

The Impact of Danmaku on High School Students' Video Learning: A Qualitative Analysis Based on the Uses and Gratifications Theory Model

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Abstract

The development of the internet has made online video learning more personalized and diversified; however, problems such as poor interactivity, the inability of teachers to monitor students' learning states, and a lack of sense of presence remain prominent. As a novel interactive approach, danmaku (bullet-screen comments) can mitigate the shortcomings of limited interaction in online video learning and improve learners' viewing experience. Nevertheless, whether danmaku can satisfy high school students' psychological needs in online learning and enhance their video-based learning remains controversial. Grounded in the Uses and Gratifications Theory, this study employs a grounded theory approach to explore how danmaku fulfills high school students' psychological needs in a video-learning environment. The findings reveal that danmaku satisfies students' goal-oriented needs: maintaining interpersonal communication and interaction, enhancing interactivity, and entertainment during video learning. Furthermore, high school students actively operate danmaku and engage in interaction with danmaku-enabled learning videos. Danmaku also influences students' psychological states during video learning, exerting both positive and negative effects.

Keywords

High school students danmaku; video learning; uses and gratifications theory; danmaku interaction.

1. Introduction

The high Internet penetration rate in China has laid a solid foundation for the country's online education. With the development and application of artificial intelligence and big data analytics, learning has become personalized and diversified. Virtual reality technology has also been applied in educational scenarios, enabling learning to transcend the limitations of campus walls and broadening the scope of students' learning. However, online video learning also has some obvious drawbacks. First, because remote video learning lacks interaction among users, the perceptions and experiences associated with teacher-student and student-student interactions are often characterized by loneliness [1]. Second, when video is used for teaching, teachers and students, as well as students and their peers, are separated in time and space. Teachers cannot observe students' learning behaviors [2], resulting in a lack of effective monitoring of the learning process. Finally, in online learning environments, the lack of the sense of presence associated with offline learning leads to an inadequate classroom atmosphere, which may affect learners' learning outcomes. In this context, it is particularly important to continuously optimize online learning resources and improve the effectiveness and efficiency of online teaching [3].

Danmaku (bullet comments), as a new online interactive medium, allows users to post large numbers of scrolling comments over videos. Users can immediately share and exchange details of video content while watching and express their feelings and opinions about a particular moment [4]. Danmaku alleviates the shortcoming of insufficient interactivity in online video learning and enhances learners' experience of watching learning videos. How danmaku affects the psychological and behavioral outcomes of learners in online learning remains controversial across different studies. However, the fact that high school students tend to turn on danmaku while watching learning videos suggests that danmaku satisfies certain needs of high school students in video learning. Based on the Uses and Gratifications Theory model, this study employs a grounded theory approach to interview and analyze high school students' psychological needs when using danmaku during video learning. It explores which psychological needs of high school students are satisfied by danmaku in online learning videos, thereby providing a research foundation for further exploring the impact of danmaku on secondary school students' video learning.

2. Literature Review

Katz et al. [5] proposed the Uses and Gratifications Theory (UGT) in 1973 to explain users' psychology and behavior in choosing and using multimedia and IT products when their needs are satisfied [6]. The theory assumes that users' selection and use of media are goal-oriented, meaningful, and motivated behaviors for them [7]. People use the Internet because they have needs; their Internet use behavior is related to their underlying needs, which are often overlooked because they are difficult to perceive. The various functions provided by the Internet satisfy users' different needs, thereby generating different Internet needs among users. Further research on UGT describes an audience-centered perspective, with the following assumptions: (a) media behavior is purposeful, goal-oriented, and motivated by specific motives; (b) people select media content to satisfy their needs or desires; (c) social and psychological attributes play a moderating role in behavior; (d) media can compete with other forms of communication—or be functionally interchangeable with them—for selection, attention, and use; for example, interpersonal interaction may be chosen for these purposes [8]. Chen et al. [9] described UGT as an approach that “assumes that audiences actively select media to satisfy specific needs and desires, and that these behaviors are moderated by social and psychological attributes.” UGT emphasizes multiple dimensions and structures, and this model can be broadly divided into five needs or values: purposive needs, self-discovery needs, needs for maintaining interpersonal interaction and connection, needs for enhancing social interaction, and entertainment needs. Purposive needs refer to achieving certain informational and instrumental purposes. Self-discovery needs represent the desire to understand oneself through social interaction. Needs for maintaining interpersonal interaction and connection refer to establishing and maintaining relationships with others and benefiting from them. Needs for enhancing social interaction refer to obtaining acceptance and recognition from others. Entertainment needs refer to the desire to obtain pleasure or relaxation through playing or interacting with others. The main principles underlying these five needs suggest that users select media according to their needs and expectations, which can provide them with satisfying experiences [10]. According to this theory, learners' use of danmaku in video learning is a meaningful and motivated behavior. When learners' five needs are satisfied in a danmaku video environment, this will further reinforce their behavior of turning on danmaku when watching videos with danmaku.

According to statistics, by the end of 2022, 82% of Bilibili users belonged to the generation born between 1995 and 2009. The development of danmaku technology is closely aligned with the inner needs of young people and has provided a demographic and emotional foundation for its

application in young people's video learning [11]. Existing empirical studies have shown that danmaku can, to a certain extent, satisfy some psychological needs of learners. For example, in terms of satisfying purposive needs, because high school students are more inclined toward the group effects of collective discussion and sharing, these behaviors affect the role of danmaku among high school students. When learners turn on and send danmaku in videos, they can obtain relevant learning information, reduce the boredom of videos, and increase positive viewing experiences [12]. In terms of satisfying interpersonal interaction needs, the anonymity of danmaku allows users to express themselves more freely and can also satisfy users' needs for social interaction [13]. Unlike teacher-led instruction in traditional classrooms, danmaku videos enhance real-time interaction among learners and reduce high school students' learning pressure. In terms of the need to enhance social interaction, danmaku can facilitate emotional communication between teachers and learners and among learners. High-quality danmaku closely related to the learning content of instructional videos can enhance learners' social presence, learning satisfaction, and academic performance [14], [15], thereby significantly promoting learning. In terms of entertainment needs, danmaku content is strongly related to the topic, close to everyday life scenarios, and highly entertaining [16], and it can reduce the loneliness experienced in online video learning [14]. Song et al. [17], through a meta-analysis, found that compared with graduate and undergraduate students, danmaku had a more pronounced effect on improving the overall academic performance of secondary school students. Interesting popular internet slang and lighthearted textual content are also more consistent with secondary school students' cognitive developmental characteristics and the online-era context in which they live, and can stimulate their enthusiasm for learning and promote improvements in academic performance. Based on prior computer-assisted self-regulated learning, Wang & Zhang [18] studied the "Study with Me" (SWM) live-streaming community on Bilibili. They argued that SWM live-streaming activities can promote learners' learning behavior in two ways. On the one hand, the initiator of the live stream needs to seek supervision from others, find study companions, and obtain others' company. On the other hand, the live-streaming learning community can enhance learners' social presence and encourage more people to participate. The realization of these two functions is perceived through the danmaku sent on the screen by the live-stream initiator and learners, thereby satisfying the psychological needs of learners in online communities. Among these, the needs of online communities include cognitive needs, social activity, cognitive support activities, and social support activities.

However, other studies have shown that the presence of danmaku may interfere with learners. The processing of enormous amounts of information through different sensory channels imposes a considerable burden on cognitive channels and occupies limited attentional resources [19]. At the same time, danmaku also occupies learners' attention and reduces their focus on the main content of the video [20]. Whether high school students can satisfy their learning-related psychological needs because of the presence of danmaku and benefit from video learning still requires further exploration, so as to guide the design and use of danmaku in video learning environments. Therefore, this study adopts the grounded theory interview method and selects high school students who view danmaku during video learning as research participants to explore the role of danmaku in video learning, thereby providing a basis for leveraging the interactive role of danmaku and improving the effectiveness of video learning.

3. Research Design

3.1. Research Methods and Tools

This study adopts a qualitative research approach to examine students' use of danmaku in learning videos. Interviews and analyses were conducted on high school students'

psychological needs regarding danmaku use during video learning, in order to further understand which psychological needs of high school students are satisfied by danmaku in learning videos and to provide a research basis for further exploring the impact of danmaku on high school students' video learning. Using qualitative analysis software NVivo11 to code and analyze the collected interview data.

3.2. Research Participants

This study adopted convenience sampling and followed the principle of purposive sampling in qualitative research. Sixteen high school students with experience using danmaku in learning videos were interviewed. Among them, there were 9 male and 7 female students. The interviewees were aged between 16 and 17, and all had experience watching learning videos with danmaku. The number of years since they had registered video accounts ranged from 2 to 8 years, and the time they spent on danmaku video websites per week ranged from 0.5 to 8 hours, with an average of 2.90 hours per week. After coding 12 interview transcripts, the remaining 4 reserved interview transcripts were used for a theoretical saturation test. The results showed that no new concepts or categories emerged; therefore, theoretical saturation was judged to have been reached.

3.3. Research Procedure

Preparation Stage: The interview team consisted of a doctoral student in Education, a PhD in Psychology, and two graduates with master's degrees in Developmental and Educational Psychology from the School of Psychology. There were two female and two male members. After reading research materials related to danmaku and the Uses and Gratifications Theory model, they jointly participated in developing and revising the interview guide for this study and jointly determined the specific interview procedures.

In this study, After reviewing and synthesizing the relevant literature, the interview guide for this study was developed through repeated discussions by the interviewer team. Five high school students were selected for pilot interviews and discussions, and the formal interview guide for this study was ultimately finalized. The formal interview guide consisted of two parts. The first part covered the interviewees' basic information (gender, age, and grade level) and their basic usage of danmaku video websites. The second part involved the interviewers conducting interviews with the participating students according to the interview guide to investigate what learners gained from danmaku during video learning, which psychological needs of learners were satisfied by danmaku, and what effects danmaku had on learners' psychology and behavior. The semi-structured interview included the following questions: ① What are the reasons for turning on danmaku in learning videos with danmaku? What are the reasons for turning it off? ② What help has danmaku brought to your video learning? (in terms of emotions and knowledge learning) ③ What content would you like to see in danmaku? ④ Would you interact with danmaku while watching learning videos? What types of danmaku would you usually send? ⑤ What effects has using danmaku during video learning had on your learning outcomes?

Initial Stage: The study was explained to the interviewees to alleviate their concerns and worries. During the interviews, sincerity, respect, and curiosity about the research were conveyed to the interviewees in order to establish good interview rapport. Interviewees were encouraged to elaborate fully and in detail on the research questions. For unclear information, questions and follow-up questions were promptly raised, and careful listening was maintained to avoid the interviewer's personal presuppositions and attitudinal bias.

Closing Stage: In this study, all interview content was audio-recorded. Within 24 hours after the end of each interview, the interview recordings were transcribed into verbatim transcripts, and the data were organized.

For data analysis, this study adopted the grounded theory method and used NVivo11 software to code and analyze the collected data. With the three-level coding of open coding, axial coding, and selective coding as the core, a top-down in-depth analysis of the data was conducted. First, based on the interview guide, a preliminary analysis of the collected information was conducted to extract content relevant to the interview themes. Second, the extracted content was sorted and integrated, coded into core themes, and then the content under the same core theme was summarized and generalized to form relatively independent core viewpoints. Finally, viewpoint analysis was conducted to form the final results of this interview study. The specific coding table is shown in the table below:

Table 1. Interview Coding Table

First-level coding	Second-level coding	Third-level coding
Needs and desires	Purposive needs	Extending knowledge; different viewpoints; detailed explanations; learning methods; problem-solving methods; correcting errors; broadening lines of thought; supplementing knowledge; content evaluation; highlighting key points
	Need for maintaining interpersonal interaction and connection	Encouragement and support; shared interests; co-viewing; empathy; understanding others
	Need for enhancing social interaction	Gaining recognition
	Entertainment needs	Avoiding boredom; interesting explanations; using memes
Interaction behavior	Turning on danmaku	Acquiring information; deepening understanding
	Turning off danmaku	Meaningless information; content obstruction; negative comments; screen flooding; provoking flame wars; incorrect information; avoiding distraction
	Sending danmaku	Expressing opinions; answering questions; changing the atmosphere
	Recording and comparing danmaku	Pausing and noting key points; comparing danmaku content; slowing down
Impact of danmaku in learning videos	Positive	Broadening thinking; enhancing confidence; maintaining motivation; alleviating boredom; obtaining different insights; positive atmosphere; stimulating interest and curiosity
	Negative	Flame wars; childish content; unfriendly atmosphere; information bias; irrelevant information; missing valuable information

4. Research Results

4.1. High School Students' Needs for Using Danmaku in Learning Videos

High school students choose to use danmaku in video learning mainly because danmaku satisfies their purposive needs, need for maintaining interpersonal interaction and connection, need for enhancing social interaction, and entertainment needs in learning.

Within purposive needs, what learners reported was a need to acquire learning information, mainly including obtaining extended knowledge, different viewpoints, detailed explanations,

learning methods, problem-solving methods, error correction, broadening lines of thought, and supplementary knowledge. Among the interview data from the 16 students, detailed explanations had 16 reference points. Learners believed that when some learning videos did not explain things clearly enough, some skilled viewers in the danmaku might explain them using better ways of understanding; for places they did not understand, there were more detailed explanations; danmaku might use plain and easily understandable language to explain a knowledge point; if there was a section they did not understand, some danmaku might provide a more complete and detailed explanation; sometimes danmaku explained things relatively clearly; sometimes popular science videos did not have subtitles, and some people voluntarily added subtitles to those videos, providing explanatory information to help others; and some danmaku explained the content of the video.

Supplementary knowledge had 11 reference points. Learners believed that when video creators explained things too simply and concisely, making them difficult to understand, danmaku could serve as a supplement; there were some relatively professional people in the danmaku who would mention fragments of university-level knowledge and appropriately provide supplements; for knowledge points taught by teachers, danmaku provided annotations and supplements; and some danmaku supplemented the video content.

Different viewpoints had 11 reference points. These learners believed that using danmaku mainly brought different viewpoints and allowed them to compare different viewpoints to see which ones they could accept more easily; if there were different opinions, they would pause the video first, see what the danmaku said, and then think about what their own views were; and they could look at different people's views on a given question.

Problem-solving methods had 9 reference points. Learners pointed out that for some physics-related problems, they might try some of the solutions in the danmaku; in mathematics videos, the danmaku generally contained some experts sharing problem-solving ideas, so one could look at different people's views on the problem; sometimes danmaku users shared their rough problem-solving process; and for knowledge points taught by teachers, the danmaku provided some problem-solving ideas for the question. For physics, the simpler the methods that appeared in the danmaku, the better, because they saved more time.

Error correction had 8 reference points. Learners indicated that some video creators also made some errors when teaching; if they had doubts about this, they would turn on the danmaku to see whether others also had doubts and whether the video creator had really made a mistake; sometimes video creators also corrected some of the content they had taught in the danmaku area; and sometimes video creators made scientific errors, which the danmaku could correct.

Content evaluation had 6 reference points. Learners believed that the reason for turning on danmaku was to see whether a method was generally applicable and what evaluations people had of the method; danmaku could effectively reflect viewers' evaluations of the video, other viewers' evaluations of whether the video was good or bad, and could also help judge whether learning methods were excellent; sometimes danmaku also highlighted key points—for very long videos, which could only be understood through one's own viewing, it was certainly impossible to summarize them well in one viewing, and danmaku could remind them which parts were important; after watching a video, everyone would express views and evaluations about a certain chapter; and danmaku reflected the value of the video from a certain angle and also made you more willing to watch it.

Extended knowledge had 5 reference points. These learners indicated that some people in the danmaku posted extended knowledge points and typed them on the screen; some historical stories were extended to what other stories happened to these historical figures in history, providing some expansion; some people posted which supplementary teaching material was more useful and which was less useful; or they shared the source of a problem in the video, for

example, they had done that test paper and knew which question bank or exercise book it came from. If they could share it, it would be more convenient for me to look it up later.

Learning methods had 5 reference points. Learners pointed out that some high school students recorded videos sharing their own learning methods, and through danmaku one could see whether the method was generally applicable and what evaluations and views people had of it; when reviewing for exams, they would find some review videos and follow them to see how to review and how to clarify their thinking; and better memorization methods and more practical learning methods would appear in the danmaku.

Broadening lines of thought had 3 reference points. Learners indicated that danmaku improved their learning considerably, allowing them to view things from different angles and broaden their way of thinking; they could be exposed to relatively advanced thinking abilities; they could see other people's views and ideas, so they would not be too closed-minded; and through danmaku, they could see more lines of thought.

Highlighting key points had 1 reference point. Learners believed that relatively dense danmaku indicated that many people were also unclear about this part, or that many people had watched this part many times, suggesting that this was a relatively difficult-to-understand or important part.

The need for maintaining interpersonal interaction and connection mainly includes encouragement and support, shared interests, co-viewing, empathy, and understanding others. Encouragement and support had 5 reference points. Learners stated that some senior schoolmates in their final year of high school would encourage everyone and post positive and uplifting danmaku to guide their learning; video creators also offered friendly encouragement and support. Co-viewing had 5 reference points. Learners believed that having danmaku in videos made the experience more immersive, as if classmates were beside them; one enjoyable aspect of danmaku was being able to watch together with others. When many people were watching and the video received considerable attention, they were more inclined to watch. Understanding others had 3 reference points. Learners stated that if they had doubts about something, they would turn on the danmaku to see whether others also had doubts. In some relaxing popular science videos, they wanted to understand other viewers' thoughts through danmaku; when watching mathematics videos on spatial geometry, they would turn on danmaku to see what others were saying; sometimes when a video covered a knowledge point they already understood, they would turn on danmaku to see what other students were saying; and for relatively popular videos, they were curious about what others had commented on. Sometimes when video creators mentioned memes or something very funny, they would also check whether the danmaku reacted to it. Shared interests had 1 reference point. For learners, danmaku in the same video was like a community of shared interests, where they discovered that many people had common hobbies. Empathy had 1 reference point. Learners believed that sometimes when watching psychology-related videos, the danmaku showed empathy, and those danmaku comments made them feel especially caring.

Entertainment needs were mainly manifested as avoiding boredom, interesting explanations, and using memes. Avoiding boredom had 8 reference points. Learners stated that danmaku could alleviate the boredom they felt while watching videos; it made videos less boring and video learning more interesting; if a video creator covered content they already knew, they would find it somewhat boring, and staring at the screen continuously would be useless, so they would turn on the danmaku; when they felt bored while studying, they would also turn it on to take a look, relax a little, and then continue studying; when they had nothing to do, they might turn it on; and watching danmaku made learning less boring. Interesting explanations had 8 reference points. Learners stated that in the danmaku, they might see someone mention a homophonic pun about a certain knowledge point, which might make them smile knowingly; sometimes amusing content appeared in the danmaku that could lighten their mood;

sometimes the danmaku contained playful remarks; danmaku made the learning atmosphere more relaxed; and danmaku was relatively interesting and could make the atmosphere more lively. Using memes had 3 reference points. Learners believed that in the danmaku, for example, regarding historical events, viewers used homophonic puns to tell a joke. Humorous, meme-based danmaku would make them laugh when their thinking was very tense and they were engaged in high-intensity thinking; relaxing a little allowed them to learn better. Posting danmaku containing memes made the video more interesting.

The need for enhancing social interaction was mainly manifested as gaining recognition from others, with 3 reference points in total. Students stated that if they posted a comment and others liked it or commented on their danmaku, they felt quite a sense of achievement, because on the one hand they gained recognition and on the other hand they interacted with others. Sometimes I posted my views on the video through danmaku, and some classmates would come to watch and like it, which made me feel that my danmaku could help others. When my danmaku helped others and others liked it, I would feel a little happier because I received positive feedback.

4.2. High School Students' Interaction Behaviors in Learning Videos with Danmaku

This study also focused on high school students' interaction behaviors with danmaku while watching videos with danmaku. In addition to turning on danmaku, which satisfies the above learning needs, their behaviors also included turning off danmaku, not sending danmaku, sending danmaku, and performing simple operations on danmaku.

The main reasons learners turned off danmaku were negative comments, meaningless information, avoiding distraction, content obstruction, screen flooding, provoking flame wars, and incorrect information. Negative comments had 12 reference points. Learners believed that danmaku sometimes made the video learning environment less pleasant; sometimes there were opposing and malicious views; sometimes younger users flooded in, and high-quality danmaku became relatively rare; and some users posted useless, low-quality remarks or even engaged in personal attacks. Meaningless information had 10 reference points. Learners believed that there was some meaningless content in danmaku, such as content largely unrelated to the video, meaningless bandwagon remarks claiming that the video creator was awesome, mindless meme use, meaningless statements, and invalid information. Users who sent such information were not really there to learn, and instead affected other users' viewing. Avoiding distraction had 10 reference points. Learners believed that studying required a certain degree of concentration; danmaku was like classmates, and talking with classmates would interfere with one's study. When a teacher was explaining knowledge points, or when they wanted to follow the video creator's explanation or needed to think hard, they would first turn off danmaku. If the danmaku sent were all irrelevant content, it was better to turn it off; after watching too much danmaku, they could no longer keep watching the video content. If there was too much useless danmaku, it was harmful and affected the overall experience of watching the video. Content obstruction had 7 reference points. Learners believed that when there was too much danmaku, it would obscure the video content; at such times, because there was too much danmaku and they were afraid it would affect their learning, they would turn off danmaku. Screen flooding had 6 reference points. Learners believed that in some old videos on the website, there was screen-flooding danmaku, and the content was relatively homogeneous. They did not want to see so much bandwagon danmaku content making unsolicited comments on the side; sometimes they felt somewhat annoyed because there was too much danmaku, and some videos were covered entirely by danmaku, which made them somewhat unable to keep watching. Provoking flame wars had 3 reference points. Learners believed that some danmaku made rather unpleasant remarks, similar to flame wars, but this was relatively rare; some

videos had a lot of danmaku, but they were basically all flame wars. Incorrect information had 2 reference points. Learners believed that some danmaku contained biased and incorrect information, which could mislead viewers; or in the current commenting environment of video websites, some content was erroneous.

The main reasons learners sent danmaku were to express opinions, answer questions, and change the atmosphere. Expressing opinions had 5 reference points. Learners stated that when watching learning videos, if there were more convenient and concise ways of thinking, unique insights, or agreement with the viewpoints in the video, they would also send danmaku; if an entire video had no danmaku, they would post some of their own ideas. Answering questions had 1 reference point: learners might send danmaku when answering the video creator's questions. Changing the atmosphere had 1 reference point: learners sent danmaku while watching learning videos in order to make the learning videos more interesting.

In addition, learners performed some simple operations on danmaku, such as pausing, comparing, and slowing down. Pausing for danmaku had 5 reference points. Learners stated that if there were different opinions in the danmaku, they would pause the video first, see what the danmaku said, and then think about what their own views were. Sometimes there were things in the danmaku that the video creator had not mentioned, so I would pause and copy them down. Sometimes when the teacher explained something vaguely and the danmaku also mentioned it, I could record it in my book as well. Comparison had 1 reference point. Learners believed that by comparing these different viewpoints in the danmaku, they could see which viewpoints they were more able to accept. Slowing down had 1 reference point. If the danmaku all gave a video positive reviews and posted their own summaries after watching the video, in such cases I would generally slow down the playback speed and watch slowly.

4.3. Impact of Danmaku on Learning Outcomes in Learning Videos

In the interviews conducted for this study, learners also pointed out the positive and negative effects of danmaku on learning outcomes in learning videos. In addition to the aforementioned learner needs satisfied by danmaku, the positive effects also included enhancing thinking ability, increasing confidence, maintaining learning motivation, alleviating mood, creating a positive atmosphere, and stimulating interest and curiosity.

Enhancing thinking ability had 1 reference point. Learners stated that in a danmaku environment, they could be exposed to relatively advanced thinking abilities. Increasing confidence had 1 reference point. Learners stated that danmaku could further increase their confidence. For example, they might originally feel that they could not handle the content and would skip it, but after seeing better ways of thinking or some words of encouragement, they would want to stay a little longer or watch a little more in this area. Maintaining motivation had 1 reference point. Learners believed that in some videos, sometimes after reading danmaku they felt more motivated to continue learning. Alleviating mood had 2 reference points. Learners believed that the appearance of some amusing danmaku in videos could lighten their mood; danmaku could alleviate the boredom they felt while watching videos. Positive atmosphere had 7 reference points. Learners stated that after studying for too long, their attention became somewhat scattered; at such times, someone in the danmaku would tell a slightly humorous little joke that also contained a knowledge point; danmaku used humorous language to explain a knowledge point; sometimes they made use of the knowledge in the danmaku, such as some relatively funny content, which made it more interesting—for example, using homophonic puns to tell a joke about a historical event. Stimulating interest and curiosity had 2 reference points. Learners stated that some danmaku aroused their curiosity and made them really want to learn. Danmaku could stimulate interest in learning, and they could watch how others commented on the side.

The negative effects brought by danmaku included the main reasons why learners blocked danmaku, which have been analyzed in detail in the above section.

5. Discussion

From the above results, it can be seen that the main reason high school students watch danmaku in video learning is that danmaku satisfies their purposive needs, need for maintaining interpersonal interaction and connection, need for enhancing social interaction, and entertainment needs in video learning. Self-discovery needs are not the main purpose for high school students to watch danmaku in learning videos. Learning videos with danmaku first satisfy learners' purposive needs, namely the need to acquire learning information. In addition to the video creator's explanations, the purposive needs that learners hoped to satisfy through danmaku included detailed explanations, supplementary knowledge, obtaining different viewpoints, obtaining problem-solving methods, error correction, content evaluation, extended knowledge, obtaining learning methods, broadening lines of thought, and highlighting key points. Among these learning purposes, detailed explanations, supplementary knowledge, obtaining different viewpoints, obtaining problem-solving methods, and error correction were mentioned most frequently. It can thus be seen that in learning videos with danmaku, learners can clearly understand their learning purposes and can consciously regulate their psychology and behavior; for example, on the basis of the video creator's explanations, they consciously pay attention to relevant danmaku information as a supplement to learning. Previous research analyzing danmaku on the Bilibili website also supports this conclusion: information needs are the most important motivation for users to use danmaku [21].

Second, learners also satisfied their need for maintaining interpersonal interaction and connection through danmaku in learning videos, namely encouragement and support, co-viewing, understanding others, shared interests, and empathy. Among these, encouragement and support, co-viewing, and understanding others were mentioned most frequently. Online learning videos are usually watched and studied by learners alone, lacking real interaction among learners; therefore, danmaku can compensate for this deficiency in online video learning in certain respects. According to the compensation hypothesis of Internet use, individuals may turn to the Internet to satisfy their needs because certain factors in real life remain unsatisfied [22]. High school students under high-pressure learning environments, who may lack social support and peer interaction due to excessive academic pressure, watch learning videos with danmaku to obtain a more relaxed learning atmosphere and to interact with fellow learners.

Third, learners satisfied their entertainment needs through danmaku in learning videos, namely avoiding boredom, interesting explanations, and using memes; among these, avoiding boredom and interesting explanations were mentioned most frequently. During learning, learners regulate their learning emotions by watching danmaku content. Finally, learners also satisfy their need for enhancing social interaction by watching danmaku, mainly manifested as gaining recognition from others by sending danmaku and thereby obtaining a sense of achievement. This conclusion further verifies the research of Liao et al. [23], namely that the main motivations for users to use danmaku include information acquisition, entertainment and leisure, and interactive communication.

The interaction behaviors of high school students in learning videos with danmaku mainly included turning on danmaku, turning off danmaku, not sending danmaku, sending danmaku, and performing simple operations on danmaku. The main reasons learners turned off danmaku were negative comments, meaningless information, avoiding distraction, content obstruction, screen flooding, provoking flame wars, and incorrect information. Among these, negative comments, meaningless information, avoiding distraction, content obstruction, and screen flooding were the main reasons learners turned off danmaku. This shows that in the process of

learning with danmaku videos, learners are able to clarify their learning purposes, actively adjust their learning environment, and avoid irrelevant and meaningless information interfering with learning. The main reasons learners sent danmaku were expressing opinions, answering questions, and changing the atmosphere. The most important reason was to express their own views and share their views and problem-solving approaches with fellow learners and co-viewers, so as to enhance interaction and improve the emotional atmosphere of learning. In addition, learners also performed some simple operations on danmaku, mainly pausing, comparing, and adjusting the playback speed. From the interview results, learners adopted these operations in order to further deepen the processing of certain useful danmaku information and thereby promote learning outcomes. Learners' operational behaviors toward danmaku can be explained by Zimmerman's [24] triadic model of self-regulated learning, namely that learners actively regulate the person, behavior, and environment to achieve their expected learning outcomes.

The positive effects of danmaku on learners' learning outcomes, in addition to the learner needs that danmaku can satisfy, also include enhancing thinking ability, increasing confidence, maintaining learning motivation, alleviating mood, creating a positive atmosphere, and stimulating interest and curiosity. It can thus be seen that, to some extent, danmaku influences learners' learning psychology during the learning process, including thinking ability, learning emotions, learning motivation, and emotions. However, danmaku can also have negative effects on learners. The main reasons lie in the interference it causes with video viewing and the impact of negative comments on learners' learning emotions.

6. Research Conclusions and Suggestions

Many learners like to turn on danmaku in serious learning videos, and the psychological factors behind this have attracted the attention of many researchers. This study adopted a semi-structured interview method, was based on the Uses and Gratifications Theory model, and used qualitative analysis. It interviewed 16 high school students with experience in learning with danmaku videos to explore which psychological needs of high school students are satisfied by the presence of danmaku in learning videos. The results showed that danmaku satisfied high school students' purposive needs, needs for maintaining interpersonal interaction and connection, needs for enhancing social interaction, and entertainment needs in learning. To achieve learning purposes, high school students, while watching danmaku videos, chose interactive behaviors such as turning off danmaku, not sending danmaku, and sending danmaku, or operational behaviors such as liking, replying to, excerpting, and reflecting on danmaku. In high school students' subjective reports, the impact of danmaku on video learning had both positive and negative effects. According to Vygotsky's social constructivist theory, the positive impact of danmaku on high school students' video learning may lie in the fact that learners are not passive recipients of knowledge and information, but actively generate and construct knowledge through active interaction with the environment [25]. Therefore, learners can actively operate danmaku, actively obtain information beneficial to themselves from the rich danmaku information in the learning video environment, and construct their own knowledge system.

Danmaku satisfied high school students' needs for achieving learning goals, maintaining interpersonal interaction and connection, enhancing interaction, and entertainment. If high school students' interaction with danmaku were not restricted, danmaku might also satisfy other psychological needs of high school students, such as the need for self-expression, the need to share, and the need for recognition. This suggests to educators that in the production of learning videos with danmaku, they need to fully consider learners' psychological factors, avoid danmaku content that has negative effects on learners, and optimize the environment for

danmaku video learning. Recent research has shown that learners' need for knowledge remains the main reason they use danmaku, which can be regarded as a manifestation of information-acquisition motivation in danmaku content [11]. This also provides insights for educators: the characteristics of danmaku can be used to promote video learning outcomes. For example, teachers can design guiding danmaku based on the teaching content and embed them in advance in instructional videos to guide learners' learning [26]. Alternatively, before learning, students engaged in video learning could be given basic tests on danmaku etiquette and the learning content to ensure that they have proper learning motivation and the necessary prerequisite knowledge. In addition, a danmaku filtering system can be established on danmaku learning video platforms to filter out danmaku content containing sensitive words, repeated words, or content unrelated to the video. Teachers can identify important terms in the danmaku system and highlight key points using special fonts or colors. Students should be encouraged to think actively and post danmaku related to the learning video content, and danmaku should be used to create a relaxed and interactive video learning environment to improve high school students' video learning outcomes.

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