Investigating the Influence of Computer-Mediated Interaction, Modality and 3D Animation on Work Settings and STEM Education: A Cross-Cultural Analysis of Educational YouTube Channels

Dr. Vishal Shrivastava, Shriya Singh
Affiliated to the Computer Science & Engineering Department, Arya College of Engineering & I.T., Jaipur

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Introduction

In the wake of the global pandemic, the world experienced an unprecedented surge in the digitization of platforms and communication methods. Traditional modes of communication were swiftly abandoned, making way for new approaches to bridge the gap created by the necessity of remote interactions. As individuals adapted to this unfamiliar landscape, it became evident that active participation in every aspect of virtual meetings was not always essential. Technology offered a means for participants to communicate their level of engagement selectively. Recognizing this, arguments have emerged advocating for video meeting systems to expand the spectrum of engagement levels available to remote participants. This ongoing research seeks to explore the common behavioral changes prompted by the global pandemic, particularly focusing on the intensified frequency of mandatory online meetings and conferences. Many professionals, students, and individuals found themselves grappling with the challenge of acclimating to this new mode of interaction, leading to heightened exhaustion. Within this context, several questions arise for investigation:

- Why did individuals find online meetings exhausting?
- Were there alternative approaches to alleviate this exhaustion?
- What is the impact of text and sound in imparting and retaining information, particularly when compared to the use of visual imagery and motion?
- How quickly are learners able to grasp differing STEM concepts when viewed in three dimensional visualizations?
- What measures can be taken to enhance the effectiveness of task-based online interaction?

Addressing these questions is crucial to gaining a comprehensive understanding of the challenges and opportunities presented by computer-mediated communication in the post-pandemic era. By examining the factors contributing to meeting exhaustion, exploring alternative approaches, and assessing the influence of different modalities in information delivery, we can inform the development of strategies and technologies that mitigate fatigue and enhance remote collaboration. Additionally, examining methods to

decrease meeting frequency and optimize task-based online interaction can contribute to improved productivity and well-being in virtual work and educational environments.
In the following work, we will analyze how different modes of knowledge acquisition and information delivery affects remote collaboration and learning STEM based concepts.

Abstract

Social connection in our environment is increasingly being mediated by technology. And modern technologies affect our attempts to communicate. "Are we increasingly becoming technological conversationalists, or is technology increasingly becoming conversational?" was the question that was posed by Ian Hutchby in his book *Conversation and technology: From the telephone to the Internet*. He concentrated on four examples: telephones, workplace computerized expert systems, speech-based public inquiry systems, and multi-user Internet spaces. Contemporary theory and empirical studies in conversation analysis, ethnomethodology, and the social creation of technology are all incorporated into Conversation and Technology. Hutchby contends that while we ourselves are shapers of both the cultural and interactional properties of these technologies, technological media can profoundly shape the ways in which we interact. His original contributions to each of these fields supported this claim. The book started out by looking at various theoretical stances on this problem. Truly, the time has arrived for us to develop a new appreciation of the relationship between human communication and technology.
While embracing online communication technologies can never replicate the in-person conversations, it has been found that avoiding communication has also become much easier now, lower social engagement on video meetings being not just a product of network limitations is a plausible argument today. There are teams, groups, companies, regions, countries, and many more types and levels of culture that may be important to comprehending how low engagement in online meetings could be a social practice. However, notwithstanding these restrictions, it has been speculated that it is very likely true for some subset of any community that low engagement can be a social decision, not merely a reaction to limits but also an exploitable social resource on the basis of those limitations. Although most video meeting services and meeting gurus would certainly disagree with this decision, it does have its own design ramifications. The point of the matter is that we need to understand which method of communication (text, sound, visual, emoticons) could be a better option for different tasks such as learning, allotting assignments, giving directions, and more.
The digitization of education has transformed the teaching and learning of STEM concepts, with computer-mediated interaction and 3D animation playing a crucial role in enhancing educational experiences. This paper investigates the impact of computer-mediated interaction and 3D animation on STEM education through a comprehensive case study of ten prominent educational YouTube channels from diverse cultural backgrounds. The channels studied include Professor of How, Kurzgesagt - In a Nutshell, TED-Ed, The Infographics Show, CrashCourse, MinutePhysics, CGP Grey, India In Pixels by Ashris, OverSimplified, and Veritasium. These channels employ various strategies, such as gamification, visual storytelling, and interactive elements, to engage learners and facilitate understanding of STEM concepts.

1. Performance Metrics Analysis:

- ❖ Analyzing views, likes, comments, and video length to understand the factors contributing to the success of specific videos on the studied YouTube channels.
- ❖ Investigating the impact of search engine optimization techniques, including video tags, on the visibility and ranking of STEM education videos.

2. Language Adaptation and Cross-Cultural Context:
   - ❖ Exploring the role of language in video creation and its influence on the comprehension of STEM concepts across different cultural contexts.
   - ❖ Highlighting the importance of language adaptation and culturally inclusive content to enhance learners' understanding and engagement.
3. Effective 3D Animation Strategies:
   - ❖ Examining the use of gamification, visual storytelling, and interactive elements in 3D animated videos to foster student engagement and knowledge retention.
   - ❖ Assessing the correlation between video length and viewer engagement, and the impact of search engine optimization techniques on video visibility and ranking.
4. Designing Interactive Learning Experiences:
   - ❖ Proposing the integration of quizzes, simulations, and emerging technologies like virtual reality (VR) and augmented reality (AR) to create immersive STEM learning environments.
   - ❖ Highlighting the potential of interactive elements in enhancing student engagement and facilitating deeper understanding of STEM concepts.
5. Long-Term Impact Assessment:
   - ❖ Emphasizing the need for longitudinal studies to assess the long-term impact of computer-mediated interaction and 3D animation on students' retention and application of STEM knowledge.
   - ❖ Investigating the transferability of learning from virtual environments to real-world problem-solving situations.

In this study, we will investigate how the modality—such as speech, text, or visualization—in which information is delivered affects how that information is interpreted. The project will also specifically concentrate on the investigation and comparison of two preferred communication contexts: computer-mediated human user communication and human agent communication. This paper aims to delve into these areas of inquiry, offering insights and recommendations that bridge the gap between the advances in research and the practical adoption of technologies for computer-mediated communication in education and work settings.

Related Work

Many companies are working to overcome the stigma associated with the lower ambient employee visibility of remote work. Remote working is on the rise, and video meetings are one of the enabling technologies in the 'any time, any device, any place’ work revolution. Nevertheless, there are still many constraints when joining meetings remotely and video-mediated communication research is littered with systems developed to address these constraints. The growing field of Attentional User Interfaces (AUI) focuses on opportunities for "enhancing computing and communications systems by treating human attention as a central construct and organizing principle". Developing our understanding of the key

properties of attentive systems, a rapidly growing body of AUI research explores attention from the perspective of managing computational resources, disruption of users, and as a source of information for predictive models on users' goals, intentions, and needs.

As always, though, there is a gap between advances in research and the reality of commonly adopted current technology. People adapt to technological constraints, and in turn, they adapt technology as a frame for their social practices. These social practices are methodical, active, and reasonable treatments of the technology. Understanding such practices provides a valuable context for designing new solutions into the existing usage landscape.

Another body of research examines the influence of specific animations and visualizations on understanding and conceptual change for students of varying ages in various science subjects. The studies provide information about specific types of visualization, purposes for and methods of application, and the contexts and conditions in which visualizations have been used successfully to support conceptual understanding. Although some studies have found that animations do not make a significant difference in student learning and conceptual change, others have shown that under certain circumstances animations can be a useful learning resource.

Özmen, Demircioğlu and Demircioğlu (2009) investigated the effects of animations on overcoming alternative conceptions of chemical bonding. The study included 28 students who received conceptual change texts coupled with computer animation instruction, and a comparison group of 30 students who received regular instruction with a teacher who used lots of examples and illustrations in a "chalk and talk" approach. The computer animation instruction, which involved active engagement and interaction, did not significantly change students' alternative conceptions of chemical bonding. These results suggest that it may be necessary to consider other ways of enhancing the learning of particular chemistry concepts. In contrast, Yarden and Yarden (2010) compared the comprehension of the polymerase chain reaction (PCR) by Grade 12 students using animations as an aid with that of students using still images. The most salient finding was that PCR animations showed a distinct advantage over still images for student learning. However, the researchers caution that although animation was effective for demonstrations of molecular phenomena, the results may not generalize to other physical phenomena, such as motion.

Research on the influence of animations and visualizations on understanding and conceptual change in science education has explored their effectiveness and the specific conditions under which they are most beneficial. Studies have shown that the use of animations can be a useful learning resource, although their impact may vary depending on the subject and context. For instance, animations have been found to be effective in overcoming alternative conceptions of chemical bonding. However, the effects of animations may be dependent on factors such as the complexity of the learning material and the meaningful representation of processes or systems. Comparative studies have highlighted the advantages of dynamic media, such as 3D animations, over static media in enhancing learning performance. The effectiveness of animations is influenced by instructional practices, such as providing practice opportunities, cueing students' attention to graphic details, and integrating animations with other instructional activities. Additionally, computer visualization programs have been developed to supplement traditional textbooks, facilitating visualization, understanding, and manipulation of chemical interactions.

The role of diagrams in science learning has also been investigated, revealing that students may face difficulties in comprehending certain types of diagrams. The combination of diagrams with explanatory

text has been found to enhance recall, comprehension, and attitudes toward laboratory work. However, visualizations and diagrams are most effective when explicit instruction is provided on how to use them and when students possess the necessary visual and spatial skills. Explicit instruction and careful planning are essential to ensure effective use of visualizations in science education. While visualizations have the potential to transform and communicate complex scientific concepts, their usefulness depends on understanding how to interpret and employ them appropriately in different contexts.

Method

To gather performance metrics for the ten YouTube channels studied in this research, the following methodology was employed:

1. Selection of YouTube Channels: Ten educational YouTube channels were selected based on their popularity, relevance to STEM education, and availability of publicly accessible data. The selected channels included Professor of How, Kurzgesagt - In a Nutshell, TED-Ed, The Infographics Show, CrashCourse, MinutePhysics, CGP Grey, India In Pixels by Ashris, OverSimplified, and Veritasium.

2. Performance Metric Analysis: SocialBlade, a third-party analytics platform specializing in YouTube channel analytics, was utilized to retrieve performance metrics for the selected YouTube channels. SocialBlade provides comprehensive insights into channel rankings, subscriber growth, video views, estimated earnings, and other relevant metrics.

3. Data Collection: The performance metrics for each YouTube channel, including subscriber ranks, video views ranks, estimated earnings, and other relevant statistics, were extracted from SocialBlade. The data covered a specific timeframe, typically up until August 2021, to ensure consistency and comparability across the channels.

4. Analysis and Interpretation: The collected performance metrics were analyzed to understand the reach, engagement, and overall impact of the YouTube channels in the context of STEM education. The metrics were used to identify patterns, trends, and variations among the channels, allowing for insights into their effectiveness and popularity.

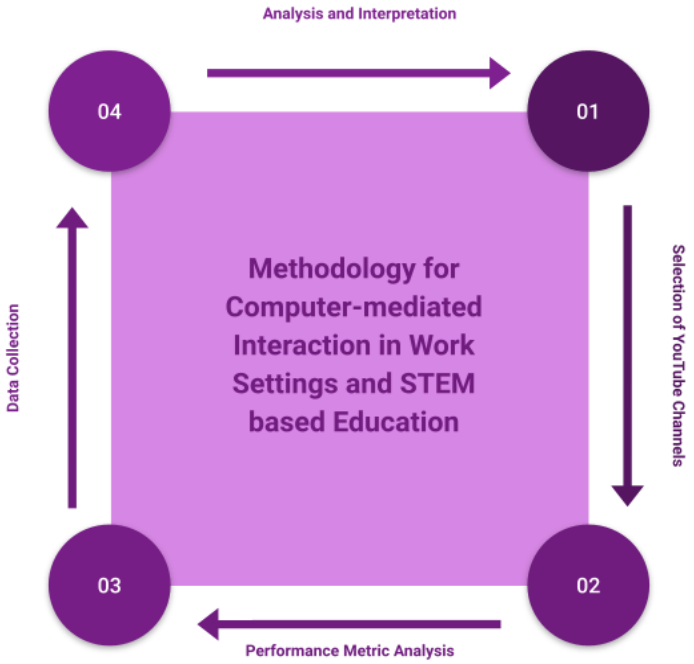


Figure 1. Methodology Diagram

Importance and Selection of SocialBlade:

SocialBlade was chosen as the analytics tool for this study due to its wide adoption and reputation for providing reliable YouTube channel data. It offers a user-friendly interface, comprehensive metrics, and a robust database of YouTube channel statistics. By using SocialBlade, we were able to access key performance indicators, such as subscriber ranks, video views ranks, estimated earnings, and growth trends, which are crucial for understanding the impact and reach of the YouTube channels. SocialBlade's popularity among content creators, researchers, and YouTube enthusiasts ensures that it remains a valuable resource for obtaining accurate and up-to-date performance metrics. The tool's ability to provide historical data, track changes over time, and present metrics in an organized manner makes it particularly useful for analyzing the performance of YouTube channels. By utilizing SocialBlade in this research, we were able to gather relevant and insightful performance metrics for the selected YouTube channels, allowing for a comprehensive analysis of their influence and effectiveness in STEM education.

Result

Our research showed us that users generally felt that the technological constraints of video meetings lead to lower engagement in meetings by remote employees. It was found that engagement was an active social choice in two specific ways. First, turning video on or off could signal engagement obligations. Second, joining remotely could be a deliberate signal of low engagement. We generated performance metric reports for the analysis of their channels and to find out which videos were performing better and

how the effects were transforming across different cultures, that is, on channels from different countries and languages.

We selected ten YouTube channels for the research and this was based on several criteria aligned with the research subject, which focused on the impact of computer-mediated interaction and 3D animation on STEM education. The criteria for channel selection included:

1. Relevance to STEM Education: The channels were chosen based on their focus on educational content related to STEM subjects, such as science, technology, engineering, and mathematics. This ensured that the selected channels were directly applicable to the research subject.

2. Popularity and Reach: The channels selected had a significant subscriber base and a high number of video views, indicating their popularity and reach among the audience. This allowed for a more comprehensive analysis of the impact of computer-mediated interaction and 3D animation in STEM education.

3. Variety of Content: The selected channels represented a diverse range of content styles and formats, including animated explanations, short clips, full-length videos, and gamified learning approaches. This diversity allowed for a broader exploration of the effectiveness of different approaches in engaging and educating learners in STEM subjects.

4. Cross-cultural Perspective: The selection of channels may have aimed to include a global perspective by considering channels from different regions or countries. This allowed for an examination of the impact of computer-mediated interaction and 3D animation on STEM education across different cultural and educational contexts.

5. Channel Reputation: The channels chosen may have had a reputation for providing high-quality educational content and being recognized as reliable sources for learning in STEM subjects. This ensured that the research was based on channels with a strong educational focus and credibility.

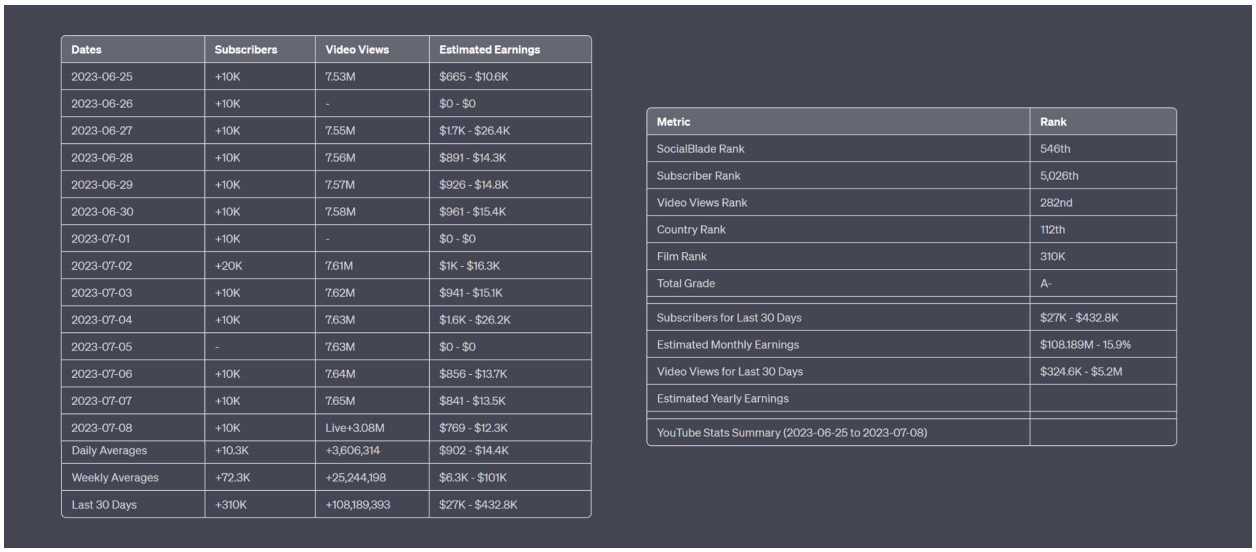
The performance metric reports were calculated and scrutinized.

(a) Professor Of How

According to their YouTube channel description the channel's videos are owned by BrainRig Studios located in Jaipur, India. Their vision is for their channel to be a platform where youth turn to visualize "How Things Look & Work?" in three dimensions.

The YouTube channel, Professor of How, ranks 5,026th in terms of subscribers, 282nd in video views, and 546th in Social Blade ranking. It is ranked 112th in India. The estimated monthly earnings range from $27K to $432.8K, with an estimated yearly earnings of 108.189M. The channel has shown consistent growth in subscribers and video views over the last 30 days, with an average increase of 10.3K subscribers and 3.6 million video views per day. Overall, Professor of How demonstrates strong performance metrics, indicating its popularity and success in the

YouTube educational space. The video topics cover a wide range of subjects, including health (fever, crying, stye), science (clouds, electricity, poison), general knowledge (earth's end, jellyfish, vehicle keys), and safety (fire extinguisher).



Dates	Subscribers	Video Views	Estimated Earnings
2023-06-25	+10K	7.53M	$665 - $10.6K
2023-06-26	+10K	-	$0 - $0
2023-06-27	+10K	7.55M	$1.7K - $26.4K
2023-06-28	+10K	7.56M	$891 - $14.3K
2023-06-29	+10K	7.57M	$926 - $14.8K
2023-06-30	+10K	7.58M	$961 - $15.4K
2023-07-01	+10K	-	$0 - $0
2023-07-02	+20K	7.61M	$1K - $16.3K
2023-07-03	+10K	7.62M	$941 - $15.1K
2023-07-04	+10K	7.63M	$1.6K - $26.2K
2023-07-05	-	7.63M	$0 - $0
2023-07-06	+10K	7.64M	$856 - $13.7K
2023-07-07	+10K	7.65M	$841 - $13.5K
2023-07-08	+10K	Live+3.08M	$769 - $12.3K
Daily Averages	+10.3K	+3,606,314	$902 - $14.4K
Weekly Averages	+72.3K	+25,244,198	$6.3K - $101K
Last 30 Days	+310K	+108,189,393	$27K - $432.8K

Metric	Rank
SocialBlade Rank	546th
Subscriber Rank	5,026th
Video Views Rank	282nd
Country Rank	112th
Film Rank	310K
Total Grade	A-
Subscribers for Last 30 Days	$27K - $432.8K
Estimated Monthly Earnings	$108.189M - 15.9%
Video Views for Last 30 Days	$324.6K - $5.2M
Estimated Yearly Earnings	
YouTube Stats Summary (2023-06-25 to 2023-07-08)	

Figure 2: Performance Metrics Report of the Professor Of How YouTube channel

(b) Kurzgesagt - In a Nutshell

Kurzgesagt – In a Nutshell is an animated educational channel that has been producing engaging content since 12,013 originating from Germany. With a philosophy of optimistic nihilism, the channel aims to explain complex concepts and ignite curiosity about science and the world. The team consists of talented illustrators, animators, and number crunchers, all dedicated to delivering captivating storytelling through their videos. Their unique approach proves that no topic is boring when presented with a compelling narrative. Their YouTube channel maintains a strong performance and popularity in the educational content category. The channel holds a Total Grade of B+ and a Social Blade Rank of 202nd. It ranks 2nd in terms of video views in Germany and demonstrates significant estimated monthly earnings of 41.435M (18.6%). With a Subscriber Rank of 3,883rd, Kurzgesagt – In a Nutshell stands out as a successful channel in terms of viewership and financial performance.

Metric	Value
Total Grade	B+
Social Blade Rank	17,481st
Subscriber Rank	212th
Video Views Rank	3,928th
Country Rank	2nd
Education Rank	21st
Subscribers for Last 30 Days	100K+
Estimated Monthly Earnings	$7.2K - $115.7K
Video Views for Last 30 Days	28.921M
Estimated Yearly Earnings	$86.8K - $1.4M

Figure 3: Performance Metrics Report of the Kurzgesagt - In A Nutshell YouTube channel

(c) The Infographics Show

The Infographics Show is a popular YouTube channel that focuses on creating animated and informative videos covering a wide range of topics, including history, science, geography, and mysteries. The channel uses engaging animations and narration to present facts, statistics, and interesting stories in a visually appealing manner. With a large subscriber base and millions of views on their videos, The Infographics Show has become a go-to source for people seeking educational and entertaining content. The channel's unique approach of combining information with captivating visuals has contributed to its success in sparking curiosity and knowledge exploration among its audience.

Metric	Value
Total Grade	B+
Social Blade Rank	8,608th
Subscriber Rank	286th
Video Views Rank	1,257th
Country Rank	169th
Education Rank	45th
Subscribers for Last 30 Days	100K+
Estimated Monthly Earnings	$12.6K - $202.3K
Video Views for Last 30 Days	50.563M
Estimated Yearly Earnings	$151.7K - $2.4M

Figure 4: Performance Metrics Report of The Infographics Show YouTube channel

(d) TED-Ed

TED-Ed is a prominent educational YouTube channel associated with TED Talks, known for producing high-quality animated educational videos. The channel features a wide array of topics, from science and history to literature and philosophy. With its captivating animations and engaging storytelling, TED-Ed aims to make complex concepts and ideas easily accessible to viewers of all ages. The channel boasts a large subscriber base and has accumulated millions of views on its videos. TED-Ed's commitment to sharing knowledge and fostering curiosity has made it a valuable resource for learners seeking informative and thought-provoking content.

Metric	Value
Total Grade	B+
Social Blade Rank	17,070th
Subscriber Rank	231st
Video Views Rank	2,179th
Country Rank	117th
Education Rank	25tht
Subscribers for Last 30 Days	200K+
Estimated Monthly Earnings	$7.1K - $113.9K
Video Views for Last 30 Days	28.485M
Estimated Yearly Earnings	$85.5K - $1.4M

Figure 5: Performance Metrics Report of the TED-Ed YouTube channel

(e) CrashCourse

Crash Course is a popular educational YouTube channel that offers in-depth and entertaining courses on various subjects, including history, science, literature, and more. With its engaging hosts and dynamic animations, the channel aims to make learning fun and accessible for viewers of all ages. Crash Course has garnered a large following and boasts millions of views on its videos. The channel's comprehensive courses and well-researched content make it a valuable resource for students, educators, and curious minds alike. Through its entertaining approach to education, Crash Course continues to inspire and enlighten viewers on a wide range of topics.

Metric	Value
Total Grade	B+
Social Blade Rank	67,973rd
Subscriber Rank	271st
Video Views Rank	5,585th
Country Rank	156th
Education Rank	36th
Subscribers for Last 30 Days	--
Estimated Monthly Earnings	$1.7K - $27.1K
Video Views for Last 30 Days	6.778M
Estimated Yearly Earnings	$20.3K - $325.4K

Figure 6: Performance Metrics Report of the CrashCourse YouTube channel

(f) MinutePhysics

MinutePhysics is a popular educational YouTube channel that specializes in explaining complex physics concepts in short and engaging animated videos. The channel's content is delivered by its creator, Henry Reich, who uses simple animations and clear explanations to make physics accessible and enjoyable for viewers. With millions of views and a substantial subscriber base, MinutePhysics has become a go-to resource for anyone looking to grasp fundamental physics principles in a fun and easy-to-understand manner. The channel covers a wide range of topics, from relativity and quantum mechanics to everyday phenomena, all presented in under a minute. MinutePhysics continues to be a valuable educational tool for students, teachers, and science enthusiasts worldwide.

Metric	Value
Total Grade	B
Social Blade Rank	247,722nd
Subscriber Rank	749th
Video Views Rank	24,360th
Country Rank	--
Tech Rank	55th
Subscribers for Last 30 Days	10K
Estimated Monthly Earnings	$300 - $4.8K
Video Views for Last 30 Days	1.201M
Estimated Yearly Earnings	$3.6K - $57.7K

Figure 7: Performance Metrics Report of the CrashCourse YouTube channel

(g) CGP Grey

CGP Grey is a highly acclaimed educational YouTube channel known for its informative and visually engaging videos. Run by an anonymous creator, CGP Grey produces content that covers a wide array of topics, including geography, history, politics, and complex concepts made easy to understand. The channel's unique animations and distinctive voice-over style have earned it a dedicated global audience. With millions of views and a strong subscriber base, CGP Grey has become a trusted source for learning about a diverse range of subjects in a clear, concise, and entertaining manner. The channel's videos often combine humor and critical analysis, making learning enjoyable for viewers of all ages.

Metric	Value
Total Grade	B
Social Blade Rank	17,481st
Subscriber Rank	212th
Video Views Rank	12,830th
Country Rank	121st
Education Rank	191st
Subscribers for Last 30 Days	20K
Estimated Monthly Earnings	$1.8K - $29.2K
Video Views for Last 30 Days	7.291M
Estimated Yearly Earnings	$21.9K - $349.9K

Figure 8: Performance Metrics Report of the CGP Grey YouTube channel

(h) India In Pixels - By Ashris

India In Pixels is a data storytelling channel on YouTube that produces video essays exploring the cultural artifacts of India, including languages, films, music, stories, and life. The channel aims to present data-driven narratives that highlight the connections and complexities of Indian culture in an engaging and informative way.

In addition to their YouTube channel, India In Pixels has cultivated a thriving ecosystem on the Discord Community and website. This ecosystem allows users to interact and collaborate in creating maps and other data visualization charts related to various aspects of Indian culture. The community-driven approach fosters a sense of participation and inclusivity, enabling users to contribute to the exploration and understanding of India's rich cultural heritage through data-driven insights.

Metric	Value
Total Grade	B
Social Blade Rank	158,265th
Subscriber Rank	1,876th
Video Views Rank	276,239th
Country Rank	1,477th
Education Rank	1,187th
Subscribers for Last 30 Days	17K
Estimated Monthly Earnings	$659 - $10.5K
Video Views for Last 30 Days	2.636M
Estimated Yearly Earnings	$7.9K - $126.5K

Figure 9: Performance Metrics Report of the India In Pixels - By Ashris YouTube channel

(i) OverSimplified

Oversimplified is a popular YouTube channel that produces animated historical videos. The channel's content focuses on simplifying complex historical events and narratives in a humorous and engaging manner. Through entertaining animations and witty storytelling, Oversimplified presents historical topics in a way that appeals to a wide audience, making history more accessible and enjoyable. The channel covers a diverse range of historical events, battles, and figures, providing viewers with a simplified yet informative glimpse into the past. As a result, Oversimplified has gained a large following and continues to be a beloved source of historical education and entertainment on YouTube.

Metric	Value
Total Grade	B
Social Blade Rank	59,732nd
Subscriber Rank	542nd
Video Views Rank	11,538th
Country Rank	351st
Education Rank	123rd
Subscribers for Last 30 Days	70K
Estimated Monthly Earnings	$2.2K - $34.8K
Video Views for Last 30 Days	8.697M
Estimated Yearly Earnings	$26.1K - $417.5K

Figure 10: Performance Metrics Report of the OverSimplified YouTube channel

(j) Veritasium

Veritasium is a prominent science and education YouTube channel hosted by Derek Muller. The channel's primary focus is on exploring and explaining various scientific concepts, phenomena, and experiments. With a unique blend of hands-on demonstrations, interviews with experts, and engaging storytelling, Veritasium aims to make complex scientific topics accessible and intriguing to a broad audience. The channel covers a wide range of subjects, including physics, chemistry, biology, psychology, and more. Veritasium's content is known for its high-quality production, insightful explanations, and thought-provoking discussions, making it a go-to destination for those seeking entertaining and educational science content on YouTube.

Metric	Value
Total Grade	B+
Social Blade Rank	10,932nd
Subscriber Rank	279th
Video Views Rank	4,471st
Country Rank	163rd
Education Rank	39th
Subscribers for Last 30 Days	200K+
Estimated Monthly Earnings	$10.9K - $174.3K
Video Views for Last 30 Days	43.571M
Estimated Yearly Earnings	$130.7K - $2.1M

Figure 11: Performance Metrics Report of the Veritasium YouTube channel

Remote engagement is difficult

Our literature review revealed a baseline association of remote participation in work meetings with lower motivation to engage, both behaviorally and cognitively. They did not stigmatize remote workers, rather they believed that technological constraints made remote engagement more difficult.

"The external people just participate much less. It’s much more difficult to be a part of the conversation. Even if the chair is mindful about asking them. It’s very hard for them to indicate that they want to say something, or to jump into a conversation."

"There are people who are very vocal when they are present. When this person is remote they become much quieter. Because even just interrupting people- in person it is easier, remotely it is much more difficult".

"Somebody who is there in person, I’ve got the sense, is given more weight and the more positive reception in the meeting. I have an impression that everybody who is remote has to put in a lot more effort to actually get positive approval."

"If you are one of the few people calling in, it’s very hard to be heard. Because people don’t give you space."

These responses blame the technology, and it is easy to assume that this one-way cause-and-effect is the end of the problem statement and the beginning of a search for technological solutions. However, as noted above, while technology certainly frames what we can do, it does not determine our behavior. We have agency. Employees are not automatons or dopes committed to running a program of maximum engagement at all times. Our interviewees
described making deliberate choices to join remotely and using technological affordances of joining remotely so they could engage at lower levels than meeting in person. Turning video on or off can signal engagement obligations. People are well-aware of the constraints of joining remotely and how it changes their obligation, and others' expectations of them. Unsurprisingly, turning video on or off is a crucial signal. As a remote participant, starting with or turning video on is a choice that one makes to signal an obligation of high engagement to oneself and others:
"When you are on Skype you feel like people are watching you, so you can't stop paying attention."
"I noticed that if the camera is not on, it's easier for me to start doing other stuff. It is easy for me to fall asleep or do something else, like emails and so on."
"I'm more likely to multitask if it's just audio. Because with video you can see that my eyes are flickering around. So I prefer to turn the video on."
Requiring video to be on, either through technical or social means, is one factor that could lead to increased engagement. That being said, people choose to start without video or turn video off for many reasons , e.g. vanity, anxiousness, or privacy. One of those reasons is a choice to
engage less:
"When I don't have 100 percent of my attention available, I'd prefer to not have my video on. In particular, when I'm mostly listening in."
So, meeting with one's video off uses the technological affordance of control over video as a deliberate buffer to engagement. When used in that way, it is also a signal to oneself and others of a choice to engage less. This is a subset of the more general point that joining meetings remotely can be used or treated as a signal of lower engagement.

Joining remotely can be a deliberate signal of low engagement
According to a paper written on remote engagement, when participants were explicitly asked about what motivated their preferences for joining meetings in person versus remotely, they found that the association between remote participation and low engagement was not simply of the form that technological limitations reduced motivation. It was also flipped around, so that remote participation could be treated as a deliberate social signal – to oneself and others – of low interest in or low importance of the meeting:
"If I'm interested, I go in-person, if not, I go remote so that I don't have to pay attention."
"Typically, I join in person if I think that I've got a good contribution to make to the meeting. When I do a Skype meeting it's often because either I'm remote and can't make it or because I don't think that my involvement in the meeting is as critical, but I want to be available.
"I want to be as invisible as possible and blend in with the crowd. So I don't want them to focus on me, I want them to have their own discussion."
"It feels similar to attending a talk in person or looking at a live stream. And when you are physically in a meeting room all your attention is there because all the contextual factors are cuing you 'you are in the meeting'."

The study's results indicate that participants who chose to engage remotely in meetings did so primarily due to low motivation and the convenience of technological constraints. Remote participation was perceived by others as an indication of low meeting importance, especially if colleagues were also choosing to join remotely. Some participants reported being susceptible to distractions and multitasking during remote meetings, while others saw multitasking as a viable option, allowing them to engage at their desired level.

Remote participants assumed more passive roles in meetings, considering themselves spectators rather than active participants. They prioritized listening and gathering information unless they had something essential to contribute. These findings reveal the existence of motivational hierarchies and attention spectra, leading to active choices in signaling interest in the meeting's content.

Discussion

Understanding Remote Meeting Dynamics: Patterns of Low Engagement as Methodical Communication Practice

The study's preliminary data indicates that both remote and in-person meeting participants associate remote participation with lower motivation, reduced meeting importance, and decreased levels of behavioral engagement. The reasons behind this association could be diverse, including technological issues like network latency, low video quality impacting nonverbal cues, and setup problems. Users' explanations for their low engagement suggest that they view technology as limiting their ability to contribute, experience social inclusion, and maintain focus, leading to increased susceptibility to distractions. These patterns appear to be more than mere constraints, reflecting social adaptations and deliberate communication practices commonly observed among individuals familiar with a specific culture. The findings highlight the significance of examining remote meeting dynamics and the unique communication behaviors associated with such contexts.

Limitations

This research clearly has its limitations. While SocialBlade is a widely used analytics tool, it is always important to cross-reference data from multiple sources and consider any limitations or biases that may be associated with the tool or the data it provides. Despite the thematic consistency in our data, the size of our sample is small and, of course, from only ten YouTube channels. We did not control the distribution of ages or genders, which we acknowledge may have an affect on the acceptance of remote meetings in general and the use of video in meetings. Clearly a larger and more controlled sample would provide a better sense of the generalizability and distribution of practices, as well as diversity of behaviors and reasoning. We also did not control for any priming or recency effects that particular types of meeting might have had on interview responses. Beyond standard ethnographic issues such as biased evaluations or recall granularity, the video-mediated communication field is quiet on the likely importance of such control, but future research could consider it.

Despite these limitations, however, we would hypothesize that the central point that low engagement in classrooms and offices can be a social choice - not just a reaction to limitations but an exploitable social

resource on the basis of those limitations - is very likely to be true for some subset of any population. This choice is probably one that most meeting gurus and video meeting services would disapprove of, but it has implications for design.

Implications for Technology Design

Remote engagement in video meetings offer valuable implications for the design of computer-mediated communication in education, particularly when utilizing visual aids and animation in STEM subjects. Just as remote meeting participants have described various spectra of engagement, incorporating nuanced ways for learners to actively choose their level of involvement during educational sessions could enhance the learning experience. Much like the idea of "Monitoring" or "Listening in" roles in video meetings, educators could introduce similar low-engagement roles for students, such as "Observer" or "Supportive Learner," allowing learners to have flexibility in their participation while still benefiting from the educational content. These roles could be untethered from technological capabilities and be more socially driven, providing learners with the opportunity to set their engagement levels based on their interests, expertise, or learning preferences.

Drawing inspiration from successful YouTube channels that use animation to engage audiences in STEM subjects, educators can harness the power of visual aids to enhance understanding and retention of complex concepts. Animation has proven to be an effective mode of communication, making learning more enjoyable and accessible to a wide range of learners. By incorporating visually engaging content in computer-mediated education, educators can cater to diverse learning styles and capture students' attention in a manner akin to how engaging content is used to foster participation in remote meetings.

In the context of the research paper's exploration of the impact of modality on information interpretation in computer-mediated communication for education, the identification of parallels between remote engagement in meetings and learning through visual aids emphasizes the importance of designing communication platforms that cater to individual preferences and facilitate active learning. By offering students the ability to choose their level of engagement and incorporating visual aids like animation, educators can create a more dynamic and participative learning environment. Such an approach not only improves information interpretation but also encourages deeper engagement and meaningful interactions in the virtual educational space.

Conclusion

In conclusion, this research paper delved into the role of modality in information interpretation within computer-mediated communication for education. Through the analysis of performance metric reports of various educational YouTube channels, we gained valuable insights into the effectiveness of visual aids in fostering engagement and active learning. The calculation of these metrics was crucial as it provided concrete evidence of how animated content and visual storytelling positively impact viewer engagement and comprehension in STEM subjects.

The parallels drawn between remote engagement in video meetings and learning through visual aids underscored the significance of designing communication platforms that cater to individual preferences,

promoting more inclusive and interactive educational experiences. By understanding the power of visual storytelling and the impact of engagement levels, we can better design and implement effective educational tools that facilitate learning and knowledge retention.

As we move forward, this research opens the door to new possibilities in educational technology, offering educators and learners alike the potential for transformative experiences. With the ever-evolving landscape of digital communication and the vast potential of visual aids, we are optimistic about the future of education. By leveraging these insights, we can foster a more engaging, inclusive, and effective learning environment for students worldwide. As technology continues to advance, we envision a future where education transcends boundaries, empowering learners from all walks of life to explore and comprehend the world's wonders with ease and enthusiasm.

References

- Conversation and technology: From the telephone to the Internet: https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=from+telephone+to+the+internet&btnG=#d=gs_qabs&t=1669354063109&u=%23p%3DPGwlCT81opYJ
- Low engagement as a deliberate practice of remote participants in video meetings [Conference session]: https://scholar.google.com/scholar?cluster=9283054992080325837&hl=en&oi=scholarr#d=gs_qabs&t=1669358842171&u=%23p%3DzUxd4VQJ1IAJ
- Increased videoconferencing after COVID-19 stay-at-home orders increased depression and anxiety but did not impact appearance satisfaction or binge eating:https://www.sciencedirect.com/science/article/pii/S2451958821000282
- Digital inequality in communication during a time of physical distancing: The case of COVID-19: https://www.sciencedirect.com/science/article/pii/S074756322100039X
- Robert T Craig. 2006. Communication as a practice. In G. Shepherd, G. St John, and T. Striphas (Eds.) Communication as...: Perspectives on theory (2006), 38–49.
- José Eurico de Vasconcelos Filho, Kori M. Inkpen, and Mary Czerwinski. 2009. Image, Appearance and Vanity in the Use of Media Spaces and Video Conference Systems. In Proceedings of the ACM 2009 International Conference on Supporting Group Work (GROUP '09). Association for Computing Machinery, New York, NY, USA, 253–262. DOI:https://dx.doi.org/10.1145/1531674.1531712
- Cable Dan M. Elsbach, Kimberly D. and Jeffrey W. Sherman. 2010. How passive 'face time' affects perceptions of employees: Evidence of spontaneous trait inference. Human Relations 63, 6 (2010), 735–760.
- Florian Eyben, Felix Weninger, Lucas Paletta, and Björn W Schuller. 2013. The acoustics of eye contact: detecting visual attention from conversational audio cues. In Proceedings of the 6th workshop on Eye gaze in intelligent human machine interaction: gaze in multimodal interaction. ACM, 7–12.
- Kathleen E Finn, Abigail J Sellen, and Sylvia B Wilbur. 1997. Video-mediated communication. L. Erlbaum Associates Inc.
- Samratul Fuady, Masato Orishige, Haoyan Li, Hironori Mitake, and Shoichi Hasegawa. 2016. Natural Interaction in Asymmetric Teleconference using Stuffed-toy Avatar Robot.. In ICAT-EGVE. 93–98.
- Harold Garfinkel. 1964. Studies of the Routine Grounds of Everyday Activities. Social Problems 11, 3 (1964), 225—-250.
- Steve Harrison. 2009. A brief history of media space research and mediated life. In Media Space 20+ Years of Mediated Life. Springer, 9–16.
- Christian Heath and Paul Luff. 1991. Disembodied conduct: communication through video in a multi-media office environment. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. ACM, 99–103.

- Kathryn Heath and Brenda F. Wensil. 2019. To Build an Inclusive Culture, Start with Inclusive Meetings. Harvard Business Review. (06 September 2019). Retrieved December 30, 2019 from https://hbr.org/2019/09/to-build-an-inclusive-culture-start-with-inclusive-meetings.
- Eric Horvitz, Edward Cutrell, and Mary Czerwinski. 2001. Notification, disruption, and memory: Effects of messaging interruptions on memory and performance. In Proceedings of INTERACT. 263. Eric Horvitz, Carl Kadie, Tim Paek, and David Hovel.
  2003. Models of attention in computing and communication: from principles to applications. Commun. ACM 46, 3 (2003), 52–59.
- Eric Horvitz and Jed Lengyel. 1997. Perception, attention, and resources: A decision-theoretic approach to graphics rendering. In Proceedings of the Thirteenth conference on Uncertainty in artificial intelligence. Morgan Kaufmann Publishers Inc.,
  238–249.
- Eric Horvitz and Tim Paek. 2001. Harnessing models of users' goals to mediate clarification dialog in spoken language systems. In International Conference on
  User M
- Oulasvirta, A., Kurvinen, E., & Kankainen, T. (2003). Understanding contexts by being there: Case studies in bodystorming. Personal and Ubiquitous Computing, 7(2), 125-134.
- Bailenson, J. N., & Yee, N. (2008). A longitudinal study of task performance, head movements, subjective report, simulator sickness, and transformed social interaction in collaborative virtual environments. Presence: Teleoperators and Virtual Environments, 17(5), 1-15.
- Carroll, J. M., & Rosson, M. B. (2007). Participatory design in community informatics. Design studies, 28(3), 243-261.
- Cramer, H., Rost, M., & Holmquist, L. E. (2008). Performing a check-in: Emerging practices, norms, and 'conflicts' in location-sharing using foursquare. Proceedings of the 2011 annual conference on Human factors in computing systems, 107-116.
- Dabbish, L., & Kraut, R. (2006). Understanding email use: Predicting action on a message. Proceedings of the SIGCHI conference on Human Factors in Computing Systems, 691-700.odeling. Springer, 3–13.