

Knowledge Sharing Live Streams: Real-time and On-demand Engagement

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Keywords: HCI, Live Stream, Knowledge Sharing, Social Media.

Abstract: Live streams have been gaining importance in Human-Computer Interaction research and practice. A specific type of these broadcasts is the knowledge sharing live stream (KSLS). Embrapa (Brazilian Agricultural Research Corporation) uses KSLSs to disseminate its research results. In this paper we investigate its audience engaged with the material at different moments. We monitored nine of Embrapa's broadcasts, applied an online survey to the viewers, analyzed access statistics and conducted semi-structured interviews. Our goal was to contrast our findings in KSLS's audience engagement in live and on-demand periods with the literature on this topic, answering the following research questions: How does the engagement of KSLSs viewers differ in real-time and on-demand? Which features could increase this engagement in these two different periods? In this way, according to our results, the takeaways of this work are i) the live period attracted the public more and promoted more interactions, ii) the live audience wishes that the video be made available on-demand, iii) new features, such as support for content documentation, multiple-choice questions, and temporal segmentation could increase the engagement in real-time and on-demand moments, and iv) our public did not have a large preference for interacting via audio in the chat.

1 INTRODUCTION

A live stream is a synchronous form of communication through the web, which involves those who transmit the content, also called a streamer, a live video, and a public chat in which interaction via text messages is possible (Faas et al., 2018). It can also be understood as the distribution of content in video format, through the web, to a real-time audience, using streaming technology. Thus, the public can watch the content while it is being broadcasted, instead of waiting for the complete file to download (Sakthivel, 2011).

A live stream contains both a broadcasting element, in which a person transmits content to an anonymous audience, and an interpersonal element, since real-time interaction is possible through text chat (Wohn et al., 2018). A live stream is different from other video communication forms. For example, in a live video call, communication is synchronous, but it happens between people who know each other, usually in a private environment. Also, the interaction is symmetrical, since everyone partic-

ipates with the same resources (audio and video). In a live stream, people who do not necessarily know each other can participate and the access is public. Moreover, the interaction is asymmetrical because the broadcaster communicates via audio and video, and the viewer via text messages (in the chat). In another example, on large-scale video sharing services on-demand, communication is asynchronous, without the "real-time" component. YouTube allows both synchronous communication, through comments during a live stream, and asynchronous communication, through comments on videos available on-demand (Tang et al., 2016).

Several studies indicate live stream as an emerging research topic within Human-Computer Interaction (HCI), and call for more research to achieve the objectives of this tool's users more efficiently and appropriately (Wohn et al., 2018; Tang et al., 2017; Robinson et al., 2019; Faas et al., 2018; Lu, 2019).

For HCI, live streams present a rich context for investigating how technology can facilitate one-to-many (from the streamer to participants) and many-to-many (between participants) interactions (Lessel and Altmeyer, 2019). Recently, workshops were held to discuss how researchers in this area study and de-

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sign interactions on live streams (Robinson and Isbister, 2019; Kriglstein et al., 2020).

Video game-related live streams have become extremely popular. The creation of the Twitch¹ platform in 2011 has greatly contributed to it. Twitch is the game streaming leader, and its recent numbers show more than 100 million unique views and more than 1.7 million people streaming content per month (Robinson et al., 2019). There are also popular news and live events (Tang et al., 2017), and entertainment with subjects related to travel, music shows, films, and TV shows (Lu et al., 2018b).

Platforms like Facebook Live² and Periscope³ allow their users to start live streams via smartphones, taking this experience to social media (Robinson and Isbister, 2019). A novel but growing fundraising method used by charity organizations is the charity streaming. The idea is to stream content over some time to raise donations and awareness (Mittal and Wohn, 2019).

Another type is the creative live stream, in which artists share the process of building their artifacts, with the challenge of dividing their time between feedback to the public who interacts live and the creation of their works (Fraser et al., 2019a).

Finally, there are also live streams to share knowledge (knowledge sharing live stream — KSLS) and research about tools, practices and challenges specific to KSLS has sought to improve engagement and communication with the public to better support knowledge sharing in this online environment (Lu, 2019).

Embrapa (Brazilian Agricultural Research Corporation) uses KSLSs to disseminate its research results. In this paper we investigate its audience engaged with the material at different moments. We monitored nine of Embrapa's broadcasts, applied an online survey to the viewers, analyzed access statistics and conducted semi-structured interviews. Our goal was to contrast our findings in KSLS's audience engagement in live and on-demand periods with the literature on this topic, answering the following research questions:

1. How does the engagement of KSLSs viewers differ in real-time and on-demand?
2. Which features could increase this engagement in these two different periods?

In this way, according to our results, the takeaways of this work are i) the live period attracted the public more and promoted more interactions, ii) the live

audience wishes that the video be made available on-demand, iii) new features, such as support for content documentation, multiple-choice questions, and temporal segmentation could increase the engagement in real-time and on-demand moments, and iv) our public did not have a large preference for interacting via audio in the chat.

The remainder of this paper is organized as follows. Section 2 presents related works on some types of live streams, including knowledge sharing. Section 3 reports Embrapa's reasons for using KSLS and how the company conducts its transmissions. Section 4 describes the studies conducted. Section 5 presents the results and discussions. Finally, Section 6 concludes the paper and points to future work.

2 RELATED WORK

In an interview, streamers who transmitted different contents (both entertainment in general and knowledge), stated that starting a live stream requires low effort, requiring only a few clicks. However, they revealed that you need great work to attract the public and build a community (Tang et al., 2016).

Raman et al. (2018) conducted a study with live streams on Facebook Live covering several domains (news, entertainment, religion, arts, education, shopping, fitness, etc.). The authors propose to measure audience engagement while the video is live and when the same video goes on-demand. They collected the amounts of likes, comments, and shares and reported that, according to their results, most of the interaction happens one day after transmission.

Chatzopoulou et al. (2010) stated that, on average, a video available on YouTube receives a comment, a rating or is added to a favorites list once every 400 views. This data indicates low engagement and low interactivity in videos accessible on-demand. Tang et al. (2016) claimed that this asynchronous way of consuming content produces a limited amount of social engagement.

Faas et al. (2018) highlighted the growth of mentoring-type live streams, in which the streamer explains their actions to perform a specific task, and the audience acquires knowledge during the broadcast. The study deals with the experience of sharing content in the game programming area using the Twitch platform. Initially intended for content related to video games, since 2015, Twitch has expanded the types of transmissions carried out, allowing it to indicate non-game content as a subject. Although Twitch is used as a learning platform, the authors pointed out that it was not designed for this purpose. Moreover,

¹<https://www.twitch.tv/>

²<https://www.facebook.com/formedia/solutions/facebook-live>

³<https://www.pscp.tv/>

there is an opportunity for software development that will give greater support to the streamer in the role of teacher.

Lu (2019) also notes the opportunity to design and develop tools for knowledge sharing live streams to achieve more efficient communication and engagement. He introduced StreamWiki to support the collaborative creation, in real-time, of documentation related to the transmission. The streamer or the moderator can create small tasks to be done by the people who are watching, potentially benefiting learning. By contrast, the public can write, vote, and propose improvements in summaries about the content presented. They can also vote for their favorite comments. During the study of the tool's deployment, it was detected that its use requires additional public effort. However, in general, the participants did not consider it intrusive or disturbing in the sense of distracting attention from the presented content.

Still on documentation related to the transmission, Yang et al. (2020) present Snapstream. It is a feature that allows users to capture snapshots of the live stream, make notes, drawings, cuts, and share them in the chat. The main objective is to improve the interaction and communication between the streamer and the public in the domain of creative live streams. Despite this, users mentioned in the evaluation questionnaire that they would like to download the snapshots to review later. The authors themselves discuss expanding the feature for the domain of live streams that involve learning, assisting with documentation.

Participants of creative live streams were asked, through an online survey, how to improve their viewing experience (Fraser et al., 2019b). Several respondents mentioned that it could be enhanced watching the broadcast after the live moment when available on-demand. It was said that a summary with information and direct links to parts of the content could help. A similar result was reported in the KSLS domain, indicating that learning from a transmission available on-demand may be difficult because the navigation options are limited (Lu et al., 2018a). Fraser et al. (2020) then present a semi-automatic approach to creating a temporal segmentation of creative live streams videos available on-demand. The system proposes a video division into sections using the audio transcript and the streamer's software log. Also, indicate titles that can optionally be changed by the person in charge.

Chen et al. (2019) addressed the common limitation of the viewer's interaction with the streamer to only a text-based chat during the live stream. In the field of language learning, they investigated whether, in addition to text, the use of audio, video, image,

and stickers would favor greater engagement by learners. The study's conclusions indicated that multi-modal communication produces instant feedback and increases engagement. Moreover, its use depends on several factors, such as group size, environment, and duration of the live stream. In general, the participants said that the most useful communication modalities were audio (mainly to check the pronunciation) and stickers.

Haimson and Tang (2017) stated that interaction is one aspect that can engage the audience in a live stream and that this is an active, rather than a passive, viewing video. However, they emphasized that excessive interactivity could be harmful in the sense of distracting those involved from the presented content. They concluded that finding a balance for this interactivity is a challenge for designers and live streaming platforms' moderators.

Fraser et al. (2019b) claim that, although individuals perform many live streams, professional ones carried out by companies are growing in popularity. Moreover, they report the experience of Adobe⁴, which produces creative software. This company's live streams address various topics (graphic design, photography, video editing, etc.) and aim to teach new skills and encourage the use of its products.

3 EMBRAPA'S KSLS'S

Founded in 1973, Embrapa is under the aegis of the Brazilian Ministry of Agriculture, Livestock, and Food Supply. Its mission is to provide research, development, and innovative solutions for the sustainability of agriculture and Brazilian society's benefit (Embrapa, 2020b). For this, it has an organizational structure composed of both centralized and decentralized units. Embrapa Dairy Cattle is a decentralized unit of Embrapa and devises solutions for the sustainable development of the dairy agribusiness, emphasizing the production segment in the tropical climate (Embrapa, 2020a).

The dairy agribusiness is economically and socially important in Brazil. There are 1.3 million producers, about 2,000 legalized dairy industries and more than 11,000 transporters, amounting to close to 4 million workers across the chain. This sector has expanded in recent years and 99% of Brazilian municipalities produce milk (Arbex and Martins, 2019).

According to the document "Vision 2014–2034: the future of technological development for Brazil-

⁴<https://www.adobe.com/>

ian agriculture”⁵ developed by Embrapa, the research carried out at the company generates knowledge that needs to be publicized appropriately to rural producers, technicians, and society in general, in order to enable scientific recommendations to be effectively adopted. It also states that social media will increasingly allow everyone to participate and directly influence the public debate on agriculture, food, biotechnology, and others, at the speed of the web.

In this context, Embrapa Dairy Cattle perceived the opportunity to use KSLs as an additional way to share the results of its research with its public. They are distributed all over Brazil — a country with continental dimensions — and even abroad.

Live streams have been held systematically since 2018 with pre-scheduled dates, themes, and speakers. They discuss various topics related to the dairy agribusiness. They happen simultaneously on Embrapa’s YouTube channel⁶ and RepiLeite⁷ (Research and Innovation Network in Dairy — a thematic social network maintained by the company). The speaker uses slides to support their speech. A moderator makes the presentation of the event, forwards the questions of the public, and assists with technical difficulties that they may have to follow the event. Figure 1 shows the live streaming environment on YouTube and Figure 2 on RepiLeite.



Figure 1: YouTube’s live streaming environment.



Figure 2: RepiLeite’s live streaming environment.

⁵<https://www.embrapa.br/busca-de-publicacoes/publicacao/995649/visao-2014-2034-o-futuro-do-desenvolvimento-tecnologico-da-agricultura-brasileira> (in Portuguese)

⁶<https://www.youtube.com/embrapa>

⁷<http://www.repileite.com.br>

At the end of the live stream, in-depth materials are made available (videos, podcasts, articles, website links, etc.). The video and materials indicated for further study are available on both the YouTube channel and the RepiLeite network for viewers who could not watch it live. It is possible to continue interacting even in the asynchronous period. The comments posted after the live stream are forwarded by the team to the speaker to provide the appropriate responses.

4 STUDY METHODS

For this study, we monitored nine KSLs performed by Embrapa (denoted as LS1 – LS9). They took place between May and September 2020 and were able to be followed simultaneously on Embrapa’s YouTube channel and the RepiLeite network (embedded video). We used three sources to obtain data on user behaviors and preferences: online survey, access statistics, and semi-structured interviews.

The online survey had questions about the user’s profile and their interactions in real-time and on-demand live stream periods. For answers in 7-point scales, we considered options 1 and 2 as negative; options 3, 4 and 5 as neutral; and options 6 and 7 as positive. In the middle and at the end of each live stream, the moderator invited participants to answer anonymously and voluntarily to the survey. Later, to reinforce this request, participants received an email with instructions on how to access the survey. We obtained a total of 550 responses, but 14 people did not authorize the use of their feedback for this research. Thus, we worked on the analyses with 536 responses. Table 1 presents information about each live stream monitored.

YouTube Studio, a tool that YouTube offers to the channel administrator, provides several access statistics. For this study, we consider it relevant to use the following data referring to each accompanied live stream: the number of views, likes, shares, and the quantity of watch duration. We monitored each transmission in the live period and the first sixty days available on-demand.

We conducted semi-structured interviews with viewers to complement the results obtained in the online survey, the access statistics, and the literature. We leave a contact email for respondents to the LS9 online survey, inviting them to participate in this qualitative round. We also invited people who participated in the chat of other KSLs conducted by Embrapa Dairy Cattle. We obtained 12 responses. The interviews took place remotely by video or phone call in October and November 2020. They lasted an aver-

Table 1: Information about the KSLSs monitored in this study.

ID	Month	Theme	Responses
LS1	May	Transition period and fertility in dairy cows	87
LS2	Jun	Depuration and recovery of bovine livestock manure	68
LS3	Jun	“IN 76”, “IN 77” and collections for milk quality analysis	48
LS4	Jun	Data science applied to dairy farming	50
LS5	Jun	Environmental legislation: perspectives and challenges for the adequacy of dairy farms	58
LS6	Jul	Good Management Practices for CBT reduction	48
LS7	Jul	iLPF in the Northeast: lessons learned and challenges	39
LS8	Aug	Good agricultural practices to reduce CCS and the impact on the dairy industry	39
LS9	Sep	Cow's food is grass	99
Total			536

age of 20 minutes. All respondents' participation was voluntary.

The individual and combined analyses of the data from these three sources, together with the researched literature, support the results and discussions presented in the next section.

5 RESULTS AND DISCUSSIONS

The next subsections present the results and discussions obtained with the KSLSs monitored in this study. The following results are addressed: respondents' profile, viewers' engagement in real-time and on-demand periods, and other features to engage the audience.

5.1 Respondents' Profile

The first questions of the online survey aim to identify the respondents' profile. The results are presented below. Figure 3 shows a fairly uniform distribution among the various age groups. Figure 4 shows areas of activity/interest with different types of profiles, varying mainly between rural extension and technical assistance, research and/or teaching, dairy farmer and student. In addition, the answers to question “In which state do you live?” indicate a large geographic area covered. There were 25 Brazilian states and the Federal District⁸, plus four other countries (Angola, Colombia, Portugal, and USA).

We also checked the profile of the interviewees (denoted as E01 – E12), as shown in Table 2.

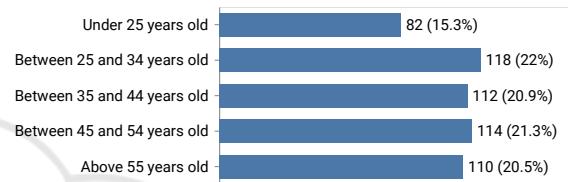


Figure 3: Question - What is your age group?

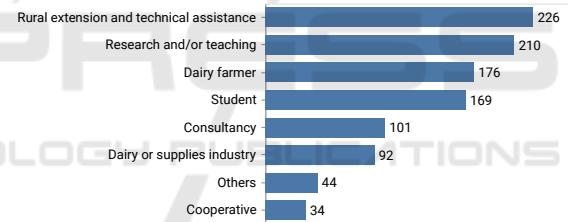


Figure 4: Question - Select your main areas of activity or interest. If you want, you can select more than one option.

Table 2: Interviewees' profile.

ID	Age group	State	Area of activity
E01	< 25	SP	Student
E02	35 – 44	DF	Dairy farmer
E03	45 – 54	TO	Research/teaching
E04	35 – 44	GO	Research/teaching
E05	25 – 34	BA	Consultancy
E06	35 – 44	MG	Research/teaching
E07	45 – 54	MG	Rural extension
E08	45 – 54	MG	Research/teaching
E09	45 – 54	MG	Research/teaching
E10	35 – 44	RO	Dairy farmer
E11	25 – 34	BA	Dairy farmer
E12	25 – 34	PR	Rural extension

⁸Brazil has 26 states plus the Federal District, so the survey covered most of the country.

Table 3: Live streams participants' engagement in live and on-demand periods according to views, watch duration, likes, shares, and technical questions.

		LS1	LS2	LS3	LS4	LS5	LS6	LS7	LS8	LS9
Live	Views	1,331	906	472	1,843	744	763	1,217	782	3,060
	Watch duration	497.5	202.7	134.6	495.8	196.1	216	286.3	190.3	851.6
	Likes	75	85	38	172	74	97	139	77	336
	Shares	26	17	12	47	23	25	38	24	132
	Questions	30	19	16	33	14	14	40	16	54
On-demand (1st to 3rd day)	Views	646	581	390	1,031	578	620	834	499	4,155
	Watch duration	110.6	68.8	48.6	135.8	81	89.3	156.4	81.1	1,223.1
	Likes	31	26	27	74	44	25	53	25	254
	Shares	9	9	19	25	10	5	11	11	154
	Questions	0	0	0	0	0	0	0	0	0
On-demand 4th to 60th day)	Views	385	125	180	533	160	396	477	302	9,638
	Watch duration	79.2	19.3	29.6	89.2	29.5	63.7	127	65.6	3,757
	Likes	14	8	10	21	10	14	24	8	400
	Shares	8	1	5	12	5	6	6	2	278
	Questions	1	0	0	1	0	0	1	0	4

5.2 Viewers' Engagement in Real-time and On-demand Periods

Raman et al. (2018) conducted a study with live streams on Facebook Live covering several domains (news, entertainment, religion, arts, education, shopping, fitness, etc.). The authors propose to measure audience engagement while the video is live and when the same video goes on-demand. They collected the amounts of likes, comments, and shares. The videos received an average of 6.7 likes, 8.4 comments, and 0.54 shares during the live moment. One day after transmission, these averages rise to 29.84, 16.33, and 1.33, respectively. The authors report that in the next eight months, these numbers do not vary much. Thus, according to their results, most of the interaction takes place one day after transmission, thereby demoting the importance of the live moment.

By contrast, Chatzopoulou et al. (2010) stated that, on average, a video available on YouTube receives a comment, a rating or is added to a favorites list once every 400 views. This data indicates low engagement and low interactivity in videos accessible on-demand. Tang et al. (2016) claimed that this asynchronous way of consuming content produces a limited amount of social engagement.

In this way, we seek to investigate the engagement of viewers in the context of KSLS, in real-time and on-demand periods. We used five indicators to measure engagement in broadcasts: views, watch duration, likes, shares, and technical questions. Monitoring took place in three periods: live, on-demand from the first to the third day, and on-demand from the fourth to the sixtieth day.

Table 3 presents the results. The light blue cells represent the indicator's predominance over the other two periods, even if added together. For example, the number of views at LS1's live moment (1,331) was greater than the sum of views over the entire on-demand period, which presented 1,031 in total (646 from the first to the third day and 385 from the fourth to the sixtieth day). The light gray cells indicate the predominance over the other two periods separately (not over their sum). For example, the number of views in the live moment of LS3 (472) was the highest of the three monitored periods, but it was not greater than the sum of the other two, which obtained 570 in total (390 from the first to the third day and 180 from the fourth to the sixtieth day). It is possible to observe the concentration of engagement in the live period. LS9 does not follow this trend, concentrating most of the interaction in the on-demand period from the fourth to the sixtieth day. An investigation would have to be done specifically on this KSLS to understand the reason for this behavior. In addition, the period analyzed with the largest number of days is the fourth to the sixtieth, but except for LS9, the indicators of views, watch duration, likes and shares have significantly reduced in this period. For example, at LS5, the number of views across the three periods decreases (744, 578, 160). This indicates a decrease of engagement over time.

In the interviews, we asked the participants if they knew, before the broadcast, that they could watch the content after the live moment. If they responded positively, we questioned the reason for choosing the live moment. If they answered no, we asked them what the choice would have been if they had known. Three

respondents did not know that it would be available on demand, and nine did. But everyone chose (or would choose) to watch it live and mentioned the possibility of asking questions as one of the reasons for the decision. This respondents' preference is in accordance with the data presented in Table 3. The total number of technical questions sent at the live moment of the KSLSs is 236. In the entire period on-demand (from first to the sixtieth day) is 7. This indicator is relevant for the spectators' clarification, highlighting the importance of the live period to knowledge sharing.

In addition to this, participants also mentioned in favor of the live moment:

- E09: "In videos on-demand, I do not interact. I do not seek contact with the author."
- E04: "I already realized by my behavior that it is more difficult for me to watch later."
- E12: "I think that even the concentration becomes better (live period). If I leave it to watch later, anything else already takes the focus off, it takes away my attention. The fact that it remained recorded, I think it serves as a basis for later revisiting a specific part of the video, something in that sense."
- E05: "When doubts arise and can be resolved at the moment, there is nothing better. There is nothing worse than an unanswered doubt."
- E06: "Sometimes I postpone to see the rest later (on-demand video), but the time never comes, and I end up not watching it."

Although our results show most of the engagement happening in real-time, they also reveal the importance of making the recorded transmission available on demand. The question from the online survey "Have you ever watched a video of a broadcast that had been live, but that you didn't see it at the time?" shows that 89.2% (478 of 536) had watched a video recorded from a live broadcast, which they were unable to watch at the time of the live transmission (Figure 5). If the participant answered "Yes", two complementary questions were asked. The first one asked "How many times have you watched a video of a broadcast that had been live, but that you didn't see at the time?". Five times or more was the answer of 50% (239 of 478). The second one asked "Why didn't you watch the stream on time?". The main reason was another appointment scheduled at that time (Figure 6).

5.3 Other Features to Engage the Audience

As stated in Section 2, there are opportunities to design and develop tools for knowledge sharing live



Figure 5: Question – Have you ever watched a video of a broadcast that had been live, but that you **didn't see at the time?**

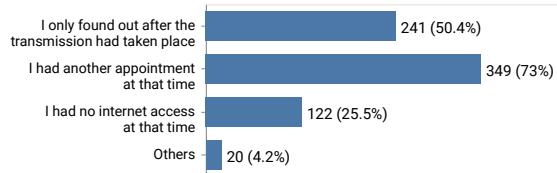


Figure 6: Question – Why **didn't you watch** the stream on time? If you want, you can select more than one option.

streams to achieve more efficient communication and engagement (Lu, 2019; Faas et al., 2018). Also, there are studies proposing tools to help viewers document the broadcast content in the live period (Lu et al., 2018a; Yang et al., 2020), to create small tasks to be done by the viewers (Lu et al., 2018a), to create a temporal segmentation of live streams videos available on demand (Fraser et al., 2020), and to offer multimodal communication, mainly audio, in the chat (Chen et al., 2019). On the streaming platform used in this study, these features are not available. We then asked some questions to investigate whether our audience would be interested in similar features.

In the online survey, the question "Did you take any notes or record the screen (photo or print screen) during the live stream?" shows that 62.5% (335 of 536) of the respondents took at least one note or recorded the screen (Figure 7). This indicates that functionalities to support the documentation of the content presented could help this KSLS audience.

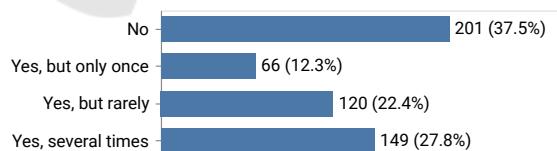


Figure 7: Question – Did you make any **notes or record the screen** (photo or print screen) during the live stream?

Another survey's question was more speculative: "How interesting would it be to interact with the lecturer during the stream by answering a multiple-choice question raised by them?". The majority of users (57.5%, that is, 308 of 536) answered 6 or 7, indicating they consider this type of interaction with the speaker interesting (Figure 8).

In the interviews, we asked the participants if they had already watched a video with temporal segmentation. Five of them said they already watched (E01,

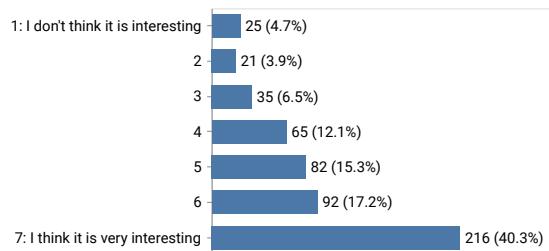


Figure 8: Question – How interesting would it be to interact with the lecturer during the stream by answering a **multiple-choice question** raised by them?

E02, E05, E11, and E12), and four of these said they had already used this feature (E02, E05, E11, and E12). Despite knowing it or not, this feature was perceived as useful by eleven of our interviewees. The exception was E07, who said he did not know how to give an opinion. Those who have already used it highlighted that temporal segmentation was very useful to facilitate the content search in the video (E02, E12), to save time (E05), and to go straight to the doubt (E11). Next, we highlight some quotes from the other participants.

- E04: “I find it very useful because today we want information faster and we have a lot of information. And I already got a lot of videos with a subject that I thought would solve my doubt, and that didn’t happen. So this index would be more interesting because I would go straight to the point.”
- E06: “One of the big video problems is that sometimes you want to see a part of it. So you scroll through the content looking for the part that interests you. Pull the control to one side, pull to the other. Do not find and ends up abandoning the video.”
- E09: “I think it would be a great feature because then I’ll go straight to what interests me more.”

Our study did not confirm a large preference for using audio in the chat as found by Chen et al. (2019). Only 31.7% (170 of 536) of the online survey participants were interested in this resource, answering 6 or 7 in the speculative question “How encouraged would you feel to send questions to the lecturer if you also had the option to send them via audio?”. Figure 9 shows the complete result.

To complement this result, in a KSLS conducted by Embrapa Dairy Cattle, we offer the option for participants to send questions also by audio, through a WhatsApp⁹ business number. At the beginning and in the middle of the transmission, the moderator warned about this possibility. In parallel, a QR Code was

⁹<https://www.whatsapp.com/>

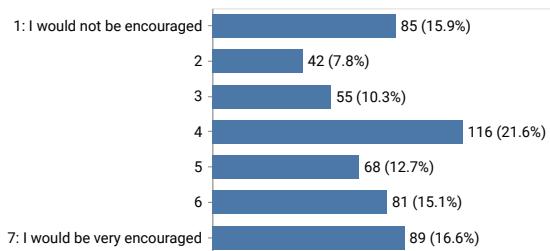


Figure 9: Question – How encouraged would you feel to send questions to the lecturer if you also had the option to send them via **audio**?

available on the screen and a link in the chat, allowing the viewer to send their question directly. Thus, the spectator could use either their smartphone or the web environment for this. In addition, four times the following informational text was passed at the bottom of the video: “Send your question via chat. If you prefer to use audio, send via WhatsApp to the number XX XXX-XXXX (omitted) or by accessing the link available in the chat”. Thus, whenever the moderator warned about sending questions, it was offered to do so by text or audio.

During the KSLS, viewers sent 12 questions, all of them via text in the chat. A few hours after the live moment, with the video available on demand, a question was sent to the WhatsApp contact, but also by text.

We chose WhatsApp because it is trendy in Brazil. Recent researches show that it is installed on 99% of Brazilians' smartphones¹⁰ and that 80% of them use the app at least once every hour.¹¹ Nevertheless, a limitation of this experiment is that the possibility of sending questions by audio required an extra step from the viewer, using this third party application.

6 CONCLUSIONS

In this paper, we investigate KSLSs' audience engagement in live and on-demand periods. The target audience comprised users who had watched at least one broadcasting from Embrapa Dairy Cattle. The results obtained in this study can contribute to improve the engagement and to design for better KSLSs experiences, supporting richer interactions. We found indications that the public wants mechanisms for interaction in addition to comments in the chat, which

¹⁰<https://panoramamobiletime.com.br/pesquisa-mensageria-no-brasil-fevereiro-de-2020/>

¹¹<https://www2.deloitte.com/br/pt/pages/technology-media-and-telecommunications/articles/mobile-survey.html>

is the functionality currently available on the streaming platform used in this study. From our results, we highlight that:

- the live period attracted the public more and promoted more interactions.
- the live audience wishes that the video be made available on-demand.
- new features, such as support for content documentation, multiple-choice questions, and temporal segmentation could increase the engagement in real-time and on-demand moments.
- our public did not have a large preference for interacting via audio in the chat.

As future work, we plan to enrich the knowledge acquired in this study by conducting usability studies with the viewers, which could help us understand why the recommended could increase the engagement in real-time and on-demand periods. Another possibility is to segment the data by areas of activity or age to check if there are relevant differences in the results. In addition, we plan to explore the streamers' perspectives, adding their vision to knowledge sharing through live streams.

Finally, we would like to highlight that the live streams and the application of the online survey and the interviews of this study took place in a period of social isolation due to the COVID-19 pandemic. At this time, due to the difficulty of face-to-face events, the number of live streams has grown considerably. Future studies outside this period would be interesting to learn how lasting this trend will be, and to check whether there will be a significant change in viewers' behaviors and preferences.

ACKNOWLEDGEMENTS

The authors would like to thank all study participants who voluntarily answered the online survey and interviews. They also thank the financial support to this work provided by CAPES and CNPq (process #311316/2018-2).

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