WebRTC with Danmaku: A More Interactive Teleconferencing Client

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WebRTC is a free open source project that provides real-time communication between browsers and devices, offering the ability to transfer voice, video and data. Danmaku is a Japanese term that can also be translated as 'bullet curtain'. It is a subtitling system that allows users to make touching comments as the video plays. These comments are displayed on the screen in real-time in the form of "bullet shots". In this report, we explore the impact of the Danmaku feature on WebRTC. Based on this, we made a WebRTC client with Danmaku functionality and used 15 university students as respondents to provide findings on the impact of the Danmaku system on WebRTC usage. Our findings show that participants found the use of a WebRTC application with Danmaku functionality more conducive to user interaction. When using the WebRTC client with the Danmaku system, participants are able to participate more actively in the discussions.

CCS Concepts: • **Human-centered computing** → **Usability testing**.

Additional Key Words and Phrases: WebRTC, Danmaku, Interaction, Online education

1 INTRODUCTION

With the Covid-19 epidemic raging, a lot of work and study has been forced online. Studying or working online is not as convenient as doing it face-to-face. For students attending online lectures, there are so many limitations to online learning, including equipment issues, network issues, communication issues and application issues.

Many students have encountered situations where the questions they raised could not draw the lecturer's attention during the online lecture. In this case, students' questions about the content of the classes were not answered in time, which greatly affected the students' learning progress. Questions in the text chat are easily overlooked when lecturers are sharing their screens. Therefore, our group project was to find a way to enable better interaction between lecturers and students during online learning. In our project, we use an open-source technology called WebRTC and implement the Danmaku system in our application.

1.1 Background

1.1.1 Introduction of WebRTC. WebRTC is an open-source, peer-to-peer project-based on browser-to-browser communication, providing real-time communication (RTC) capabilities for audio and video chat and data transfer [5]. Unlike traditional browser to web server communication, it builds direct communication between browsers. One of the main advantages of WebRTC is that it is integrated into most modern web browsers and runs without the need to install external plug-ins or applications. Users can communicate in real-time over a link at any time.

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1.1.2 Introduction of Danmaku. Danmaku is a new design for online video commenting that originated in Japan. Unlike traditional video forums where comments are displayed asynchronously on the video screen in the chronological order in which they are posted, Danmaku's comments are superimposed on the video screen [9]. When a user sends a comment, the comment is displayed on the video screen from right to left in Danmaku's practice. Users can send Danmaku comments anonymously while watching a video and see other users' Danmaku comments in a synchronised manner.

2 RELATED WORKS

2.1 Understanding Danmaku's Potential in Online Video Learning[10]

According to the research conducted by Yao [10], the use of Danmaku features in online video learning has great potential and usefulness. Firstly, the Danmaku feature simulates real-life interaction between people, which will make users feel less isolated when participating and encourage them to engage more in discussions and learning. Secondly, the social element of the Danmaku feature will be part of the video content, allowing students to self-express and share their personal understanding with others, leading to a deeper understanding of the lecture content.

2.2 Beyond Talking Heads: Multimedia Artifact Creation, Use, and Sharing in Distributed Meetings [7]

The "Talking Head" issue is considered as the nature of web conferencing nature, which has restricted the enhancement of usability and user experiences [4]. In this paper, researchers studied different applications in the workspace and app stores for the online conferencing genre. They put forward their point-of-view on mitigating and improving the usability aspect of web conferencing applications in the human-computer interaction area. In this paper, researchers indicate that a more rich-in-content and rich-in-interaction solution should be considered when developing such applications to enrich the user experience and collaboration features.

3 RESEARCH QUESTION

From the past research, we assume that the Danmaku function can have an impact on the user experience during online learning. However, there has been no research into the use of Danmaku functionality in a WebRTC application or similar using scenario. This report, therefore, poses the research question:

Whether interaction by Danmaku can improve the user experience of a WebRTC-based application in online education scenarios?

4 METHODOLOGY

In order to explore the research questions posed earlier in the text, a series of research processes were designed to test, collect data and study. We felt that in this question, we should focus on whether students (as the primary software users) would have a better experience with the additional Danmaku functionality in the specific context of the 'online classroom'. Therefore, we decided to develop a customised Zoom-like client with Danmaku functionality based on a simple WebRTC technology using a JavaScript implementation to conduct our experiments. As our main research focus is on the user experience aspect, this experiment is characterised as a qualitative study [1]. We used the method of Control Experiment to compose our usability test. Participants were divided into several groups of 3, using both versions of the application, each for a short online teaching session with questions to answer in the chat system. The

experiment would be concluded with a survey questionnaire, including both Likert scale questions and Open-ended questions.

4.1 Control experiment

Our main research focus is on the user experience aspect. We used a comparative approach [6] to compare users' perceptions of using the version with or without the Danmaku functionality, so we composed a controlled comparison experiment. In this experiment, we developed a major version of the application with the Danmaku functionality built-in. And with some simple modifications to remove the Danmaku functionality, we also get a plain version with pure WebRTC.

We asked the same group of users to use two different versions of the application to complete an online tutorial. During the tutorial, users were asked to answer questions posed by the experimenter using the built-in chat board with or without the Danmaku functionality. Data on user experience were collected primarily using itemised scales, supplemented by data on the age group of the subjects and their gender and history of use. At the same time, we also record the entire experiment in the background using an external video recording program to collect all the user responses for a single experiment. This quantitative data can also be used to indicate whether users prefer to use the version of the app with Danmaku for classroom interaction and communication.

4.2 Implementation

For achieving the project objectives, we proposed a version of WebRTC-based online conferencing web application with Danmaku function embedded. The idea behind the application is relatively simple. We first composed or used an existing WebRTC application with source code available. Once we have the source code, the code section of implementing chat function needs to be located. Developers would find the module where the incoming chat message has listened. Once located, the code for catching the message and rendering the chat into the form as flying comments could be inserted. In this way, the chat content can be transformed into Danmaku.

In practice, we utilised two existing GitHub open source repositories as our primary implementation.

4.2.1 WebRTC Online Conference Chat [2]. In order to keep our experimental code as simple as possible, we set the following goals when selecting existing projects:

(1) The project should preferably be implemented in pure JavaScript and the associated library.
(2) The code should preferably not use any existing front-end frameworks.
(3) The back-end related content should be as simple as possible. However, due to the need for multiple users to connect simultaneously, a back-end Signalling server is essential. In this regard, it is best to use only NodeJS or SocketIO as the implementation, as NodeJS is considered the most appropriate web application framework for Google Chrome browser [3].
(4) It is best to already have chat-related functionality, and if not, we need to facilitate the use of SocketIO for this.

After some searching, we found Amirsanni's implementation library. This project met all our requirements, i.e. it doesn't use any advanced front-end service frameworks, it only uses Bootstrap as an aid to CSS-Styling; and it uses NodeJS, ExpressJS and SocketIO to implement all the user connection functionality. These advantages made this project relatively easy to Danmaku-ize the chat function on top of the codebase.

4.2.2 Danmaku Engine [8]. Danmaku Engine is a JavaScript library to display flying comments on HTML media elements (video and audio). It can also display comments to your container in real-time without a timestamp. It supports both media mode and streaming mode. In this project, due to the requirement of real-time rendering, we set the implementation of the library in streaming mode.

For implementing the Danmaku function into the conferencing application, an extra HTML container is added to the top of the application layout. The HTML tag is used as the Danmaku rendering and displaying container, which is accessible through the DOM engine provided by the Danmaku Engine. The extra Danmaku listener is added into the SocketIO chat channel subscriber in the source code to achieve the function of real-time Danmaku rendering. We also added another listener to the local chat sender so that users could also see their own message rendered as a Danmaku message, just like other users did. For avoiding the Danmaku container blocking other mouse events, we put an extra "pointer-events:none" property into the in-line CSS styling. Therefore, any mouse event would be pass-through directly to other elements on the page. The implementation of the non-danmaku version is relatively simple as well. We only need to set both of the Danmaku containers and related on/off switch to a hidden element.

4.3 Experimental setup

The experiment environment is to be set up as the next step. We design the experiment to be composed of two stages: a pilot test, which is to ensure the quality of the applications; and a series of comparison examinations, which is to verify if the Danmaku feature could add to the usability and user experience of a WebRTC application. The detailed experiment preparation documentation could be found in Appendix 1 of this report. For ease of testing, we mounted both versions of the application to Heroku.com in order to simulate the real-world environment of an online conference and a teaching case. Due to the nature of NodeJS and for preventing further bugs, we asked all our participants to use Google Chrome or browsers that is using Chromium core. We recruited five groups of participants in our research, each group was run by one of the project team members with the same tasks and setups. Each participant received an Email for the invitation to participate which include our PIS form and a Consent Form to sign. Forms could be found in Appendix 2 of this report. Once the researcher received the signed consent form, they would confirm the time slot with each participant to ensure the experiment could be held. In the experiment, participants were asked to watch a video, and the researcher would ask several questions related to the video, and participants would need to answer the questions through the chat function. The same process with different videos and questions would be running two times, each using the application with or without the Danmaku function. After the experiment, participants would receive a questionnaire that included questions about their basic information and usability experience regarding two versions of the applications. Please refer to Appendix 3. The questionnaire includes both Likert questions open-ended questions for different areas of analysis. Meanwhile, researchers would collect the total number of chats in both applications as the numerical data to be analysed.

5 RESULTS

To collect the data of the experiment, we have designed some questionnaires to get the data that we want. The questionnaire includes checking the participant's background, user preference, and quality evaluation, collecting and open answers to collect more feedback on improvement advice and opinions on the product. For the specific analysis of the quantitative problem based on the sample size and the nature of the experiment, we did not use too sophisticated statistical tools (e.g., R language); we used excel to analyse the data we needed to use and performed the analysis. We divided the experiment into five groups of three people each; a total of 15 surveys received 14 valid responses. In the

	How helpful the Danmaku feature is for online education
mean	4.14
medium	4
std	0.915
var	0.901
95% Confidence	0.479
Interval min	3.664
Interval max	4.622
Plural	5

Table 1. Answers Received from the question "How helpful the Danmaku feature is for online education"

survey, we collected the age information of the participants, which is 78.6% for the 22-25 age range and 7.1% for 18-21, 26-28 and 29-32. This dramatically shows that the 22-25 age group is the main part of our participants. We also collected gender information. In our experiment, the male had 71.4%, so in this experiment, the proportion of males accounted for the majority. Therefore, we collected the participants who used WebRTC before and listed some applications which use WebRTC. We can see from the survey response that approximately 50% of the participants used the WebRTC or WebRTC related application. Another half of the participants do not think they used it, which means the WebRTC needs to be more popularised that more people can understand what WebRTC is. All participants used WebRTC or related applications, but some people do know that the application they used is based on WebRTC or related technology. During the experiment, 71.4% can find and use the Danmaku function very quickly, 21.4% with medium speed and 7.1% spent quite a long time. While most people can easily find the Danmaku, chat, or other features very quickly, some people cannot find and apply the functions quickly. Therefore product All participants preferred the version with the Danmaku function. We also have the other two open-ended questions to collect the participants' feedback after the experiment. The questions aim to collect feedback on how the Danmaku function influences the online learning environment and to collect further advice on improving the WebRTC based online learning product feedback from participants. On the questions of how helpful the Danmaku feature is for online education, latency, and sound quality with the Danmaku version; and future scenarios for the Danmaku feature, we used a simple Likert index to get them to rate between 1 and 5. We decided to use the mean to represent the general level of our data because when describing a set of samples with a one-dimensional statistic (a number), the mean is the most reflective of the overall situation. The data rated 1-5 do not have a significant outliers effect and have more of an impact than the plural (crowd). For how helpful the Danmaku feature is for online education, we get the mean (4.14), median (4), and plural (5). 0.915 standard deviation proves that the data is concentrated, and there is no significant influence of outliers. 95% confidence interval is between 3.66 and 4.62, which proves that data in this area can be trusted.

For latency and sound quality with the Danmaku version, we get the mean (3.71), median (4), and plural (4). The standard deviation of 1.16 is slightly larger than the previous data set, but it still proves that the data are more concentrated and not too extreme. 95% confidence interval is between 3.11 and 4.32, which proves that data in this area are reliable data.

In the question of the future scenario of the Danmaku feature, the data are the same as those obtained in the question of how the Danmaku feature can help in online education, i.e., they represent the same mean, median, plurality, standard deviation, and confidence interval.

	Latency and sound quality with the Danmaku version
mean	3.714
medium	4
std	1.161
var	1.451
95% Confidence	0.608
Interval min	3.664
Interval max	4.322
Plural	4

Table 2. Answers Received from the question "Latency and sound quality with the Danmaku version"

	Future scenario of the Danmaku feature
mean	4.14
medium	4
std	0.915
var	0.901
95% Confidence	0.479
Interval min	3.664
Interval max	4.622
Plural	5

Table 3. Answers Received from the question "Future scenario of the Danmaku feature"

	Response amount without Danmaku	Response amount with Danmaku
Data Entries	5	5
mean	22.4	32.8
medium	22	32
std	2.059	5.980
var	5.3	44.7
95% Confidence	1.805	5.242
Interval min	20.595	27.558
Interval max	24.205	38.042

Table 4. Quantitative Data: Response amount without Danmaku Response amount with Danmaku

We also counted the enthusiasm of the subjects' responses (obtained from the total number of responses) in both product versions separately. For the version without Danmakus, the mean number of responses was 22.4, the median was 22, and the standard deviation was 2.06. For the version with Danmakus, the mean number of responses was 32.8, the median was 32, and the standard deviation was 5.98. Because the standard deviation was slightly more significant for the version with Danmakus, we believe that this data set may have some dispersion, so we used the median to represent the two sets of data levels. The median for the first group is 22 entries, and the median for the second group is 32 entries. The 95% confidence interval for the first group is between 20.6 and 24.2, and 22 is the data that can be trusted. The 95% confidence interval for the second group is between 27.6-38.0, and 32 is the data that can be trusted.

6 DISCUSSION

After we get the feedback results from the participants, we have collected some useful feedback from the survey, and the feedback is helpful on our project. Firstly, there are many participants using the WebRTC product, but they don't know those applications are using the WebRTC technology, which means the WebRTC now is not famous enough, WebRTC, and the benefits of this real-time communication technology need to be more widely used. A small part of users think it is quite hard to find the Danmaku function chat, which seems for online education, a good UI interface is important, and simple and clear function design is helpful for the users. Since the participants in the experiment are all students, the lecturer should also need to find and apply the functions quickly to save time. From the result, we can see all the participants preferred the version with Damaku, which means the Danmaku is really a helpful function to help the students and lecturer learn and interact. The data analysis concludes that 4.14 shows that the Danmaku feature is beneficial for online education. 3.71 It can be assumed that the sound quality and screen measurement with the Danmaku version is Comparatively good. 4.14can be assumed that Danmakus can be of great help to the future scenario of webRTC. The median number of responses for the version with Danmaku is significantly greater than the number of responses without Danmaku, proving that the Danmaku version increases user activity and response enthusiasm.

From the open answer, we can see that Danmaku is more interesting than a chatbox. It will also reduce the number of students who wander off during class. So maybe the Danmaku should develop more interesting features. The participants advised some interesting features for Danmaku, which might be a good idea for future improvement. The net connection sometimes is not stable. Online communication needs a strong connection to keep the students and lecturer interactions successfully. The Danmaku font colour and size should be able to be customized to increase users' motivation to use Damaku to communicate. Also, the Damaku should add the emoji function to allow users to share their feelings with Damaku. For example, users can send question emojis to indicate that they don't understand the content or see the smiling emojis to greet the lecturer. In addition, the beauty camera function can also be an improvement to let users be more willing to open the camera and interact. This is confirmed by the increased response rate and user activity found in our analysis after the addition of the Danmaku feature to webRTC. The Damaku can provide entertainment, information, self-expression, and a co-viewing experience, which will be helpful to students learning online [10].

Whereas we considered the improvement of this usability problem existed in the WebRTC applications, we are confident that the implementation of Danmaku feature increased the interaction level for users by more directly displaying other user's chat message. By making the using scenario rich-in-interaction, we have partially achieved the target of mitigating "the talking head" issue we previously mentioned in the relative literature. Our users' positive overall feelings and supportive feedback also showed that the Danmaku feature implementation was successful. Moreover, our participants also show us a willingness to continue using this kind of feature if this could be broadly implemented into other similar but wider used applications such as Zoom, Microsoft Team, proving this is overall a nice approach and technical solution with large potential.

7 CONCLUSION

In this project, we've explored Danmaku as a way to improve interaction in online education scenarios. We developed two WebRTC based web clients, one with the basic chat functions and the other with the Danmaku feature in addition. We then conducted a control experiment to see if Danmaku could add to the interaction between lecturers and students. The experiment and survey results answered our research question. They clearly show that Danmaku has enabled participants to interact better in online education scenarios, and therefore improved their user experience. During

the developing stage, we've found that program stability is a critical factor that developers shall pay special attention to when using open source repositories. Also, we've realized that a realistic goal set at the beginning will help avoid unnecessary work. During the experiment stage, we've learnt that network condition significantly impacts the user-perceived quality of lectures held through WebRTC clients. Therefore, it is important to perform the experiment under a constant and stable networking environment and eliminate unpredictable external influences on the outcomes. Due to the restricted time and resources, there are some limitations of the research. Taking those into consideration, we have identified some possible directions for future works. Firstly, In this experiment, we have focused only on the experience of the "student" role in an online lecture. However, we realized that the Danmaku feature could also help the lecturers see the responses from the audience in a more direct way. In this sense, they will be able to react flexibly without delay, compared to using a traditional chat panel. Further research could involve participants playing the role of the "lecturer", and study whether their experiences will be improved by Danmaku. On the other hand, under the current lockdown situation, the participants in our experiment are limited to UoA master students, and most of them are from a technical background. For future works, we may extend to students doing bachelor or PHD degrees, and also from various backgrounds like arts or commercials.

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Appendix A CONSENT FORMS

Please refer to the Consent Forms.pdf in the Appendices folder.

Appendix B PIS

Please refer to the PIS.pdf in the Appendices folder.

Appendix C QUESTIONNAIRE

Please refer to the Questionnaire.pdf in the Appendices folder.

Appendix D PROTOCOL

Please refer to the Protocol.pdf in the Appendices folder.