and engaging for the user [7, 8]. Although the value of social media in education has been investigated in the last few years, certain sites, such as Twitter, have received more attention due to their textual characteristics [9]. However, different social media sites may have different platform cultures and practices attracting a dissimilar audience. For example, YouTube has seen fast growth and widespread success in the last 18 years of its presence. YouTube primarily hosts video-based content which has emerged as highly attractive, making the platform the second most popular social media platform in 2023 and with a high percentage of usage (over 70%) spread across all age groups [10]. Beyond the hosting of video content, YouTube also provides functions for enhancing public engagement with videos through reactions (e.g., ‘like’, ‘share’) or through a chat utility which creates a space for the exchange of ideas among interested users.

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YouTube's popularity and the straightforward manner by which one can upload video content, positions the site as an advantageous place for communicating and learning about scientific topics. Studies show that many use the platform to retrieve information on scientific topics [6]. Moreover, users engage in discussions on the topic of climate change on YouTube chat (underneath relevant videos) and comments tend to go beyond the exchange of simple information to argumentative deliberation, possibly contributing to knowledge acquisition [11, 12]. Additionally, video-based learning includes other affordances such as the potential of eliciting emotion using audio-visual channels including various elements such as text, newsreels, animation, and songs, among other video characteristics which could enhance learning outcomes [13]. An increased interest in video-based learning on social media can be seen as indicative of a positive shift towards more learner-centric and interactive science education [14, 15]. However, further study is needed to elucidate features that can effectively contribute to the engagement with such media as well as the acquisition of accurate knowledge.

Beyond the benefits, YouTube has also been found to host science-related content inclusive of low-quality information, misinformation, or even conspiratorial content [16, 17]. Therefore, despite YouTube's enormous potential as a science education platform, it is yet unclear to what extent this is fully utilised or whether it is primarily a fertile ground for the development of inaccurate and misleading content given the platform's lack of internal content checks [18].

Despite the ease of uploading video content on YouTube, a video's success in attracting viewers is not straightforward and is not only dependent upon video quality. A video's success can be related to several factors including the channel's popularity, video content and style characteristics (presenter attributes, use of music, animation), other unrelated factors (e.g., timing of video upload), and most importantly YouTube's video recommendation system [19, 20]. Welbourne and Grant (2016) in looking at science communication videos found that the three most influential factors were: the video being user-generated (not sourced from a professional media source), the presenter being a consistent YouTuber, and the video being short in length. Other studies have also emphasized the role of additional features in science communication such as the role of the presenter (e.g., scientist being more engaging than politician) and the approach of the video on the topic (e.g., solution-focused instead of blaming) [21]. Given the multitude of variables on YouTube video content, however, more work is needed to fully identify the components of an effective science education video.

1.2 Climate change content on YouTube

In the past few years, climate change has become an inspiration for various types of content on YouTube. YouTube videos have different types (e.g., documentaries, newsreels, scientific and informational) and different focuses (e.g., promoting changes in behaviour, increasing knowledge on the topic, promoting misinformation on the topic). The quality of YouTube videos on climate change is not guaranteed despite an increase in successful science communication channels on the medium [22]. For example, the accuracy of scientific videos on YouTube has been greatly challenged in previous studies [23], expressing concerns that YouTube videos could be complicit in spreading misinformation. This issue is important considering a study by Chen (2020) indicating that YouTube viewers of climate change videos tend to trust video content [24].

The topic of climate change on YouTube videos has been the focus of a few studies. In analysing 200 YouTube videos on climate change, Allgaier (2019) found that most of the videos in their sample supported views on the topic of climate change that were not consistent with current scientific knowledge. They also observed that the videos supporting scientifically accepted information had only slightly more views than those containing errors or misinformation, highlighting that video quality may not determine video engagement. Another study arrived at different conclusions after reviewing the 100 most popular videos on the platform. They found that most of the videos supported common scientific beliefs on climate change and that most videos focused on climate change's impact on the environment rather than on presenting solutions [3]. The same study by Duran-Becerra et al., noticed a lack of climate change videos targeting young audiences. A third study [25], found that presenters with a political undertone were more common on YouTube videos rather than scientists, raising concerns regarding the accuracy of the content. Despite several interesting findings, these studies only partially analysed video features (e.g., content quality, presenter type) which may help explain their conflicting findings. Yet, more can be done to clarify which video content, style, or other audio-visual factors attract user engagement with YouTube videos on the topic of climate change.

1.3 Present study

This study aimed to perform manual content analysis of YouTube videos on the topic of climate change to identify which factors predict user engagement. For this study, we defined user engagement according to the conceptualisations of Brodie et al. [26] and Xenos et al. [27] who described it as the result of observable user actions within a specific online community adding to the creation of value and knowledge. According to Xenos et al., such observable engagement is often focused on clicking and commenting on online content. On YouTube, user engagement included user behaviours that were observable and freely accessible through YouTube API (Application Programming Interface) such as viewing, liking, and commenting on a video post.

Specifically, this study coded for video-related (i.e., presenter characteristics), content-related (i.e., information, scientific, misinformation), and other external video factors (i.e., date of video posting,

channel popularity, country of video origin) to broaden understanding of factors affecting YouTube video popularity on climate change. Based on previous literature on YouTube science video engagement, we predicted:

H1. Most YouTube videos on climate change are expected to be consistent with widely accepted scientific knowledge on the topic.

H2. Scientist- and celebrity-presented videos will be more engaging than videos hosted by politicians.

H3. The inclusion of scientific evidence or more than one argument on the topic of climate change compared to videos lacking in scientific merit and argumentation will not affect video engagement.

H4. Videos that are shorter in duration and with more channel subscribers will be more engaging than videos of longer duration or fewer subscribers.

Due to a lack of literature looking at additional video features (e.g., song, animation, infographic, video mood), we did not formulate a prediction but followed an exploratory approach.

2 Method

2.1. Data collection

A cross-sectional design was used to retrieve YouTube videos related to 'climate change'. We used YouTube API to retrieve the first 200 videos which emerged when searching with the term 'climate change' on the 20th of December 2022. No filtering was applied beyond the search term. 183 videos were retrieved through this method and screened for relevance, length, and language. Any video that was not in the English language, was less than 20 seconds, and/or was out of topic was excluded. The final video list included 151 YouTube videos. Content analysis of the videos occurred between 02/23 and 05/23.

2.2 Dependent variables

The study included several dependent variables which reflected aspects of user engagement within YouTube videos such as number of views, like count, comment count, number of comment threads, maximum thread length, and number of comment authors. To maximise summative engagement statistics, we calculated two algorithmic scales inclusive of these variables. The **Popularity score** was estimated by the logarithm of the sum of number of views, like count, and comment count (Min = 4.65, Max = 17.31, Mean = 11.33, *SD* = 2.69). A **Comment score** was estimated by the average of the sum of the number of comment threads, maximum thread length, number of comments, and number of authors per video count (Min=.69, Max = .29, Mean =.26, *SD* =.19).

2.3 Independent variables

To code for video characteristics the study referred to Welbourne and Grant's (2016) general coding criteria for science communication videos while including additional items related to the topic of climate change. Table 1 includes the coding system per category which were: video type, presenter type, audio-visual elements, video content, and other features. Codes were not mutually exclusive. It was possible for a video to fulfil criteria for more than one code in each coding category. For example, videos could include a scientist and a celebrity presenter (together) or have several concurrent audio-visual elements.

Table 1. Video coding criteria per category.

Coding category	Codes
Video type	Documentary, Animation, Child content, Newsreel, Song, Speech, Interview, Debate, Infographic
Presenter type	Celebrity, Politician, Journalist, Social influencer, Scientist
Audio-visual elements	Uses illustration, uses video clips, uses narration. Elicits emotions (humour, hope, sad, anger, shame, fear)
Video content	Consequences of CC Causes of CC Denies CC Solutions of CC Informational More than one argument on the topic, More than one argument by different presenters Includes referenced scientific arguments, Includes misinformation/propaganda
Other features	Nº of channel subscribers Video Length Date of video release

2.3 Analytic Plan

Three teams of researchers worked together in weekly meetings to develop and apply a joined coding system for the YouTube videos. The list of 151 videos was separated into three groups (most popular, moderately popular, and low in popularity) according to the videos' Popularity score. Thirty videos were randomly selected from each video popularity group for content analysis (*N*=90: 59,6% of the total 151 videos). The first 20 minutes of each video were coded according to the coding system in Table 1 (85.6% of videos were fully coded). Twenty-four videos (26.6%) were coded by all three research teams to ascertain interrater reliability while the rest of the videos were equally distributed among the teams. Fleiss's Kappa reflecting interrater reliability ranged from .84 to .91 throughout the coding meetings indicating a high agreement among raters. The resulting binary-coded data was then used to pursue statistical analyses in SPSS (V28). The dependent variables were screened for normality of distribution with both Popularity score and Comment score resulting in kurtosis and skewness values between -2 and +2

(George & Mallery, 2010). The number of channel subscribers was heavily skewed and kurtotic and was therefore converted using a logarithmic transformation (West, 2022). An outlier video which had a length of 04:11:05 was excluded from analyses exploring the impact of Video length.

3 Results

3.1 YouTube videos on climate change

The 90 YouTube videos analysed for this study had a minimum length of 29 seconds and a maximum length of 4:11:05 hours (Mean=13:17, *SD*=27:42). Each video was hosted on a specific YouTube channel with a reported number of subscribers (Min = 2820, Max = 95400000, Mean = 5456335,89, *SD* = 11177026,31). The videos originated from several countries, with most videos originating from the USA (n=40), the UK (n = 20), India (n = 6), Germany (n = 6), Australia (n = 3), Algeria (n = 3) and other European and International sources. The oldest video on the dataset was uploaded in December 2014 and the newest in December 2022. In terms of presenter types, most videos had social influencers as presenters (n = 44), then journalists (n = 35), scientists (n = 33), celebrities (n = 21) and lastly politicians (n = 10). In terms of video types, several videos included a mixture of elements (for example, a video could include an interview section and then present an extract from a documentary). The most usual video types included were infographic (n = 36; i.e., use of diagrams and graphical depictions), animation (n = 34), newsreel (n = 33; i.e., news report), interview (n = 29), speech (n = 21; i.e., a speech at a forum) and less frequent were documentary (n = 11), debate (n = 6), video for children (n = 6) and song (n = 5). Regarding the audio-visual elements of the videos, 64 included video clips from secondary sources, 73 used some form of voiceover narration, and 29 used illustrations. Videos also used several audio-visual elements to elicit emotions such as sadness (n=42), hope (n=37), fear (n=34), shame (n=24), anger (n=21) and humour (n=15). Regarding video content, most videos aimed to convey knowledge (informational; n=71) with only a few videos presenting a debate on the topic of climate change (n=6). However, the information conveyed greatly varied across videos. Graph 1 illustrates the frequency statistics regarding video content illustrating that most videos projected the scientifically accepted position on the topic of climate change, however, focused more on the consequences (n = 71) and causes (n = 53) of climate change and less so on solutions (n = 32). Only a smaller number of videos (n = 12) were found to be denying the existence of the phenomenon. This finding is consistent with the study's 1st hypothesis (**H1**) which predicted that most videos on YouTube will be aligned with the scientifically accepted position on the topic of climate change.

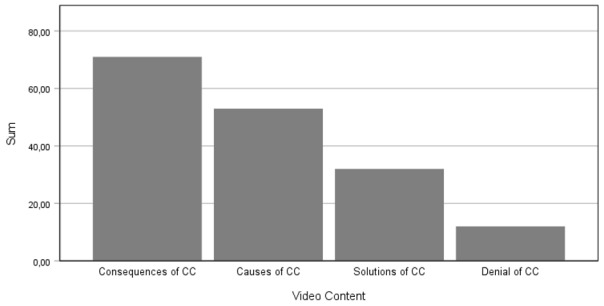

Fig. 1. Frequency of Video Content

Video content was also coded according to its scientific merit and richness of argument. In 48 (53%) videos the presenter included more than one argument to support their position on the topic, while only in 27 videos (30%) arguments were put forth by different presenters. Interestingly, some form of scientific evidence (i.e., numerical data, referenced sources) was provided in 62 (69%) of the videos. A smaller number of videos (n = 26; 28,9%) either included misinformation (i.e., presenting erroneous information or partial information) or expressed political propaganda against the scientifically accepted position on the topic of climate change.

3.2 Predictors of YouTube video engagement on Climate Change

Linear regression analyses were performed per coding category to define video characteristics that predicted increased video engagement. In examining hypothesis 2 (**H2**) the study sought to identify the most effective presenter characteristics for eliciting video engagement. A multiple linear regression was calculated to predict the Popularity score with presenter characteristics (celebrity, journalist, politician, influencer, scientist) as predictor variables (Table 2). The analysis resulted in a significant regression equation (F (5, 84) =6.17, p <.001), with an R^2 of .27. Only influencer (p = .002) and celebrity status (p= .04) were significant predictors of increased video engagement in the model while, politician status (p= .025) was a significant factor of decrease in engagement. A second multiple linear regression predicted Comment score using presenter characteristics as predictor variables (Table 2). The analysis resulted in a significant regression equation (F (5, 84) = 5.01, p <.001), with an R^2 of .23. The predicted Comment score was equal to .20 + .25 (celebrity) -.14 (politician) + .02 (journalist) + .14 (influencer) + .07 (scientist). Only influencer (p <.001) was a significant predictor of increased engagement with the comment section of the video in this analysis while politician status (p = .019) indicated a decrease in this engagement activity. These findings only partially support the 2nd hypothesis (**H2**) indicating that politicians are less successful presenters in terms of user engagement although, contrary to predictions, scientist status did not appear to predict video engagement.

Table 2. Presenter characteristics predicting popularity and comment score on the topic of climate change.

DV	Effect	Estimates	*SE*	*p*
PS	Intercept	10.47	.46	<.001
	Celebrity	1.31	.62	.04
	Politician	-1.85	.81	.025
	Influencer	1.73	.54	.002
	Journalist	–.63	.53	.24
	Scientist	.57	.52	.27
CS	Intercept	.19	.03	<.001
	Politician	-.14	.06	.019
	Influencer	.14	.04	<.001
	Scientist	.07	.04	.09
	Journalist	.01	.04	.72
	Celebrity	.03	.05	.59

Note. DV= Dependent variable; PS= Popularity score; CS= Comment score.

To examine hypothesis 3 (**H3**) we explored the impact of the type of argumentation presented on the video by regressing videos that included more than one argument on the topic, videos that included arguments by more than one presenter, videos that included referenced scientific arguments and videos that included misinformation and/or propaganda on video engagement. The regression analysis with Popularity score as a dependent variable resulted in a non-significant regression equation (F (4, 85) = .77, p = .55), with an R^2 of .04. The predicted Popularity score was equal to 10.32 +.06 (Various positions, p = .35) + .07 (Positions from different presenters, p = .92) + .79 (Scientific argument, p = .79) + .52 (Misinformation/propaganda, p = .52). Similarly, when Comment score was used as a dependent variable, the regression equation did not highlight a significant factor among these predictor variables (F (4, 85) = 1.37, p = .25), with an R^2 of .06. The predicted Popularity score was equal to .19 + .07 (Various positions, p = .13) - .02 (Positions from different presenters, p = .76) + .06 (Scientific argument, p = .21) + .06 (Misinformation/propaganda, p = .80). Consistent with expectations, the inclusion of more arguments or scientific arguments on the topic did not predict more engagement with video content. Similarly, nor did the inclusion of misinformation/propaganda on the YouTube video.

In studying hypothesis 4 (**H4**), the study examined the role of other factors (video length, number of subscribers, date of video publication) in predicting video engagement with Popularity score as a dependent variable. The analysis resulted in a significant regression equation (F (3, 85) = 20.68, p<.001), with an R^2 of .42. The predicted Popularity score was equal to 2.47 + .06 (Date of video publication) + .001 (Video Length) + .32 (Channel subscribers). Video length (p < .001) and Date of video publication (eldest most influential; p <.001) emerged as significant predictors. To elaborate on the most effective Video length, a univariate ANOVA was performed categorising Video length into 4 categories (29 seconds to 00:06:20, 00:06:21 to 00:10:06, 00:10:20 to 00:16:52 and 00:16:53 to 00:51:55). There was a statistically significant difference in mean Popularity score between at least two groups (F (3, 85) = 10.15, p <.001. Tukey's HSD Test for multiple comparisons indicated that the mean value of Video length was significantly different between category 1 (up to 00:06:20) and all the remaining Video length categories (Mean difference from categories 2, 3, 4 respectively: -2.24 [p =.005], -3.21 [p<.001], -2.77 [p=.001]. Video length was however not statistically different when comparing the remaining Video length categories to each other (categories 2-4). Notably, no significant differences emerged across Video length categories on Comment score. Table 3 illustrates the means and standard deviation for the Video length categories on Popularity score and Comment score.

Table 3. Means, Standard Deviation, and One-Way Analyses of Variance of Video length on Popularity and Comment score.

DV	**Video length categories**								***F* (3, 85**	***η*** ^{2}
	1 (n=40)		2 (n=19)		3 (n=15)		4 (n=15)			
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*		
PS	9.87	2.71	12.12	2.08	13.08	1.97	12.64	1.91	10.15	.26
CS	.22	.19	.35	.18	.33	.16	.33	.17	3.20	.03

Note. DV= Dependent variable; PS= Popularity score; CS= Comment score; Category 1 (29 seconds to 00:06:20), Category 2 (00:06:21 to 00:10:06), Category 3 (00:10:20 to 00:16:52), Category 4 (00:16:53 to 00:51:55)

When studying Comment score as a dependent variable and using the same predictors (Date of video publication, Video length, Channel subscribers), a different pattern emerged. A significant regression equation (F (3, 85) = 4.17, p = .008), with an R^2 of .19 emerged with the predicted Comment score being equal to -.06 + .001 (Date of video publication) + 4.15 (Video length) + .05 (Channel Subscribers). The significant predictors in this model were again Video length and, contrary to the previous finding, Channel subscribers.

These findings partly supported the study's 3rd hypothesis. Video length did emerge as a significant predictor of both reactionary engagement (Popularity score) and behavioural engagement (Comment score), however, contrary to expectations the very short videos were not as successful. Rather, a perusal of Table 3 illustrates that videos of a moderate length (10 to 16 minutes) may be more effective in eliciting engagement. Also, contrary to expectations, Channel subscribers were only a significant factor in behavioural engagement (Comment score) and not reactionary engagement (Popularity score).

Finally, an exploratory analysis was conducted to identify video types, audio-visual and emotive elements that may be influential in the elicitation of video engagement on YouTube on the topic of climate change. In a first analysis, the study conducted a stepwise multiple regression analysis including video types

(Documentary, Animation, Child content, Newsreel, Song, Speech, Interview, Debate, Infographic) on Popularity score. The best fitting model resulted in an R^2 of .42 including video types such as infographic, song, speech, newsreel, debate, and documentary (F (6, 83) = 9.99, p < .001). Excluded variables were child content, animation, and use of interviews (Table 4 shows the regression estimates for each video type). Interestingly, in a similar analysis using Comment score as a dependent variable, only use of infographic emerged as a statistically significant predictor in the model (F (6, 83) = 6.04, p =.016), illustrating that perhaps numerical or graphical information may influence the initiation of comments. The predicted Comment score was equal to .25 + .10 (infographic) with a small R^2 of .06.

In examining the impact of audio-visual features (illustration, narration, video clips) in a stepwise multiple regression analysis, only illustration emerged as a significant predictor of Popularity score (F (1, 88) = 25.04, p < .001; R^2 of .22, β = .2.69). Moreover, both illustration (β = .10) and narration (β = .11) emerged as significant predictors of Comment score (F (1, 88) = 5.39, p = .006; R^2 of .11).

Finally, the study sought to explore the impact of video mood (anxiety, shame/guilt, anger, sadness, hope, comedy) on user engagement in a stepwise multiple regression. Only comedy and shame/guilt emerged as significant predictors of Popularity score (F (1, 88) = 6.76, p =.002; R^2 of .14, see Table 4). Moreover, none of these variables emerged as significant predictors of Comment score in a separate analysis (F (6, 82) = .79, p < .58; R^2 of .06).

Table 4. Video types and emotive elements affecting Popularity score on climate change videos.

Coding category	Effect	Estimates	*SE*	*p*
Video type	Intercept	10.10	.37	<.001
	Infographic	3.36	.46	<.001
	Song	2.98	.98	.003
	Speech	1.98	.58	.001
	Newsreel	– 1.85	.51	<.001
	Debate	2. 94	.93	.002
	Documentary	1.60	.71	.026
	Animation	.68	.66	.67
	Child content	.041	.46	.88
	Interview	.114	1.19	.76
Emotion elicitation	Intercept	10.66	.33	<.001
	Humour	1.87	.72	.011
	Shame	1.48	.61	.017
	Sad	-.01	-.07	.95
	Fear	.09	.87	.09
	Anger	.04	.33	.04
	Hope	.08	.83	.41

4 Discussion

This study sought to explore the potential of YouTube as a fertile ground for promoting education on the topic of climate change and to clarify video characteristics that increase user engagement.

As expected, in our 1st hypothesis and contrary to the findings by Allgaier (2019), most of the videos on the topic of climate change on YouTube were consistent with the widely accepted scientific knowledge on the topic. This finding is reassuring given evidence that users of this social medium find the content of videos on the topic trustworthy [24]. It is also a finding that supports the potential of using videos on YouTube for enhancing science education on the topic of climate change. In fact, only a smaller percentage of videos explicitly denied the existence of climate change (13%), although almost one-third of the videos (28.9%) included misinformation, propaganda, or erroneous content. One of the qualitative observations made while coding the videos was that within the 'misinformation' category, video presenters often did not explicitly deny the phenomenon of climate change but focused more on questioning specific scientific arguments related to climate change. This resulted in videos in the group coded as 'misinformation' often presenting a mixture of misinformation and errors as well as some accurate information. The confusing content of some videos may make it harder for social media users to distinguish between video content of higher accuracy and educational quality, although 69% of videos provided references or data to support their arguments. In their study on the topic, Allgaier (2019) raised concerns about the accuracy of YouTube videos on the topic and even claimed that most YouTube videos were not aligned with the accepted scientific position. These dissimilar findings may reflect a different methodology for sourcing the videos on the platform. Allgaier (2019) sourced the videos through Tor, an anonymising web browser and used search terms beyond 'climate change' (e.g., geoengineering) which are usually associated with misinformation on the topic. This search methodology may have increased videos of dubious content within their dataset. Arguably, their methodology provided access to a larger dataset, although not necessarily a dataset easily retrievable by daily YouTube users. Summarising, YouTube does contain content on the topic of climate change that is aligned with mainstream scientific viewpoints, although a fair percentage of this content is of questionable accuracy leaving the task of selection of quality content up to the user.

Consistent with clarifying viewers' selection criteria, in the 2nd hypothesis, we explored the role of the presenter in video engagement. Based on findings from previous studies, we had expected that a celebrity (or YouTuber/influencer) and scientist status would increase engagement compared to that of a politician [8, 28, 29]. The results indicated that both social influencer (which was often a regular YouTube creator) and celebrity status predicted increased reactionary engagement (e.g., clicks and likes) although, as expected, politician status decreased engagement. In terms of behavioural engagement with the video (e.g., writing comments), social influencer status increased such activity while politician status, again, decreased it. These findings are consistent with YouTube's portrayal by many researchers

as a social platform geared towards entertainment [30]. That is, even educational or socially sensitive videos may need to be presented in a way that is entertaining and by a presenter associated with the entertainment industry (e.g., a celebrity presenter) to reach a wider audience. This finding corresponds with the fact that videos that included strong emotive elements (often associated with entertainment) such as humour or shame, were more influential in our dataset. Similarly, specific video types and features such as infographics, songs, debate, illustration, and speech emerged as more supportive of engagement and may be reflective entertaining features within videos (i.e., compared to mainstream news reports and documentaries). We believe that this argument is further supported by the fact that behavioural engagement (i.e. writing comments) was only predicted by the social influencer presenter status. Given that individuals of this status may foster relationships with communities of followers with shared interests, this may explain the increased engagement in the comment section as a form of online social interaction within the community [31, 32]). Although we originally thought that a scientist presenter would be associated with an increase in the quality of the content and that this would drive increased engagement, this expectation did not materialise. This finding points to a need for developing a collaboration or synergy between the fields of entertainment and science for the development of accurate and engaging video education which is then disseminated on online forums such as YouTube.

In further exploration of viewers' video selection criteria, we also studied the role of the quality of argumentation within the educational YouTube video. Specifically, the coding included whether the video incorporated more than one scientific argument, whether these were presented by more than one person and whether it contained scientific data. As expected, based on findings by Allgaier (2019) who showed that videos including misinformation were only slightly less popular than accurate videos, these quality criteria did not affect video engagement. We consider this finding to be reflective of YouTube's primary role as an entertainment medium rather than a quality education platform with users placing more emphasis on the former rather than the latter. Nonetheless, YouTube is seen as a very effective medium for increasing awareness, learning, and even supporting people in making informed choices on many environmental, social, and health-related issues [30, 33, 34]. An enhancement of YouTube as an educational medium could include the opportunity to publicly endorse the accuracy of videos from valid sources (e.g., scientists). This is a common practice in other online educational sources (e.g., Wikipedia) and could promote the value of YouTube as an alternative and entertaining educational medium for the public.

Finally, in examining additional factors that promote video engagement, we highlight the role of an educational video's optimal length (over 6 minutes and under 16 minutes). Interestingly, this is consistent with findings from relevant literature on educational videos [35]. Additionally, and contrary to our expectations, the number of channel subscribers did not affect reactionary engagement but only behavioural (i.e., commenting on video). This corresponds with our previous argument that YouTubers with a committed subscriber list and community of followers are more likely to attract comments and discussions within their formed community. This is important, in view of findings that video education is more effective when the engagement of users in the comment section is increased [36]. For example, the promotion of quality science education videos on the topic of climate change may have more potential of meaningfully reaching a wider audience through posting on specific channels.

4.1 Limitations

This study suffers from certain limitations. The dataset of the YouTube videos on climate change could have been larger and more inclusive of low-quality content. Also, we could have expanded our search to include terms commonly associated with misinformation (e.g., climate engineering). The choice of not expanding the search mainly concerned our motivation to study those videos that would be easily accessible to the user interested in learning on the topic of climate change rather than deliberately searching for content to support views contrary to the mainstream scientific position on the topic. Furthermore, measuring behavioural engagement (e.g., comments) on YouTube suffers from certain methodological limitations given that we are uncertain of the content of comments and whether they consist of meaningful interactions with the video or whether they reflect the use of bots to increase traffic, or simple expressions of like/dislike of a video without meaningful cognitive engagement. Although our dependent variable took account of the number of authors and length of threats to mitigate some of these risks, a more direct analysis of the comment section may be required to fully acknowledge users engaging through the chat function on YouTube.

5 Conclusions

This study provided insight into the potential of YouTube as an educational platform on the topic of climate change as well as the video characteristics that increase engagement with this content. By using engagement metrics as a criterion, this study highlights some limitations regarding viewers' selection criteria regarding video content on the scientific topic of climate change. Specifically, characteristics such as video presenter, type, and mood of video appeared more influential in eliciting video engagement rather than video content quality criteria. We conclude that although YouTube appears to host rich and scientifically valid content on the topic of climate change, it does not, in general, offer a balanced perspective on the various aspects of the topic by emphasizing causes and consequences more than solutions and actions. Similarly, the selection of quality content for educational purposes

on the medium is not straightforward and relies on users' personal judgement.

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