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Development of new methods for assessing the quality and effectiveness of live broadcasts using digital human technologies

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Abstract. The aim of this study was to create a new, comprehensive methodology for assessing the quality and performance of video broadcasts using virtual human technologies. The research methodology included analysing existing methodologies and adapting them to the specifics of virtual hosts. New evaluation tools were developed, considering parameters such as technical quality, emotional support, interactivity, social presence, streamer attractiveness and intention to continue watching. The main results of the study showed that technological aspects of video streaming have a significant impact on viewers' perception of such videos. High video and audio quality, and broadcast stability increase audience satisfaction and engagement. In addition, the emotional interaction between the virtual host and the audience promotes a deeper understanding and increases trust. The interactivity and social presence of the virtual host create a sense of community and engagement, which positively affects the overall perception of the broadcast. Viewers' self-efficacy, information overload and cognitive dissonance factors were also examined, which helps to better understand the psychological state of viewers. The findings suggest that in order to achieve a high level of authenticity and trust in virtual influencers, it is necessary to consider technological aspects, aesthetic aspects, the level of trust in the host, parameters of its audience (their motivations, cultural and personal characteristics that can affect the specifics of assessing the quality and effectiveness of the broadcast), parameters of the host itself (realism, emotional expressiveness, interactivity, presence, and absence of humour, and so on). The proposed methodology allows for a comprehensive assessment of all these parameters, contributing to the improvement of the quality and effectiveness of live broadcasts with virtual hosts

Keywords: virtual avatar; host; streaming; perception; metrics

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Introduction

With the development of digital technologies and the popularity of live broadcasts, there is a need for new methods to assess their quality and effectiveness. Virtual hosts and avatars controlled by artificial intelligence (AI) are becoming increasingly common, offering unique opportunities to interact with audiences. Traditional evaluation methods may not take into account the specific features and benefits of these technologies. The development of new methods will enable more accurate analysis of content quality, audience engagement and overall broadcast performance, which is important for optimizing the use of digital hosts and increasing viewer satisfaction.

A number of studies have proven a significant difference between the perception of online broadcasts with and without a presenter in the frame. In a study by J. Chen & J. Liao (2022), the authors indicated that on-screen presenters create a strong sense of social presence and interaction, which has a positive effect on viewers' perception and engagement. Viewers feel that their participation is crucial when the presenter actively interacts, responds to comments, and is visually present on screen. The presenter's appearance and charisma also play a pivotal role. A study by P. Schuck *et al*. (2022) showed that the attractiveness of the presenter increases the sense of social presence and the desire to continue watching the broadcast. Presenters who show emotion and actively interact with the audience help to create a tighter emotional and social contact, which increases viewer engagement. Broadcasts with an on-screen presenter often include interactive elements such as polls, games, and real-time reactions to comments, making the viewing experience more dynamic and engaging, helping to keep viewers' attention. A study by J. Lv *et al*. (2022) confirmed that having a presenter in the frame allows for emotional support, comfort and greater engagement with the content, which is relevant for creating long-term viewer commitment to a channel or platform. It also revealed that virtual hosts have a greater impact on perceptions of social presence compared to real hosts, which is related to viewers' interest in anime and virtual characters. At the same time, real hosts elicited a higher level of trust from viewers compared to virtual hosts.

The difference between the perception of a virtual person (avatar) and a real presenter has been investigated by many scholars. For example, in the articles by S. Park & R. Catrambone (2021), the authors indicate that virtual avatars with anthropomorphic features cause strong social reactions in viewers, can stimulate social interaction not only by using facial appearance, but also by using voice (here it is critical to note that synchronization of voice and facial movements leads to a stronger social reaction compared to using only voice or only face). In the article by Y. Zhang *et al*. (2023), the authors provide evidence for the positive impact of virtual presenters on viewer engagement (especially those that are AI-driven and can respond to viewers' actions in real-time). In the study by D. Kim & D. Jo (2022), the authors also point out that while real presenters are often perceived as more trustworthy and authentic (which increases viewer trust and emotional engagement), and their ability to demonstrate live reactions and empathy creates deeper emotional connections and viewer satisfaction, virtual presenters are quite capable of achieving a similar effect, especially if they are well animated and have natural human features (which reduces viewer cognitive stress). And at the same time, any problem with the avatar's realism causes an immediate reaction of discomfort, distrust and sometimes even fear (the uncanny valley effect) (Song & Shin, 2024).

A study by M. Gerlich (2023) showed that virtual hosts are perceived as more predictable and reliable compared to real people, as their behaviour can be programmed for better content control and audience interaction. They effectively increase viewer engagement and content satisfaction by responding quickly to user requests, creating a sense of live interaction. Virtual hosts can be tailored to the needs of specific audiences, personalizing messages. Hosts with high levels of animation and human-like characteristics promote social interaction and reduce the psychological distance between host and viewer.

Thus, the perception of virtual people by the audience of online broadcasts has been studied quite deeply, but quite often traditional metrics are used for measurements, which are not always suitable for such tasks in the context of the study of virtual avatars, or non-unified author's methods, which differ from study to study and do not provide a complete toolkit for assessing the quality and effectiveness of live broadcasts using digital technologies of virtual avatars (hosts).

The aim of this research was to develop new methods for assessing the quality and effectiveness of live broadcasts using digital people technologies. To achieve this, the following tasks were formulated: 1) analysing existing metrics for assessing the quality and effectiveness of live broadcasts; 2) developing an understanding of the main existing methods for assessing the quality and effectiveness of live broadcasts using digital human technologies; 3) identifying their limitations and areas for improvement when using digital human technologies; 4) developing innovative assessment methods that take into account the characteristics of digital avatars and virtual hosts; 5) formulating a new methodology for assessing the quality and effectiveness of live broadcasts using digital human technologies; 6) developing new methods for assessing the quality and effectiveness of live broadcasts using digital human technologies.

Materials and Methods

The research involved a detailed review of existing metrics and techniques used to assess the quality and

effectiveness of live-streaming. Aspects such as sense of community, emotional support, interactivity, social presence, attractiveness of the streamer and intention to watch were considered. Based on this analysis, a new methodology was developed, including the adaptation of existing scales and metrics for the specifics of virtual hosts. Such features as the specificity of emotions expressed by virtual avatars, broadcast quality, technical reproduction, realism of virtual streamers and others were taken into account. The evaluation methodology developed consisted of six blocks that included defining key parameters.

A video and audio technical quality assessment block was formulated according to the Absolute Category Rating (ACR) methodology (in which viewers watch a video and rate it on a Likert scale from 1 to 5, where 1 is the lowest score and 5 is the highest) and the methodology of comparing the evaluated streaming broadcast with a reference quality video and the viewer's Degradation Degree Rating (DCR) of the streaming broadcast on a five-point scale, which results in the calculation of an average score. The questionnaire consisted of twenty thematic questions focusing on the subjective perception of video, audio and their combination, and viewer evaluation.

A block of measurement evaluation and analysis of technical aspects and features of the platform on which the broadcast with a virtual host is conducted included fundamental monitoring of network performance, measurement of server performance, analysis of video and audio quality, testing of the broadcast on various devices and platforms, including mobile, latency and synchronization analysis, evaluation of user experience, logging and error analysis, and use of A/B testing. The measurement block was carried out by the experimenter without the involvement of respondents and involved the use of special tools (such as Google Analytics, Hotjar, UserTesting and so on).

Block for studying the types of viewers and their characteristics included questionnaire survey of respondents. For these purposes, a questionnaire consisting of 29 questions was used, as well as a five-question questionnaire to assess viewer self-efficacy, information overload, service overload, assessment of users' dependence on streams (platform, stream content), assessment of cognitive dissonance. A block for evaluating the virtual host itself, considering the full range of relevant parameters, consisting of a 65-question questionnaire, where a Likert scale from 1 to 5 is used to evaluate each parameter. A unit for evaluating viewers' interaction with the host while watching a broadcast consisted of a 20-question questionnaire where a Likert scale from 1 to 5 is used to evaluate each parameter.

A unit for assessing the quality and effectiveness of content consisted of a 25-question questionnaire that uses a Likert scale of 1 to 5 to rate each parameter. Given the combination of the results of the application of all six blocks, the final result of the evaluation of the effectiveness and quality of live broadcasting using a virtual human (host) was calculated.

Results

Disadvantages of existing techniques

Evaluating the quality and effectiveness of live broadcasts is an important task, as such broadcasts have become an integral part of the media industry, education, and marketing. Existing evaluation methods range from simple metrics to sophisticated analytical tools, but each has its own limitations and challenges. The most common traditional evaluation methods include quantitative metrics such as number of views, viewing time, number of comments and likes. These provide a basic understanding of the popularity of the broadcast, but do not always reflect the true quality of the content and the level of audience engagement.

For example, the view count metric determines how many times a broadcast was launched, but does not take into account how much time each viewer spent watching and how closely they followed the content. The Watch Time metric shows the total time viewers spent watching, which is more informative but still does not provide a full understanding of audience engagement. Interaction metrics (comments, likes, reposts) can show viewers' reactions, but are easily manipulated and do not always reflect true opinion. They also do not separate comments from real people from bots and do not differentiate the number of comments from different people and doubles, which distorts the real statistics. With the development of AI and machine learning technologies, methods that analyse viewers' behaviour in real-time, including their emotional reactions and level of engagement, have emerged. These methods are more accurate in assessing content quality, but require significant computational resources and may face data privacy issues.

Significant limitations of current methods encompass:

- methodological limitations (traditional and advanced metrics do not take into account the qualitative aspects of interaction with content and do not show how useful or interesting it was);
- technical barriers (the use of AI and machine learning requires significant resources and high-quality data, difficult to implement and maintain);
- ethical and legal issues (collecting and analysing data on viewer behaviour can raise privacy and data protection concerns, especially with regard to the use of data from the Internet);
- technical barriers (the use of AI and machine learning requires significant resources and high-quality data, difficult to implement and maintain).

In addition, evaluation methods often do not take into account differences in internet use across regions and cultures, which can lead to misleading data and incorrect conclusions.

In order to better assess the quality and effectiveness of live broadcasts, it is necessary to consider not only quantitative but also qualitative aspects of audience interaction. The use of new technologies such as AI and machine learning opens up new opportunities for more accurate analyses, but also requires addressing a number of technical and ethical issues. There are also author's versions of assessing the quality and effectiveness of live broadcasts, including those carried out by a virtual avatar.

For example, the study by J. Chen & J. Liao (2022) analyses social presence, defined as the experience and feeling that arise in live-streaming through the interaction between viewers and streamers based on emotions and community atmosphere. The study confirmed that the level of social presence affects the number of views, interactions and viewer engagement, considering the role of streamer attractiveness. A survey of 386 viewers used the metrics of sense of community (Sjöblom & Hamari, 2017), emotional support, interactivity (Chen & Lin, 2018), social presence (Gefen & Straub, 2004), streamer attractiveness and intention to watch based on a Likert scale (1 to 5). Data were analysed using structural equation model (SEM) and partial least squares method (PLS-SEM), with reliability and validity checks (Cronbach's α and CR). Streamer attractiveness evaluation took into account external and behavioural factors, applicable also to virtual hosts with their visual and voice characteristics. Aspects of moderation analysis from the study may help to formulate criteria for analysing the differences between virtual and real hosts.

However, the study is limited because it was conducted on real streamers, which makes it difficult to transfer the results to virtual hosts, requiring adaptation of the scales. Perceptual subjectivity is also relevant, as metrics such as emotional support and attractiveness can vary. No consideration has been given to the characteristics of emotion expression by virtual avatars, broadcast quality, realism of the virtual streamer, and the presence of the "uncanny valley" effect. There are no methods to measure and analyse the technical aspects and features of the platform on which the broadcast with the virtual host takes place. The use of questionnaires and self-reports may lead to bias in the data regarding virtual hosts.

Studies of viewer types, such as the study by P. Schuck *et al.* (2022), show that viewer characteristics strongly influence the evaluation of broadcasts by virtual avatars. The viewers were divided into groups: System Alterer (SA), Financial Sponsor (FS), Content Observer (CO), Streamer-focused Observer (SO) and Social Player (SP), each influencing the selection and evaluation of streams. The methodology, based on questionnaire, exploratory and confirmatory factor analysis and SEM, analyses different aspects of viewers' interaction with streamers. This questionnaire can be adapted for virtual hosts. Minuses of the study include the limited application of results based on real streamers to virtual hosts. Metrics of emotional support and likeability can be subjective and culturally skewed, causing bias. Important technical aspects for virtual hosts, such as visual and voice characteristics, are not taken into account. The realism of the virtual streamer requires further research and adaptation of the methodology. Thus, the proposed methodology requires adaptation for application to streamers with virtual hosts.

In the article by H.-C. Chen *et al.* (2022), the authors present a methodology for assessing viewers' visual behaviour during Facebook Live broadcasts using eye movement tracking technology to analyse consumers' perception and behaviour on e-commerce platforms. The study focuses on four eye movement metrics: first fixation latency, first fixation duration, total fixation duration and number of fixations. These metrics allow to assess the distribution of visual attention and participants' behaviour in different regions of interest (ROIs) while watching the broadcasts.

Data analysis showed that men and women exhibit different patterns of visual behaviour. Men first fix their attention on the product brand (ROI3), while women first focus on the presenter of the broadcast (ROI1). Men fix their attention on the product itself for the longest time (ROI2), while women fix their attention on the product brand (ROI3). Both genders pay the most attention to the product (ROI2) and the presenter (ROI1). This confirms the importance of these areas to viewers. In addition, the presenter of the broadcast has been shown to be a significant factor influencing the attention and perception of the audience.

Continuing the theme of assessing spectator behaviour, it is worth noting the study by S. Zhang and Y. Pan (2023), which analysed the factors influencing users' intentions to stop using pan-entertainment mobile platforms for live broadcasts. The authors found that information overload, service overload, and user dependency have a positive effect on cognitive dissonance, leading to intentions to stop using the platform, while self-sufficiency reduces the impact of cognitive dissonance. Although this study does not fulfil the objectives of this analysis, it is important to consider cognitive and affective mechanisms when developing a model for assessing the quality and effectiveness of streaming with virtual hosts.

The development of the virtual people evaluation methodology was based on a number of studies that examined the influence of virtual Influencers on consumer behaviour and attitudes towards brands, trust, purchase intention and preferences between virtual and real Influencers (Gerlich, 2023). It has been investigated how the human traits of virtual characters influence users' social responses (Park & Catrambone, 2021), and the impact of the realism and believability of virtual avatars on consumers' perceptions and trust (Andersson & Sobek, 2020). The difference in audience perceptions of virtual presenters driven by "assisted" and "controlled" AI-human interaction was studied, as well as the influence of "playfulness" and "humour" elements. These

studies have shown that virtual influencers have a significant impact on consumer behaviour and preferences. Consumers trust virtual influencers more than real ones due to the lack of personal interests and the possibility of brands having full control over their behaviour. Virtual Influencers evoke strong parasocial relationships, which enhances trust and engagement. Attractive features of virtual hosts include lack of physical ageing, stability of visual appeal, ability to work without interruption, and lack of scandal.

It has also been found that virtual people can elicit social reactions similar to real people if they possess enough human features. A combination of facial expressions and voices elicits stronger social reactions than either face alone or voice alone. Perceptions of authenticity depend on the realism of appearance, behaviour and audience interaction, although high levels of realism can both increase and decrease perceptions of authenticity depending on context and consumer expectations. Participants with experience in games and virtual worlds perceive realistic virtual influencers favourably compared to those with less experience.

Virtual presenters driven by "assisted" AI-human interaction have also been found to promote higher levels of audience perception and engagement compared to "controlled" AI-human interaction, but elements of "playfulness" and "humour" can mitigate this difference. The types and intensity of parasocial relationships between virtual humans and audiences also have a significant impact on the effectiveness of using such leading broadcasts (Brown, 2020). This paper is complemented by techniques for evaluating the effectiveness of virtual influencers from the work of E. Moustakas *et al.* (2020), which include expert interviews with digital media specialists, emphasizing the success of the marketing strategy and the appropriateness of the virtual host personality selection.

Studies on the influence of information quality and interaction on the intention of customers to purchase deserve special mention (Zhang *et al.*, 2021). They showed that the quality of information, expressed in terms of credibility, vividness and usefulness, is directly related to audience behaviour and response, as is the quality of interaction with the virtual influencer (measured by responsiveness, empathy and real-time interaction). This study highlights that when evaluating the effectiveness of live-streaming, not only the quality of the streamer and the realism of the virtual host, but also the information it broadcasts should be considered.

In addition, this study has already mentioned the importance of considering technical and mechanical factors that influence the evaluation of the quality and effectiveness of live broadcasting using virtual hosts. This primarily concerns audio and video quality, which can significantly affect the audience's perception of the image and the realism of the virtual host image. There are many studies aimed at investigating this parameter. The paper investigates audio and video (A/V) quality and uses the LIVE-SJTU (A/V-QA) database of 336 A/V sequences to study the perception of the combined quality of A/V signals (Min *et al.*, 2020). Video and audio content quality assessment methods have also been applied in a study, where the 60 most relevant statistical features are identified out of 763 statistical features for streaming video quality assessment, based on which the VIDEVAL model is created. VIDEVAL provides high performance at low computational cost, suitable for user video quality assessment (Tu *et al.*, 2021). The book by S. Akramullah (2014) discusses objective and subjective metrics for video quality assessment, including peak signal-to-noise ratio and modified peak signal-to-noise ratio, and scores from a group of viewers. The latter metric is the most adaptive and suitable for evaluating the quality and effectiveness of live broadcasts with virtual humans, allowing the most accurate match to the perception by human vision and intertwined with other metrics. Thus, based on the above-described methods, authors can conditionally distinguish several most essential blocks of evaluation of live broadcasts with virtual influencers or hosts.

Proposed estimation methodology

The first block should include an assessment of the technical quality of the video-audio signal, as this component can very much affect the perception of any content of any presenter (organic and virtual). Based on the research data of S. Akramullah (2014), X. Min *et al.* (2020) and Z. Tu *et al.* (2021) this block can be implemented using: ACR method, where viewers watch a video and rate it on a scale from 1 to 5, where: 5 is excellent and 1 is very bad; a method of comparing the evaluated streaming broadcast with a reference quality video and the viewer DCR of the streaming broadcast on a five-point scale, where 5 is imperceptible degradation, 4 is perceived but not annoying degradation, 3 is slightly annoying degradation, 2 is annoying degradation, and 1 is very annoying degradation. As a result, the mean average score (*MOS*) is calculated using the formula (1):

$$MOS = \frac{nACR+nDCR}{n}, \quad (1)$$

where n – number of viewers (ratings).

The assessment should also be accompanied by a test-type questionnaire with 20 questions (Table 1).

Table 1. Video and audio quality assessment questionnaire

No.	Parameter	Question
1	Overall clarity	How crisp and detailed does the video look?
2	Colour accuracy	How natural and realistic do the colours look?

Continued Table 1.

No.	Parameter	Question
3	Smoothness of movement	How smooth does the motion look in the video?
4	Noise and interference in video	How noticeable is noise and interference in the image?
5	Edge sharpness	How sharp do the edges of the objects in the video look?
6	Compression artefacts	How noticeable are compression artefacts (e.g., blocks, bars)?
7	Contrast	How well are the dark and light areas distinguishable?
8	Brightness	How properly adjusted is the video brightness?
9	Image stability	How stable is the image, with no jitter or distortion?
10	Sound clarity	How clear and intelligible is the sound?
11	Volume	How optimally adjusted is the sound volume?
12	Noise and interference in audio	How noticeable is noise and interference in audio?
13	Sound balance	How well balanced are the volume levels between the different sound elements (voice, music, effects)?
14	Bass clarity	How clean and pleasant do the bass frequencies sound?
15	High frequency clarity	How clean and pleasant do the high frequencies sound?
16	Echo and reverberation	How noticeable are echo and reverberation, if present?
17	Synchronizing sound and video	How well synchronized are the sound and picture?
18	Dynamic range	How well are soft and loud sounds transmitted?
19	Overall perception of the audiovisual combination	How harmonious are the audio and video as a whole?
20	Emotional perception	How enjoyable and comfortable do you find watching videos in general?

Source: created by the authors

The parameter calculation methodology and interpretation of the results involves calculating the arithmetic mean of the scores received for each question from all participants (Table 2).

Table 2. Interpretation of results

Number of points	Significance	Deciphering
1-1.9	Very low quality	Video (audio) has serious flaws that make them virtually unusable for comfortable viewing or listening
2-2.9	Low quality	Video (audio) has notable problems that significantly affect perception
3-3.9	Average quality	Video (audio) has some disadvantages, but they are not critical and are acceptable to most viewers
4-4.5	Good quality	Video (audio) of high quality with minor imperfections that do not greatly affect the perception
4.6-5	Excellent quality	Video (audio) has minimal or no imperfections, providing an excellent viewing or listening experience and comfort

Source: created by the authors

The calculation steps involve collecting data, calculating the average value for each parameter using formula (2):

$$\text{Average score} = \frac{\sum \text{estimates}}{\text{number of participants}}. \quad (2)$$

The second block, which does not require the involvement of test subjects (stream viewers), should be the block of measurement evaluation and analysis of the technical aspects and features of the platform on which the broadcast with the virtual host takes place. These methods will help to assess the performance, stability, and quality of the broadcast, and identify potential bottlenecks and areas for improvement. The methods of measurement and analysis may be as follows:

1. Network performance monitoring. Measured parameters: latency, packet loss, bandwidth, jitter. Measurement tools: Wireshark, PingPlotter, NetFlow analysers. Monitoring these parameters can identify network problems affecting broadcast quality.

2. Measuring server performance. Measured parameters: central processing unit usage, random access memory usage, disk I/O activity, network I/O. Tools: Prometheus, Grafana, Zabbix, Nagios. Monitoring of server resources will allow you to determine whether the capacity is sufficient for video processing and broadcasting.

3. Analysing video and audio quality. Measured parameters: resolution, frame rate, bitrate, compression level, audio quality. Tools: FFmpeg, Video Multi-Method Assessment Fusion, PESQ (Perceptual Evaluation of Speech Quality).

4. Testing on various devices and platforms. Parameters measured: compatibility, performance, display quality. Tools: BrowserStack, Sauce Labs, real devices.

5. Latency and synchronization analysis. Measured parameters: streaming latency, audio-video sync. Tools: OBS Studio, Streamlabs, specialized scripts and tools for latency measurement. Measuring latency and checking audio-video sync will help to determine how smooth and synchronized the experience is for the viewers of such a broadcast.

6. User experience evaluation. Parameters measured: load time, user interface/user experience design, stability (crash reports). Tools: Google Analytics, Hotjar, UserTesting. Negative user experience can significantly distort the subjective perception of the quality of the stream as a whole and even affect the evaluation of the attractiveness of the virtual host.

7. Logging and error analysis. Measured parameters: error rate, error types, root cause analysis. Tools: Elasticsearch, Logstash, Kibana Stack, Sentry, Splunk. Collecting and analysing logs will help to identify errors affecting the broadcast quality.

8. Use of A/B testing. Measurable parameters: engagement, retention, conversion rate. Tools: Google Optimise, Optimizely, VWO. In this case, the specifics of broadcasts on a particular platform are meant, not the general evaluation of the stream or its host.

The third block of the methodology is aimed at studying the types of viewers, since the studies cited above clearly indicate the relationship between the type of viewer (Nasir, 2015), its characteristics, preferences and stereotypes (Chiou *et al*., 2020), and the manifestation of the effectiveness of live broadcasting, the assessment of its quality by the audience.

This block is intended to record the gender of the viewer (gender self-identification), the presence or absence of previous experience of the audience with games and virtual worlds, the presence of prejudices and cultural or religious peculiarities of perception of virtual people. The questionnaire will also include 25 statements to categorize viewers into the five categories proposed in the work of P. Schuck *et al*. (2022). Thus, the questionnaire will have the following form (Table 3).

Table 3. Questionnaire to determine the type of viewer

Type of viewer	Assertion (question)	Answers
SA	I would like to change what the streamer is showing in the stream	Yes/No
	I would like to change the parts of the game the streamer plays during the stream	
	I like influencing what happens in the game, not just watching	
	I like influencing what happens in the game to support the streamer	
	I like influencing what happens in the game to interfere with the streamer	
FS	I would like to financially support my favourite streamer	
	I financially support the streamer to help maintain good quality content on the stream	
	I donate money to the streamer to show my support	
	I can imagine donating money to streamers	
	I believe that viewers should support streamers whose content they particularly value	
CO	I like watching the game the streamer is broadcasting without the distraction of other viewers	
	I don't like interacting with others in a streamer	
	I'm more interested in what's going on in the broadcast game than I am in interacting with other viewers	
	I'm more interested in what's going on in the game being streamed than I am in interacting with the streamer	
	I don't like it when other viewers distract a streamer	
SO	As a viewer, I care more about the streamer than the game being broadcast	
	I think the streamer is the most important part of the stream	
	I'm interested in learning more about the streamer	
	I prefer to learn more about the current game situation than the streamer	
	I love it when a streamer shares personal stories or experiences	
SP	I love the contests that the streamer carries out	
	I'd like to unlock achievements in the streamer	
	I like collecting rewards while streaming	
	I would like streamers to show/use items (e.g., images, sounds, creations) sent by viewers in the stream	
	I think viewers who watch a lot of streaming should have access to more features in streaming	

Continued Table 3.

Type of viewer	Assertion (question)	Answers
	Your sex (gender self-identification)	
	Your age	
	Do you have experience with games and virtual worlds?	Yes/No
	Do you have prejudices and cultural or religious perceptions of virtual people?	Yes (positive) Yes (negative) No

Source: created by the authors

Dividing viewers into different categories helps to more accurately assess the quality and effectiveness of the stream by understanding the specific needs and preferences of each group. In terms of evaluating the target content, attention should be paid to the scores of SA and CO. SA want to influence the game or stream, so their satisfaction indicates the level of interactivity and the ability to modify content. CO are interested in the gameplay, and their satisfaction indicates the quality and interest of the game, as well as minimal distractions. To assess financial support, consider the performance of FS – viewers who are willing to donate money to the streamer. Measuring their satisfaction helps to understand whether streamers are successfully monetizing their activities. A high level of support from FS indicates that viewers value the content and consider it to be of high quality. In terms of interaction with the streamer, it is worth considering the ratings of SO – viewers who are interested in the personality of the streamer. Their satisfaction helps to assess how successful the streamer is in establishing a personal contact with the audience, how charismatic and interesting he is. Also, relevant are the responses of SP – viewers oriented towards social interactions. Their satisfaction can indicate the effectiveness of introducing game mechanics and social elements in the streamers.

An essential aspect of improving quality and customization is collecting feedback. Feedback and ratings from each category of viewers will help streamers and platforms understand which aspects of the streams need to be improved. For example, dissatisfaction with SA may indicate a lack of interactivity in the stream. This block can also include a pool of questions related to viewers' self-efficacy and parameters such as information overload, service overload and user dependency, and cognitive dissonance.

The methodology for assessing self-efficacy is to evaluate the user's level of confidence in their ability to cope with technological challenges and manage their use of the platform. Questions to assess self-efficacy:

A. How confident are you that you can effectively use all the features of the streaming platform?

B. How confident are you that you can control your time spent watching streams?

C. How easy is it for you to learn new features and tools on the platform to improve your streaming experience?

D. How confident are you that you will be able to solve any technical problems that arise while watching streams?

E. How confident are you that you will be able to successfully interact with other viewers and the streamer during the stream?

The evaluation is done using Likert scale (1 to 5). The result is presented in Table 4.

Table 4. Decoding of self-efficacy results on a five-point scale

Score	Result	Significance
1-1.9	Very low self-efficacy	The viewer lacks confidence in their ability to use the streaming platform effectively, has significant difficulty using its features and dealing with technical issues, and may need additional support and training.
2-2.9	Low self-efficacy	The viewer has difficulty using the platform but can sometimes manage basic tasks. Mastering new features is stressful and solving technical problems is time-consuming, so he or she may need occasional help and support.
3-3.9	Average self-efficacy	The viewer is relatively confident in their ability to use the platform to watch streams, can learn the basic features and solve most technical problems with some effort, needing support only for complex tasks.
4-4.5	High self-efficacy	The viewer is confident in their ability to use the platform and manage their time, easily learning new features and successfully solving technical problems, rarely needing help or support.
4.6-5	Very high self-efficacy	The viewer is fully confident in their ability to use the streaming platform effectively, easily learns any new features, and quickly solves technical problems. They are able to achieve their streaming goals on their own and need little or no help.

Source: created by the authors

Formula (3) is used to calculate the result (3):

$$\text{Average score} = \frac{\sum \text{estimates}}{\text{number of questions}}. \quad (3)$$

Techniques for assessing information overload include assessing the amount of information a user receives and their ability to process that information. Questions to assess information overload:

A. How often do you feel you receive too much information on this platform?

B. How difficult is it for you to process all the incoming data and messages?

C. How often do you feel tired or stressed by the amount of information on the platform?

D. How difficult is it for you to filter crucial information among all the content on the platform?

E. How often do you have to spend a lot of time processing information in order not to miss something important?

The evaluation is done using Likert scale (1 to 5). The result is presented in Table 5. Formula (3) is used to calculate the result.

Table 5. Deciphering the results of information overload on a five-point scale

Score	Result	Significance
1-1.9	Very low overload	The user feels virtually no information overload. Easily processes incoming information and messages
2-2.9	Low overload	The user sometimes feels some information overload, but generally copes with the amount of information. Data processing requires moderate effort
3-3.9	Average overload	The user often feels information overload and has difficulty processing large amounts of information. It takes considerable time and effort to filter and process data
4-4.5	High overload	The user often feels a strong information overload. Processing information causes stress and fatigue, and is time-consuming
4.6-5	Very high overload	The user is constantly experiencing severe information overload. Information processing becomes almost impossible without considerable effort and stress

Source: created by the authors

The methodology for assessing service overload is to evaluate the number of features and services offered by the platform and their impact on the user. Questions to assess service overload:

A. How often do you feel that platform features are redundant or unnecessary?

B. How difficult is it for you to make sense of all the features and services available?

C. How often do you feel the platform offers too many options that you don't need?

D. How confused are you about using the various features and services of the platform?

E. How often do you have difficulty finding the right function among the many available?

The evaluation is done using Likert scale (1 to 5). The result is presented in Table 6. Formula (3) is used to calculate the result.

The methodology of user dependency evaluation is to assess the level of user dependency on the platform and the user's dependency behaviour. Questions to assess user dependency:

A. How often do you feel the need to use the platform, even when it interferes with other activities?

B. How strongly do you feel that you cannot stop using the platform?

C. How often do you neglect other important activities to use the platform?

D. How much irritation or anxiety do you feel when you cannot use the platform?

E. How often do you lose track of the time you spend on the platform?

The evaluation is done using Likert scale (1 to 5). The result is presented in Table 7. Formula 3 is used to calculate the result.

Table 6. Deciphering the results of service overload on a five-point scale

Score	Result	Significance
1-1.9	Very low overload	The user practically does not feel overloaded with services. It is easy to understand all the functions and services of the platform.
2-2.9	Low overload	The user sometimes feels a bit overwhelmed by the services, but generally copes with the number of functions. It takes moderate effort to understand the functions and services.
3-3.9	Average overload	The user often feels overwhelmed by the services and has difficulty using numerous functions. It takes considerable time and effort to understand and utilize all available options.
4-4.5	High overload	The user often feels a strong overload of services. Using functions and services is stressful and time-consuming to master.
4.6-5	Very high overload	The user is constantly experiencing severe service overload. It becomes almost impossible to use the functions without considerable effort and stress.

Source: created by the authors

Table 7. Decoding of user dependency results on a five-point scale

Score	Result	Significance
1-1.9	Very low dependence	User has little or no dependence on the platform (streams). The user easily controls his/her usage and does not experience negative emotions in case of lack of access.
2-2.9	Low dependence	The user sometimes has a weak dependence on streams (platform), but is generally able to control his/her usage. Rarely neglects other activities for the sake of using the platform (watching streams).
3-3.9	Average dependence	User often feels dependent on streaming (platform) and has difficulty trying to reduce usage (viewing) time. May neglect essential tasks and feel irritated when not having access.
4-4.5	High dependence	The user is often highly dependent on streams (platform). Regularly neglects important tasks and experiences severe irritation or anxiety when unable to use the platform (watch streams).
4.6-5	Very high dependence	The user is constantly highly dependent on streams (platform). Unable to control his/her usage, which significantly interferes with other aspects of life and causes severe anxiety when not accessing streams.

Source: created by the authors

The methodology for assessing cognitive dissonance is to evaluate the level of psychological discomfort caused by the user's conflicting thoughts and actions. Questions to assess cognitive dissonance:

A. How often do you feel uncomfortable or annoyed by the use of the platform?

B. How often do you feel that using the platform conflicts with your personal or professional values?

C. How often do you find yourself thinking that you spend too much time on the platform?

D. How often do you feel that using the platform interferes with your core responsibilities and goals?

E. How often do you feel guilty after using the platform for a long time?

The evaluation is done using Likert scale (1 to 5). The result is presented in Table 8.

Table 8. Deciphering the results of the cognitive dissonance assessment on a five-point scale

Score	Result	Significance
1-1.9	Very low dissonance	There is little or no psychological discomfort for the user to use the platform and watch streams, feeling that it aligns with their values and goals.
2-2.9	Low dissonance	The user sometimes experiences slight psychological discomfort, but in general considers that the use of the platform (watching streams) does not contradict their values and goals. Rarely thinks about negative consequences of using the platform, watching streams.
3-3.9	Average dissonance	The user often feels psychologically uncomfortable and thinks that using the platform and watching streams may conflict with their values and goals. Feels irritated or guilty after prolonged or frequent use of the platform and watching streams.
4-4.5	High dissonance	The user often feels a strong psychological discomfort with using the platform and watching streams. Regularly thinks about the fact that it interferes with his/her main duties and goals and feels guilty.
4.6-5	Very high dissonance	The user is constantly experiencing strong psychological discomfort with using the platform and watching streams. Believes that it significantly conflicts with his/her personal or professional values and interferes with the fulfilment of basic duties and goals.

Source: created by the authors

The data is analysed in stages. Data is collected through online surveys of platform users using a Likert scale (1 to 5). Next, statistical analysis is performed using SEM to examine the relationships between variables. Data reliability and validity are tested through factor analysis and internal consistency assessment (Cronbach's α and Composite Reliability). A moderating analysis is then conducted to investigate the effect of self-efficacy on the relationship between information overload, service overload, user dependency and cognitive dissonance. The data are categorized into groups according to levels of self-efficacy, and differences in the impact on cognitive dissonance are analysed.

Information overload, service overload, reliance on streaming and cognitive dissonance can significantly affect viewers' perception and evaluation of live-streaming. These factors can both positively and negatively impact viewers' overall experience. For example, when receiving too much information, viewers may have difficulty processing it, leading to fatigue and irritation, reducing the ability to focus on key points of the stream and impairing the overall content experience. An

excessive number of features and services can confuse and distract viewers from the main content, causing frustration and reducing stream satisfaction. Streaming addiction can cause feelings of guilt and anxiety, especially if the viewer neglects critical activities for the sake of watching, reducing overall satisfaction and causing cognitive dissonance. Cognitive dissonance, in turn, causes feelings of dissatisfaction and internal conflict, especially if the stream content contradicts the viewer's personal values, which reduces trust in the virtual host and leads to negative evaluation of the stream.

The fourth block of evaluation concerns the virtual host itself. A methodology is proposed for a comprehensive evaluation of virtual hosts, including the following key dimensions: sense of community, emotional support, interactivity, social presence, attractiveness, intention to watch, trust, perception of information, level of expertise, realism, visual authenticity, consistency of behaviour and emotional expressiveness. The evaluation is conducted using online viewer surveys based on a questionnaire using a Likert scale (1 to 5) (Table 9).

Table 9. Virtual host evaluation questionnaire

No.	Question	Response
	Sense of community	
1	How much do you feel part of the community while watching a stream with a virtual host?	1 – no feeling at all, 5 – maximum feeling
2	How important is it to you to be part of the community of viewers of this stream?	1 – not important, 5 – very important
3	How often do you interact with other viewers during the stream?	1 – I don't communicate at all, 5 – I communicate all the time
4	How much support do you feel from other stream viewers?	1 – I don't feel it at all, 5 – I feel it all the time
5	How interested are you in participating in discussions related to streaming?	1 – not interested at all, 5 – very interested
	Emotional support	
6	How much support do you feel from the virtual host while streaming?	1 – I don't feel it at all, 5 – I feel it all the time
7	How much does a virtual host make you feel better?	1 – not at all, 5 – quite strong
8	How often do you turn to your virtual host for emotional support?	1 – do not apply at all, 5 – constantly apply
9	How important is it to you for a virtual host to be emotionally responsive?	1 – not important, 5 – very important
10	How much does a virtual host help you cope?	1 – not at all, 5 – quite significantly
	Interactivity	
11	How often do you interact with the virtual host while streaming?	1 – do not interact at all, 5 – interact constantly
12	How satisfied are you with the level of interactivity of the virtual host?	1 – not satisfied, 5 – completely satisfied
13	How interested are you in participating in the interactive elements of the stream (polls, games, etc.)?	1 – not interested, 5 – very interested
14	How responsive is the virtual host to your comments and questions?	1 – does not react in any way, 5 – actively reacts
15	How important is it to you for a virtual host to be interactive?	1 – not important, 5 – very important
	Social presence	
16	To what extent do you feel the presence of the virtual host as if they were a real person?	1 – I don't feel it, 5 – I feel it strongly
17	How much does a virtual host make streaming more personal and social?	1 – not at all, 5 – very much
18	How comfortable are you with interacting with the virtual host?	1 – not at all, 5 – very much
19	How much does a virtual host contribute to a friendly atmosphere on the streamer?	1 – not at all, 5 – very much
20	To what extent do you feel that the virtual host is really in the same space as you?	1 – not at all, 5 – very much
	Streamer attractiveness	
21	How attractive do you find the virtual host?	1 – not at all, 5 – very attractive
22	How much does a virtual host get your attention?	1 – not at all, 5 – very much
23	How important is the appearance of the virtual host to you?	1 – not at all, 5 – very much
24	How much does the appearance of a virtual host affect your desire to watch a stream?	1 – not at all, 5 – very much
25	How pretty do you find the virtual host?	1 – not at all, 5 – very pretty

Continued Table 9.

No.	Question	Response
	Intention to watch	
26	How likely are you to watch streams with this virtual host in the future?	1 – I won't, 5 – I will definitely do it
27	How interested are you in continuing to watch streams with this virtual host?	1 – not interested, 5 – very interested
28	How much do you like the content that the virtual host provides?	1 – don't like it at all, 5 – like it a lot
29	How much are you looking forward to new streams with this virtual host?	1 – not looking forward to it, 5 – very much looking forward to it
30	To what extent would you recommend this stream to others?	1 – would not recommend, 5 – would highly recommend
	Trust	
31	How much do you trust the information provided by the virtual host?	1 – I don't trust at all, 5 – I trust very much
32	How reliable do you consider the virtual host to be?	1 – I consider unreliable, 5 – I consider very reliable
33	How trustworthy is the virtual host to you?	1 – not trustworthy, 5 – totally trustworthy
34	How confident are you in the integrity of the virtual host?	1 – not confident, 5 – completely confident
35	How important is it for you to trust the virtual host?	1 – not important, 5 – very important
	Information perception	
36	How relevant is the information from the virtual host to your interests and lifestyle?	1 – not at all relevant, 5 – completely relevant
37	To what extent does the virtual host provide reliable information?	1 – its information is unreliable, 5 – its information is completely reliable
38	To what extent do you find the information from the virtual host useful?	1 – it's useless, 5 – it's very useful
39	How well does the information from the virtual host match your expectations?	1 – does not comply at all, 5 – fully complies
40	How important is it to you to get quality information from a virtual host?	1 – not important, 5 – very important
	Expertise level	
41	To what extent do you consider the virtual host to be an expert in the area in question?	1 – I do not consider, 5 – I consider a qualified expert
42	How competent is the virtual host in the information provided?	1 – not at all competent, 5 – very competent
43	To what extent does the virtual host demonstrate in-depth knowledge of their field?	1 – does not demonstrate, 5 – demonstrates profound knowledge
44	How much do you trust the virtual host's judgement on professional matters?	1 – I don't trust, 5 – I completely trust
45	How much does a virtual host help you better understand the topic at hand?	1 – not at all, 5 – very helpful
	Realism	
46	How realistic do you find the appearance of the virtual host?	1 – unrealistic, 5 – very realistic
47	To what extent does the virtual host look and act like a real person?	1 – no resemblance at all, 5 – very humanoid.
48	How important is virtual host realism to you?	1 – not important, 5 – very important
49	How well does the virtual host match your perceptions of reality?	1 – does not comply at all, 5 – fully complies
50	How believable is the virtual host in its actions and expressions?	1 – not at all believable, 5 – completely believable
	Visual authenticity	
51	How plausible are the facial and body features of the virtual host?	1 – not at all plausible, 5 – completely plausible
52	To what extent are the virtual host's appearance and behaviour consistent with its personality and history?	1 –not consistent in any way, 5 – absolutely consistent

Continued Table 9.

No.	Question	Response
Visual authenticity		
53	How natural does a virtual host look in different situations?	1 – unnatural, 5 – completely natural.
54	How realistic are the textures and lighting of the virtual host?	1 – not realistic at all, 5 – very realistic
55	To what extent does the appearance of the virtual host evoke a sense of authenticity?	1 – does not evoke, 5 – evokes
Behavioural sequence		
56	How consistently does the virtual host behave across platforms?	1 – inconsistently, 5 – completely consistently
57	How transparent and clear are the actions of the virtual host?	1 – non-transparent, 5 – completely transparent
58	How often does a virtual host change its behaviour without explanation?	1 – very often, 5 – rarely
59	How predictable is the virtual host in its actions?	1 – very predictable, 5 – not predictable at all
60	To what extent does the virtual host follow its established identity and history?	1 – does not follow, 5 – follow
Emotional expressiveness		
61	How emotionally expressive is the virtual host?	1 – not emotional, 5 – emotional
62	To what extent does the virtual host convey emotions and feelings?	1 – not plausibly, 5 – very plausibly
63	How important is it to you that the virtual host expresses emotion?	1 – not important, 5 – very important
64	To what extent is a virtual host able to elicit an emotional response from you?	1 – not at all, 5 – fully able
65	How successful is the virtual host in using facial expressions and gestures to convey emotion?	1 – sparsely, 5 – fully

Source: created by the authors

For each parameter, the average score is calculated based on the respondents' answers. The average score for each parameter is calculated as the arithmetic mean of the scores for the corresponding questions. The interpretation of the results stipulates that 1-1.9 score means very low level, 2-2.9 low level, 3-3.9 medium level, 4-4.5 high level, 4.6-5 very high level. Using this methodology, it is possible to comprehensively assess viewer perception and satisfaction with various aspects of a virtual-hosted streamer. The results will help identify strengths and weaknesses in content and interaction, as well as identify areas for improvement. The fifth block of the evaluation is aimed at examining the interaction with the host. Interaction parameters measured: view count, average watch time, chat activity. Measurement tools: YouTube Analytics, Twitch Analytics, built-in analytical tools of the platforms. It also makes sense to assess the level and quality of parasocial interactions between the host and the audience. A questionnaire with questions aimed at measuring affective, cognitive and behavioural aspects of the interaction will be used. Each aspect will be rated on 5 questions using a Likert scale (from 1 to 5, where 1 is the lowest, negative rating and 5 is the highest, positive rating) (Table 10).

Table 10. Questionnaire for assessing interaction with the virtual host

No.	Question	Response
Interaction		
1	How often do you interact with content created by the virtual host?	
2	How much do you enjoy interacting with the virtual host?	
3	How often does the virtual host respond to your comments and questions?	
4	How important is it to you to be able to interact with a virtual host?	
5	To what extent does the virtual host encourage active viewer participation in the stream?	
Affective parasocial interactions		
6	How often do you feel emotionally connected to your virtual host?	
7	How much do you worry about the virtual host as you would a real person?	
8	How important is it to you to keep the virtual host happy?	
9	To what extent do you experience positive emotions when interacting with a virtual host?	
10	To what extent do you feel that the virtual host understands your emotions?	
Cognitive parasocial interactions		
11	How often do you think about virtual hosting outside of streaming?	

Continued Table 10.

No.	Question	Response
Cognitive parasocial interactions		
12	How interested are you in the information that the virtual host provides?	
13	To what extent do you feel that the virtual host shares your views and beliefs?	
14	How much does the virtual host influence your opinion on various issues?	
15	To what extent do you consider the virtual host to be competent and informed?	
Behavioural parasocial interactions		
16	How often do you interact with the virtual host via comments or chats?	
17	How involved are you in events or activities organized by the virtual host?	
18	How often do you share your virtual host's content with friends or on social media?	
19	How keen are you to support the virtual host (e.g., through donations or subscriptions)?	
20	How often do you mimic or follow the recommendations of a virtual host in your daily life?	

Source: created by the authors

The results require calculating the mean score for each of the three aspects of parasocial interactions (affective, cognitive, behavioural). The mean score for each aspect is calculated as the arithmetic mean of the scores for the respective questions. According to the scores obtained, the score can be interpreted as very low level of interaction (1-1.9), low level (2-2.9), medium level (3-3.9), high level (4-4.5) and very high level of interaction (4.6-5).

A low level of interaction between the host and viewers indicates low interaction efficiency (e.g., viewers' questions and comments go unanswered). This can lead to lower overall satisfaction with the stream, lower audience engagement, fewer viewers and donations, loss of loyalty, and lower likelihood of viewers returning. Low affective parasocial interactions means that viewers do not feel emotionally connected to the virtual host. This can manifest as less viewer attachment and loyalty, lower levels of engagement and participation in the stream, faster loss of interest and switching to another stream. Low levels of cognitive parasocial interactions indicate that viewers do not feel that the virtual host shares their interests and beliefs, or the host does not meaningfully influence them. This can lead to reduced intellectual engagement and interest in the content, a lack of perception of the host as an authoritative source of information, and a reduced likelihood that viewers will follow the host's recommendations and advice. Low levels of behavioural parasocial interactions means that viewers do not actively engage with the virtual host through comments, donations or other forms of participation, nor do they seek to support the host or participate in its events. This can lead to a decrease in audience activity and engagement, a decrease in the number of interactions (comments, donations), which affects the financial support of the stream, and a decrease in the overall atmosphere and energy of the stream.

Low levels of parasocial interactions indicate a need for improvement in the approach to virtual host streaming. Analysing the reasons for low performance and implementing recommended improvements will help increase audience engagement, satisfaction, and loyalty.

The sixth block is aimed at assessing the quality and effectiveness of the content of a virtual host stream. In order to comprehensively assess the quality and effectiveness of the virtual host stream content, a methodology is proposed that includes the following key parameters: content relevance, informativeness, entertainment value, interactivity, and viewer engagement. Each aspect will be evaluated on 5 questions using a Likert scale (from 1 to 5, where 1 is the lowest, negative score and 5 is the highest, positive score) (Table 11).

Table 11. Questionnaire for assessing content quality

No.	Questions	Answers
Content relevance		
1	How well does the content of the stream meet your expectations?	
2	How much of the stream's content is relevant to your interests?	
3	How relevant to you is the stream topic under discussion?	
4	How important to you is the content presented in the stream?	
5	How useful is stream content to your daily life?	
Informativeness		
6	How useful was the information provided?	
7	How in-depth were the topics discussed?	
8	How clear and understandable was the information presented?	

Continued Table 11.

No.	Questions	Answers
	Informativeness	
9	How much does a virtual host help you learn new things?	
10	How much do you trust the information provided by the virtual host?	
	Entertainment value	
11	How interesting was the content of the stream?	
12	How much did you enjoy your time on the streamer?	
13	How much does a virtual host make streaming fun and engaging?	
14	How much did you enjoy watching the stream?	
15	How interested are you in going back to stream this virtual host?	
	Interactivity	
16	How often do you interact with the virtual host while streaming?	
17	How responsive is the virtual host to your comments and questions?	
18	How interested are you in participating in the interactive elements of the stream (polls, games, etc.)?	
19	How important is it to you that the stream be interactive?	
20	How satisfied are you with the level of interactivity on the streamer?	
	Audience engagement	
21	How involved were you in the stream?	
22	How actively did you interact with the content of the stream?	
23	How often did you comment or ask questions during the stream?	
24	How interested are you in participating in discussions related to streaming?	
25	How willing would you be to recommend this stream to others?	

Source: created by the authors

To obtain the result, the average score for each parameter will need to be calculated based on the respondents' answers. The average score for each parameter is calculated as the arithmetic mean of the scores for the corresponding questions. Interpretation of the results provides the possibility of obtaining a very low level of quality and efficiency (1-1.9), low level (2-2.9), medium level (3-3.9), high level (4-4.5) and very high level of quality and efficiency (4.6-5). In order to make an overall assessment of the quality and efficiency of live-streaming with a virtual host based on the data obtained, it is necessary to aggregate the results for each block into a single assessment. To do this, it is necessary to determine how relevant each block is to the overall assessment. For example, viewer self-efficacy may be more essential than technical quality. The weights can be set as a percentage of the overall score (100% total).

Calculated parameters: technical quality of the stream (results of the first block of evaluation); technical aspects and features of the platform on which the broadcast with the virtual host is conducted (results of the second block of evaluation); evaluation of the virtual host (results of the fourth block of evaluation), calculated taking into account the indicators of the third block of evaluation (types of viewers, their preferences, peculiarities of their perception and the presence of factors that distort the evaluation, such as, for example, information overload, the presence of negative stereotypes about virtual people, etc.). Once all items have been given a weight, it is worth calculating the weighted scores for each block (to do this, the average score of each block is multiplied by the corresponding weight) and adding up all the weighted scores to get a total score. Interpretation of the overall score includes the possibility of very low quality and efficiency (1-1.9), low quality and efficiency (2-2.9), medium quality and efficiency (3-3.9), high quality and efficiency (4-4.5), and very high quality and efficiency (4.6-5). In this way, it is possible not only to calculate the quality and efficiency of the stream, but also identify the most problematic aspects that affect this indicator.

Discussion

The material analysed in this study showed numerous relationships between the effectiveness of live broadcasting and various parameters. The research conducted within the framework of this article confirms the conclusions given in the article by A.A. Laghari *et al.* (2023) regarding the fact that technological aspects of video broadcasting (such as video streaming, 2D and 3D formats, the use of certain protocols for streaming, certain video compression technologies, and so on) can have a significant impact on the overall perception and evaluation of the stream by viewers. The same opinion is held by U. Sharma *et al.* (2024), who empirically proved a direct correlation between the quality and progressiveness of broadcasting technologies and viewers' satisfaction (by 20%), their desire to watch the whole stream from beginning to end (by 32%) and their desire to participate as a viewer in the next stream of the same host (by 17%). These points have been taken into account when compiling the methodology for assessing the effectiveness and quality of live-streaming using virtual streaming.

This study also revealed a direct relationship between the presenter's realism (primarily the display of six emotions on his face: happiness, sadness, surprise, anger, fear, and disgust) and the effectiveness of interaction with viewers, stimulating their consumer behaviour after watching live broadcasting, which was also pointed out in this study, which is consistent with the data of N. Bharadwaj *et al*. (2022). The authors point out the mandatory presence of the element of emotionality of the presenter, and also measure the difference between his presence in the frame and absence (taking into account the emotionality of the voice sound), which overlaps with the conclusions formulated in this study and is reflected in the developed methodology for assessing the effectiveness and quality of live broadcasting with the use of a presenter.

The present study examines the use of physical models and the impact of recreating physical space in virtual space – including for the purpose of creating a believability and realism effect (which may also apply to the host who is broadcasting with such a background) – in the context of the importance of the realism and believability of the virtual host and the positive, directly proportional impact of this realism on audience satisfaction with the content, increased engagement and willingness to interact with the virtual host, desire to perform actions provoked by the host (participate in interactives, subscribe to social networks, buy the product advertised by the host, and so on), which is directly related to the effectiveness of live broadcasting. This aspect was also reflected in the created methodology for assessing the quality and effectiveness of live broadcasts. The same opinion was held by M. Li & S. Wenjie (2021).

The results of the study also proved that realistic (bright, visually pleasing) visual effect and interactivity of live broadcasting have a tangible positive impact on consumers' willingness to participate in interactives, make recommended purchases, and follow the host's advice (which is reflected in the methodology for assessing the quality and effectiveness of live broadcasting with a virtual host created in this study). The findings are consistent with the results of a stimulus-organism-response theory-based study by C. Ye *et al*. (2022), who considered as an object of research consumers of live broadcasting tourism and came to the same conclusion.

The findings of this study indicate the success of using virtual influencers in the marketing environment, and these findings were reasonably confirmed based on an empirical study conducted by J. Looi & L.A. Kahlor (2024). The authors also complement the data of the study conducted in this article with the results of modelling the topics of the latent Dirichlet distribution, which pointed out another aspect of the perception of virtual hosts that differed from real ones by first emphasizing their identity and only then engaging in self-promotion, which is worth considering in the next studies on this topic. Furthermore, the article by J. Looi & L.A. Kahlor confirmed the findings of this study about the relationship between the characteristics of the live-streaming platform and the effectiveness of live-streaming – the authors empirically proved that the level of influence directly depended on Instagram platform validation and significantly influenced the trust in the Influencer and audience engagement.

This study was also based on the article by L. Hofeditz *et al*. (2022), which described the results of the study of the difference between the perception of real and virtual Influencers and trust in them. Within the framework of this study, what is interesting is not the conclusions reached by the authors about the preference for human influencers, but the evaluation methodology and inferences concerning the parameters of perception evaluation and the level of trust in such presenters, which confirm the correctness of including these parameters in the criteria for evaluating the effectiveness and quality of live broadcasting with virtual hosts.

When compiling the methodology for assessing the effectiveness and quality of broadcasts, the motivation of viewers was also taken into account as one of the crucial and influential aspects of the specifics of the audience's perception of the broadcast and its presenter. These inferences are confirmed by the data of the article by M.A. Camilleri & L. Falzon (2021), which analyses the importance of stream viewers' motivation, which also strongly influences the final evaluation of its quality and effectiveness. However, the metrics used by the authors may well be compensated by the metrics of viewer types used in this study (which is also related to the manifestations of their motivation). In addition, this study proves that based on motivation alone it is impossible to get a sufficiently diverse and complete picture of how the stream will be perceived and evaluated by the audience, because a number of fundamental parameters (such as, for example, the technical quality of the live broadcast, the quality of the broadcasted information, the realism, and authenticity of the virtual presenter, and so on) have been missed.

In the context of this study, it is also worth mentioning the paper by H. Wu *et al*. (2023), who emphasized the importance of combining technical and aesthetic aspects when evaluating live broadcasts, fully supporting the findings that live broadcasts (or streams) should be evaluated in a complex set of different parameters and characteristics, both purely technical (e.g., site parameters or video and audio quality) and aesthetic (e.g., visual attractiveness and realism of the host, tonality of the host's voice). However, the Disentangled Objective Video Quality Evaluator (DOVER) and DOVER++ (an approach that provides clear quality assessments from a single aesthetic or technical point of view) methods proposed by the authors can still be assessed as not quite complete and significantly inferior to the six-block multidimensional evaluation developed in this study, which includes not only output data (such as video

quality, virtual host realism, information quality, and so on), but also output data (audience parameters, their motivation, and motivation).

The results of the study showed that in order to achieve a high level of quality, efficiency, and effectiveness of live broadcasts with virtual hosts and influencers, many factors need to be taken into account. Technological aspects, the realism, and believability of the hosts, their emotional expressiveness and interactivity are important. It is also necessary to consider the experience and characteristics of the audience, which can increase the perception of information, engagement, and desire to act both within the stream (to participate in interactives, communicate with the host) and outside of it (buy recommended products, leave reactions, popularize the host or content).

Conclusions

The methodology constructed in this study took into account numerous relevant studies dealing with different aspects of video broadcast evaluation, including those using virtual hosts.

Technological aspects of video broadcasting such as video streaming, 2D and 3D formats, use of specific protocols for streaming and video compression technologies were considered critical. High-quality video and audio, as well as the absence of technical glitches, significantly increase viewer satisfaction and engagement with the content. These parameters play a key role in viewers' perception and evaluation of the stream.

The emotional interaction of the presenter with the audience also proved to be an essential factor. The realism and authenticity of the virtual presenter, his/her ability to express emotions and respond to viewers' actions contribute to deeper interaction and increase the level of trust and engagement of the audience. Emotional expressiveness and consistency of the presenter's behaviour have a positive impact on the interaction with viewers, which stimulates their activity and participation in the interactions. Parameters of interaction with the platform and technical peculiarities were also considered. Network performance monitoring, video and audio quality analysis, testing on different devices and platforms – all this helps to ensure high quality of broadcasting and minimize technical issues that can negatively affect the stream experience. The use of various technical solutions to optimize video and audio quality, as well as to ensure broadcast stability, plays a major role in increasing viewer satisfaction.

Methods for assessing different types of viewers and their preferences have been developed. Understanding the specific needs and preferences of each group of viewers allows for a more accurate assessment of stream quality and effectiveness, as well as for tailoring content to different audiences. Assessing the sense of community, emotional support, interactivity and social presence allows for a more accurate assessment of viewer engagement and satisfaction. In addition, the parameters of viewers' self-efficacy, information overload, service overload, user dependency and cognitive dissonance were included in the methodology. These parameters provide a deeper understanding of the viewers' psychological state and their perception of the stream, which helps to improve the overall effectiveness of the broadcast. The evaluation of these parameters provides an opportunity to identify potential problems and propose solutions to address them.

Limitations of the study include the limited data used and the subjectivity of viewers' perceptions, which may affect the objectivity of the evaluations. Future research needs to be more extensive, using different platforms and technologies, and to take into account cultural and regional differences in perceptions of virtual presenters. Key areas for further research include improving methods for assessing emotional interaction, adapting technologies for different types of viewers, and developing new tools for analysing and monitoring the quality of live broadcasts. This will not only improve the accuracy and objectivity of assessments, but also improve the quality and efficiency of live broadcasts with virtual hosts.

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Conflict of Interest

None.

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Розробка нових методів оцінки якості та ефективності прямих ефірів з використанням цифрових людських технологій

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Анотація. Метою цього дослідження було створення нової, комплексної методології оцінки якості та продуктивності відеотрансляцій з використанням технологій віртуальної людини. Методологія дослідження включала аналіз існуючих методологій та їх адаптацію до специфіки віртуальних хостів. Було розроблено нові інструменти оцінювання, що враховують такі параметри, як технічна якість, емоційна підтримка, інтерактивність, соціальна присутність, привабливість стримера та намір продовжити перегляд. Основні результати дослідження показали, що технологічні аспекти потокового відео мають значний вплив на сприйняття глядачами таких відео. Висока якість відео та аудіо, стабільність трансляції підвищують задоволеність та залученість аудиторії. Крім того, емоційна взаємодія між віртуальним ведучим та аудиторією сприяє глибшому взаєморозумінню та підвищує довіру. Інтерактивність і соціальна присутність віртуального ведучого створюють відчуття спільності та залученості, що позитивно впливає на загальне сприйняття трансляції. Також було досліджено фактори глядацької самоефективності, інформаційного перевантаження та когнітивного дисонансу, що допомагає краще зрозуміти психологічний стан глядачів. Отримані результати свідчать про те, що для досягнення високого рівня достовірності та довіри до віртуальних інфлюенсерів необхідно враховувати технологічні аспекти, естетичні аспекти, рівень довіри до ведучого, параметри його аудиторії (її мотивації, культурні та особистісні характеристики, які можуть впливати на специфіку оцінювання якості та ефективності трансляції), параметри самого ведучого (реалістичність, емоційна виразність, інтерактивність, наявність та відсутність гумору тощо). Запропонована методика дозволяє комплексно оцінити всі ці параметри, сприяючи підвищенню якості та ефективності прямих ефірів з віртуальними ведучими

Ключові слова: віртуальний аватар; хост; стрімінг; сприйняття; метрики