Designing Video Conference(VC) Software to Hold Teaching Assistants(TAs) Office Hours Remotely for CS Courses with Programming Coursework.

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Abstract

In Computer Science education, teaching assistants(TAs) play a vital role in reducing the faculty's workload and enabling peer-to-peer communication between students and TAs. Hence TAs office hours are as important as a classroom lecture. But due to COVID-19, all the classes moved online, and we started using the video conferencing applications more than ever to continue our education. Even though there are studies to understand what design features affect online education, TAs office hours are ignored; nonetheless, they are an integral part of CS education. So, we explore TAs office hours via video conferencing applications in this work. We ventured to understand how we can improve the effectiveness of the TAs office hours via video conferencing application from a User Experience(UX) Design perspective. We used contextual inquiry and previous work to understand what features users would like. We created a prototype based on those data and conducted usability testing to confirm the insights from the earlier methods.

Keywords: Teaching Assistants, Video Conferencing(VC) Applications, User Experience(UX) Design, Online Learning, Office Hours

1. Introduction

Teaching assistants play a vital role in a computer science education, whether in an undergraduate program or a master's program, especially when the course is programming heavy and needs inputs outside the class hours. As pointed out by [Riese and Kann, 2020], TAs are widely used in CS education as it helps to reduce the workload on the faculty and enable peer-to-peer communication. As discussed in the work [Ren et al., 2019], TAs help students understand the problem and assist them in finishing the assignment. Also, it claimed that 90% of the students who completed the semester visited the TAs over the semester. Moreover, work reveals that TAs help students in testing their assignments. In addition to this work done by [Kwik et al., 2022] presents that students use problem-based strategies where TAs and students try to address the immediate problem at hand.

Work done by [Riese et al., 2021] demonstrates that TAs faces challenges in addressing students with special needs, student dealing with personal problems, students working in-group, and other vast diversity of students. As discussed earlier, TAs play a significant role, and at the same time, they face challenges in conducting office hours. However, it was easier to run office hours in person where students could show their code, and TAs could assist in debugging the code and pointing to what needed to be fixed.

[Crick et al., 2021] discusses how COVID-19 has impacted CS Education and forced them to fall back to emergency remote teaching. We have learned to live with COVID-19 by virtually doing most of our work. TAs office hours are no different. This has only increased the challenges for TAs and students. As said by [Hill and Fitzgerald, 2020] the pandemic has pushed everyone online, and it has had a significant effect on student and teacher interaction and learning. The same applies to the TAs and student interaction. Students want to connect with TAs personally and ask questions that they cannot ask in front of the entire class.

As discussed in length by [Zhang and Vamos, 2021] the video conferencing(VC) applications came into prominence during this period, which helped deliver the lecture online and enabled many students to pursue their education safely. TAs office hours are no different. Also, it is challenging for some students to attend office hours due to their schedules. Attempting to hold TA hours on VC applications could not achieve the same effect due to the various challenges it offers. The existing VC applications are not explicitly designed for hosting TA office hours and eLearning. Even though they offer features like remote access, screen sharing, etc., one can manage to host office hours; they are not enough to hold TA hours smoothly.

1.1 Problem Statement

Even though there have been studies to understand the challenges in conducting the TAs office hour, there was no research on running TAs office hours on video conference applications. [Zhang and Vamos, 2021] explore UX perspective of VC applications on online education, they haven't considered the TAs office hour situation in their study. We strongly believe that our paper could fill the knowledge gap and address the need for the UX of VC to conduct office hours.

Even though In their paper, [Zhang and Vamos, 2021] explore the reasons behind lack of engagement in online education via video conference applications and what user experience design factors are affecting the engagement, the paper doesn't answer the question. Moreover, it is very important to study the above question because this is one of the main challenges faced by the students while attending the TA hours online.

Students who joined the VC office hours have to wait in the waiting room until TA pulls them to the main window. But the TA doesn't have any idea what's student is going to ask and can't prepare in advance. But adding visibility to what students are going to ask and question type etc. helps TA better prepare and he can combine the students whenever the question is the same.

When TA office hours involve programming subjects, most of the time students have to share the code to the TA and TA might need to edit or point out specific lines of code. Even Though we have options like Sharing the screen and providing remote access, they sometimes are not effective due to network lag or sometimes difficult to communicate. As

part of this question I want to investigate if providing a common window similar to google docs where both students and TA can edit the files helps improve the user experience.

1.2 Purpose and Research Questions

As described in the problem statement, we want to research how the UX of Video Conference applications improves the effectiveness of the TAs office hours. When a student enters the VC for office hours, there is not much visibility, and they are waiting for the TAs to allow them to join the call. Similarly, TAs knows little about what students want to ask.

So we want to understand what users want to see during office hours on VC applications. Once we know those factors, we can use them to design the UX of VC applications.

RQ1: What would the students or TAs like to see when they join office hours on video conference applications?

We can utilize the findings from the previous research question and apply them to generalize the design features and study how it affects the effectiveness of the TAs office hours.

RQ2: What design features improve the effectiveness of the TAs office hours on video conference applications?

1.3 Scope and Delimitations

In this work, we are focusing on hosting TAs office hours on video conference applications from the perspective of UX design. Also, we are considering Zoom as the video conference application as that is used the most in our university. Also, we are not considering the effects of hardware, internet connection, etc. We are evaluating solely from the UX design perspective. Also, for the study, only courses with heavy programming are considered as they are more challenging to conduct the office hours and are known to be attended by students regularly.

Studying student-TAs interaction is not straightforward. We can record the audio and video of the interactions and research, but this may not yield actual results as the participants already know they are being recorded; they might behave differently in natural settings. Also, conducting the semi-structured interview won't give enough insights as users always fail to articulate what they want and how they feel. So participatory design requires a lot of effort from a setup standpoint, and users need to be given some information to ask them to create the design.

Because of the above reasons, in our work to study the research questions identified for the focus area, Contextual Inquiry and Artifact Creation seem a better choice. We can better understand the behaviors and capture the process in its natural settings through observation in the field and inquiry. These parameters help answer the research questions better. This gives a chance to observe and probe simultaneously, which adds to the effectiveness of the research. Then by creating artifacts, we can create a working mockup of the

UI and make it available online; hence users can use it and provide feedback. We can utilize the data collected from the contextual inquiry, design the UI, and collect feedback from all the stakeholders. This way, we can effectively answer the questions.

1.4 Outline

The paper proceeds as follows: Section 2 contains a series of previous works, a review of relevant literature, and the knowledge gained from the literature. Section 3 describes our methods and the prototype creation process that we tested with online students—followed by the findings from our approaches and the analysis in Section 4. In Section 5, we discussed the adopted methods, the main results, and the related results. We concluded in Section 6 by summarizing our study together with some crucial future research directions

2. Related Work

This section reviews some previous work on CS Education, TAs roles, online education, video conference applications, and UX design. Also, we discuss how these works are related to our research and what different aspects we are bringing through our work.

2.1 CS Education and Teaching Assistants

In Computer Science education, Teaching Assistants are widely used as it reduces the faculty's workload and gives time outside the class hours for students to clarify their doubts. Moreover, it allows focusing on a smaller group of students during lab settings and office hours. In their work, [Riese and Kann, 2020] studies the experiences of the TAs through semi-structured interviews and thematic analysis and says that TAs play a role of a teacher, friend, tutor, grader, mentor, and apprentice. So, we can understand that TAs role is more complicated than what we know and needs further study on this relationship, more so in a remote setting.

Also, work done by the [Riese, 2018] highlights the improvements needed in communication channels and methodologies in performing the role of a TA in lab sessions. That indicates the importance of communication in TA-student interaction, and we need to focus on improving the communication in the remote setting.

Work done by [Ren et al., 2019] and [Kwik et al., 2022] emphasizes what kind of help students seek during TA office hours and how TAs respond. These works highlight the student-TA interaction and how it can be improved. According to [Ren et al., 2019], the student-TA setup is not studied well in CS education due to difficulties in evaluation. They use a program-design methodology to understand what students ask based on the survey data. They claim that more students seek help in testing their application and even understanding the problem. For TAs to effectively convey the message to the student requires a collaborative approach which is achieved very smoothly in the in-person scenario. In addition to this work done by [Kwik et al., 2022] presents that students use problem-based strategies where TAs and students try to address the immediate problem at hand.

Work done by [Riese et al., 2021] demonstrates that TAs faces challenges in addressing students with special needs, student dealing with personal problems, students working in-group, and other vast diversity of students. As discussed earlier, TAs play a significant role, and at the same time, they face challenges in conducting office hours.

2.2 The Pandemic and Online Learning

[Crick et al., 2021] discusses how COVID-19 has impacted CS Education and forced them to fall back to emergency remote teaching. We have learned to live with COVID-19 by virtually doing most of our work. TAs office hours are no different. This has only increased the challenges for TAs and students. As said by [Hill and Fitzgerald, 2020] the pandemic has pushed everyone online, and it has had a significant effect on student and teacher interaction and learning. The same applies to the TAs and student interaction. Students want to connect with TAs personally and ask questions that they cannot ask in front of the entire class.

Also, [Zou et al., 2020] discusses two types of online learning. They are synchronous and asynchronous. In the case of synchronous, all the participants need to be present simultaneously and can collaborate. In the case of TA-student interaction, we are expected to have synchronous online type education, so we have considered only that type of education for our study. The authors claim that VC applications like Zoom, Microsoft Teams, and Webex are not designed for eLearning and recommend improvements in screen sharing, intuitive icons, viewing students' screens during tests, etc.

In the paper [Russell et al., 2021], The panel consists of people who know about video conference system development from an early stage and discusses what did work and what didn't in case of online meetings via video conference applications during the pandemic time. The author discusses how COVID-19 mandated the use of video conferencing applications.

2.3 Video Conferencing Software

In the paper [Zhang and Vamos, 2021], the authors explore the reasons behind lack of engagement in online education via video conference applications and what user experience design factors are affecting the engagement. They discuss various scenarios where users face pain points and suggest features to make online education more effective. Both of these takeaways relate to the focus area because the authors discuss how UX design of video conference software can affect student engagement especially during the pandemic time.

In another work by [Ming et al., 2021], the authors discuss how video conference applications can be used for collaborative work and why users do not often use collaborative tools provided by the current virtual conference applications. They also provide guidelines to interface design to encourage the use of collaborative tools. These takeaways relate to the focus area because the authors provide guidelines for interface design to improve the collaboration work and in most of the time TA office hours involves collaboration between teaching assistance and the students.

Also, work done by [Meluso et al., 2020] considers hybrid collaboration where few work face to face and few online. This is a possible case in TAs office hours in today's world. The authors propose four orders of design: they are symbols, objects, action and interaction, and environments. By considering all these factors, one has to design the application.

In work done by [Karabulut and Correia, 2008], the authors compare four web-based video conferencing systems for online education and provide insights about which one is better based on student and teacher requirements. The study audio, video quality, cost, and ease of use of features were observed. They find that the instructor's audio varies according to the interface design. This study helps to understand how design of web based video conference applications enhance online teaching and provides guidelines to design such applications.

Also, in the work [Correia et al., 2020], the authors examined various VC applications and provided ideas about learning-related features. They cross-referenced with the learning cycle elements such as concrete experience, reflective observation, abstract conceptualization, etc. These features apply to TA office hours as well.

2.4 User Experience (UX) Design

As we are approaching the focus area from the UX design perspective, it is essential to understand some of the aspects of UX Design. In the work [Xu, 2012], the authors study various challenges while designing the user interface and provide step by step process to design for better usability.This study helps to follow a proven design process to improve user experience and be on track keeping the end goal in mind.

In the paper [Nonthamand, 2020], the authors study opinions of academic experts on design of teaching using the use of video conferencing applications and provide guidelines to develop teaching strategy. This study helps to understand how teaching assistants can prepare themselves while conducting the office hours using the applications and set the expectation for students as well.

Also, [Patil et al., 2016] proposes five UX activities as below to achieve effectiveness in the UX design.

- User interview and identifying user personas
- Understanding user context
- Low and high resolution wireframes
- GUI design
- Usability test

3. Method

This section describes the methods used to conduct our research. First part explains the method used to answer the first research question and the second part narrates the method

used to create the artifact. At the last we discuss the ethical considerations we have taken into account in order to protect the participants.

3.1 Literature review and Contextual Inquiry

As we know that literature reviews are the base of any research, we first reviewed the existing literature to understand cues in online learning and TAs office hour in CS education. The ideas obtained from the literature review are used as the base to conduct the contextual inquiry.

Karen Holtzblatt and Hugh R. Beyer described contextual inquiries are the best way to know how users use the product under a given context. We can collect the data about the users in the field, and this data can be used to create the prototype and conduct usability test on that to refine the concepts with the user. The method is based on the principle that people are unable to articulate their practice.

In this method, we conducted the one-on-one field interviews with the user to observe carefully how to they behave, what are their practices and ask any questions based on their action to understand their actions better.

We have identified 3-4 students each from three different types of courses: Light programming courses, Medium programming courses, and Heavy programming courses. Also, we selected 2 TAs each from corresponding classes. Also, participants will be given enough information about the method and suggested they be proactive in talking about anything they feel they want to discuss with the researcher.

So, we had 24 student-TA pairs to conduct the study. We ran the research for each TA-Student team over the semester for various assignments to eliminate any bias concerning the timings of the study. Each pair were studied for an hour session, and the participants were repeated at a different time of the semester. The participants were selected from the school of computing at the University of Utah and were paid for their participation so that the method produces trustable results. During the observation period and inquiry, notes were collected to record the data used for the analysis. Also, interviews were recorded for future reference. Once the data was collected, we analyzed the data and documented the findings by reviewing the data for 2-3 weeks.

The method provides a highly detailed user's point of view, and hence accuracy is guaranteed. As this method is unfamiliar and driven by the participants, setting the expectation is the key. Moreover, this method is time-consuming as it involves studying one individual at a time, and participants decide how long it can run. Also, data obtained by this method needs to be backed with other ways to get a more precise idea.

3.2 Artifact Creation

Based on the insights from the previous study, we have identified what users want to see during office hours through VC applications. By following the UX design process as men-

tioned in the related works, we created the prototype to allow users to test it and confirm the design features users want in a VC application.

We created the mockups using Figma by incorporating the UX features so that we can practically put the ideas we conceptualized by conducting the research for our first question. Then we made the design available for testing online, where users can give feedback. We tweaked the design to meet the user's idea based on the input, and the final prototype was finalized upon secondary usability testing.

The participants involved TAs, students, and professors. This involved many participants who could take this online survey on their own time and convenient place. The more the participants, the better it is. Hence there was no restriction on the number of participants, but we cared about who our participants were. The study involved designing the mockup for 1-2 months and then collecting feedback available for a month duration. Even though designs were open for feedback for a whole month, it generally took 1-2 hours of participant's time to rate the plans and give feedback. Then we needed a couple of weeks to study the findings and document them.

This method allows design using UX Design applications and provides the model online so that users can test the application. This helps in verifying the research findings and any issues with the application. Also, end users are engaged in this method. But the process is time-consuming and involves designing the application via design tools such as Figma. Also, we have to recruit many end-users to get accurate feedback. This is a perfect approach to testing the user experience design and gives insights about issues in design that can be rectified after the user's feedback.

3.3 Scenarios and Usability Testing

To conduct the usability test on our prototype, we have considered the below scenarios. Throughout these scenarios, we probed the users and asked them contextual questions to understand their needs for the applications. Thus the scenarios are as follows:

- Scenario 1: Student joining the Office Hour

  In this scenario, the student joins the office hour using the joining link as shown in figure 1. As we can see, there is not much information for the students, and it is sometimes frustrating as they have to wait without any information from the TAs. Also, sometimes, students stay in the waiting room without any luck as the schedule gets over for the TA; they end the meeting without any information.

- Scenario 2: TAs checking the participants to allow students to join the bridge

  In this scenario, TAs look for several students waiting in the waiting room so that they can pull them to the main room, as shown in the figure 2. In this scenario, TAs don't have much information about the students and what questions they will ask. So, this doesn't help TAs make informed decisions.

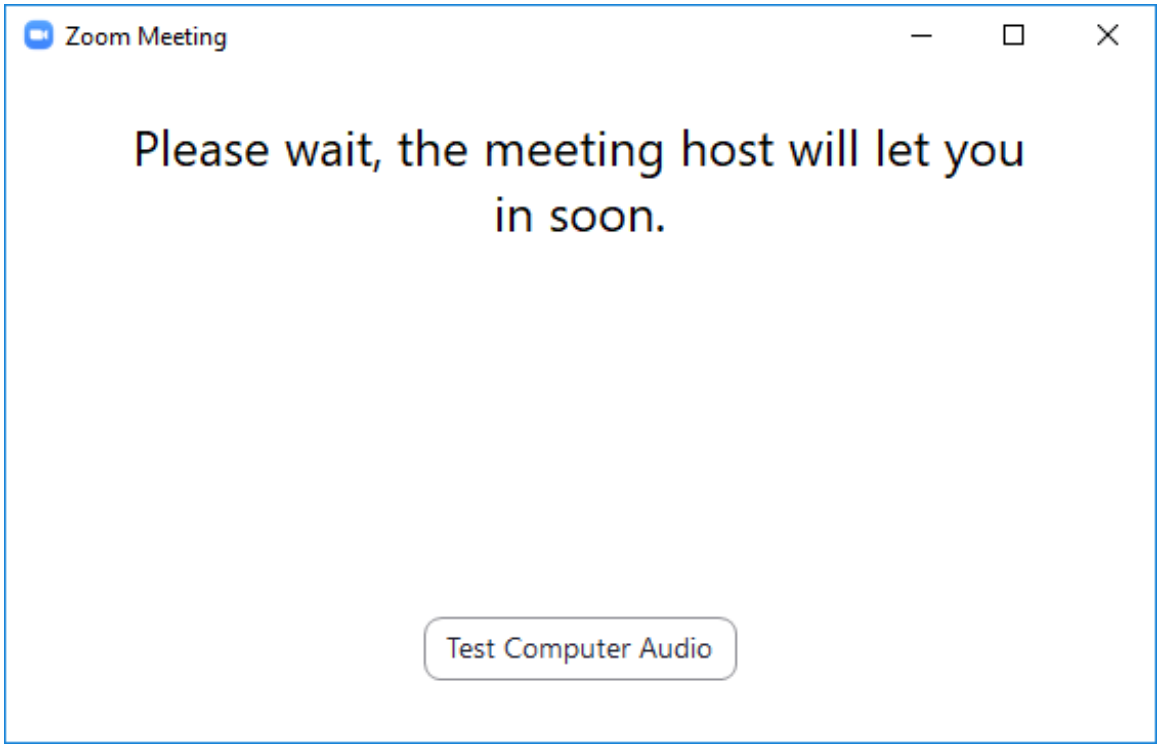

Figure 1: Student in the waiting room to join the office hour before the design changes.

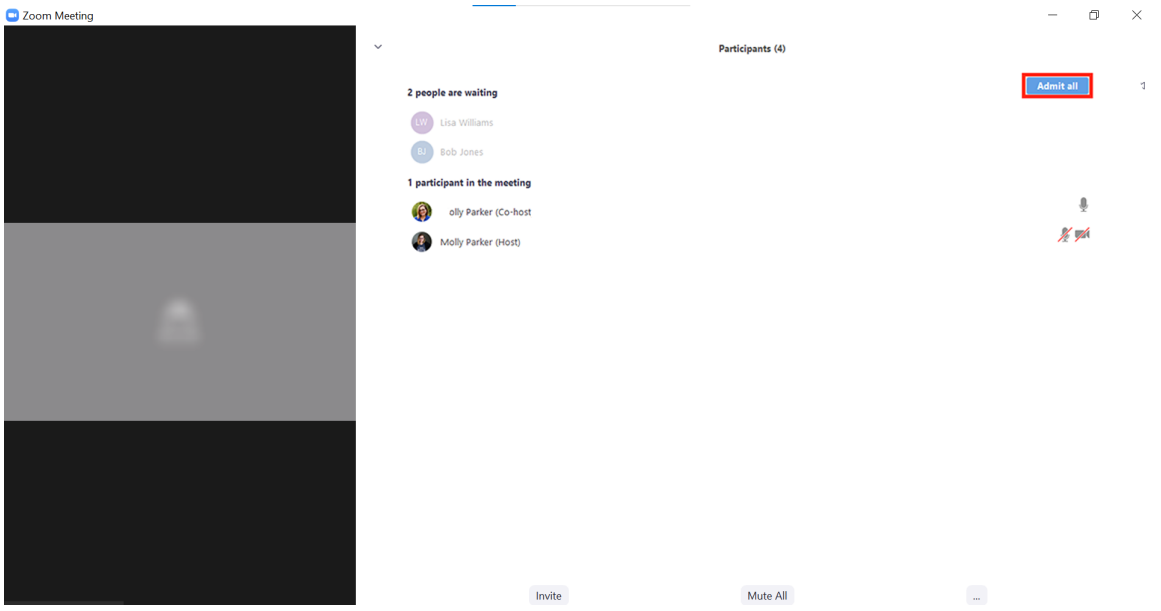

Figure 2: Participant's screen before the design changes.

- Scenario 3: Studnet and TAs debugging the code together

  In this scenario, TA and students want to debug the code together as TA couldn't figure out the issue just by looking at the code. Even though we have the option to share the screen, TAs find it challenging to debug and point out the problems in the code. So, at times it becomes challenging to communicate it to the students.

3.4 Participant's Recruitment

We have recruited the participants based on their voluntary participation. We announced our study for the student TA community of the school of computing at the University of Utah. Once we received the enrollment for the study, we studied and chose the people from courses having different programming coursework. It was challenging to identify the student TA combination from the volunteers; if we couldn't select a particular combination, we convinced the TAs by explaining the importance of the study.

To complete the usability testing, we decided to use all the students and TAs, including those not involved in the contextual inquiry. So, the prototypes were available for testing for the entire student community of the school of computing, the University of Utah, and they could provide the feedback anonymously.

3.5 Ethical Considerations

To conduct our research ethically, we didn't collect any personal data. We collected the details about their class, assignment type, etc. Their name was not used. Also, feedback for design was received by an anonymous user, and their consent was secured to use any of their data.

4. Results

This section presents the results of the research we conducted for the focus area. Insights gained from literature review and contextual inquiry are shown in the first section, followed by the design and implementation of the features that improve the user experience.

4.1 Literature review and Contextual Inquiry Data

By analyzing the data obtained from the literature review and contextual inquiry, we understood what users wanted for the scenarios we discussed in the method section. We have discussed the findings we have obtained at the end of the first stage of our study for each scenario.

- Scenario 1: Student joining the Office Hour

  As expected, in this scenario, having no information about what was happening in the background made students restless who were waiting for hours to talk to the TAs. So, users wanted to understand how many students were in the queue, how much time was spent on each student, and the estimated time for them to talk to the TAs.

- Scenario 2: TAs checking the participants to allow students to join the bridge

  TAs also had no information as to what students wanted to ask. So they had to attend one student at a time. In these cases, even though more than one student had the same question, TAs had to spend time with each student explaining the same concepts or solving the same problem. So, TAs wanted to see what students were asking; if multiple students were asking the same question, they intended to combine the students and answer them at once.

- Scenario 3: Studnet and TAs debugging the code together

  When TA and student wanted to understand the issues with the code, only the student shared the screen, and explaining the code to the TAs was not effective. Every student approaches the problem in their way and writes code differently. So even though TAs were aware of the solution, they found it difficult to understand what the student was trying to communicate and understand where the issues lie in the solution. Even though TAs guided the students to debug the code, students find it challenging to debug, especially those who are exposed to the programming courses for the first time.

  So TAs wanted an option to edit the student's solution rather than explaining the complicated code because once it works and debugs, students find it easier to understand what's going on rather than just imagining what TAs are trying to say. So, they like if they have any window where they can edit the code and share the code with students to debug and understand the solution better.

4.2 Prototype and Usability Testing Data

We designed the prototype based on the cues we obtained from the previous research, and when we conducted the usability test, some of the designs users didn't like. So, based on this feedback, we remade the designs and conducted usability testing on the new design, and the majority of the users were satisfied with the result.

5. Discussion

In this section, we discuss the methods we have used for our study and how they affected the validity of our research. Then we analyzed and discussed the results. Finally, we have pointed out some related findings not explicitly related to our research question.

5.1 Method Discussion

In this part, we have reflected on our methods, limitations, and unforeseen events. Then we have analyzed their implications on the results.

When we studied the previous work, some of the work we have studied were published

earlier than ten years or more. There is a possibility that the findings we have used in our research might not be recent. Also, some of the papers were very recent and were studied just in the last year or so. So, there hasn't been too much research on online education, and also, the research is done only for a small amount of time. So, these biases may have impacted our results as they are based on the work done significantly earlier and just in the pandemic. So, we feel that contextual inquiry eliminated these biases.

While conducting the contextual inquiry, we noticed that students have different personality traits. As they already knew that they were being observed made some of them nervous, and they didn't respond appropriately to questions on why they were feeling so in a particular context. Given that only a few students were not feeling comfortable, we believe that it might not have made much difference to the results. However, the problems they were facing were similar.

Also, when we conducted the usability testing online, we didn't know how users felt. Instead, we had to rely on the feedback we had received. So, we find it hard to understand how to make the design changes for further testing. But we consolidated the input and made the design changes. Instead of going online for the second time, we did it in person at the university. This time sample size is significantly less, but we could understand whether the user liked the design, if not, why. So those findings were beneficial in finalizing the design.

5.2 Results Discussion

The contextual study provided insight into what features users would like to have in the video conferencing application, but the artifact creation was not conclusive. So we had to change the design based on the feedback and conduct a usability test again to conform to the design features.

When the research is conducted through contextual inquiry, most students would like to see the student queue and where they stand in the line. Also, they would like to see the approximate time spent answering each student's questions, and hence they can estimate when their turn comes. The TAs would like to see a list of students in the queue and their questions. Also, students wanted to join in pairs. So we created various designs incorporating these ideas and insights. But when we conducted the online survey for the designs and mockups majority of the users disliked the design and features.

Now, both the research methods are contradicting each other, we need to analyze what could be the reason for the difference in opinion. One reason could be that the designs we have created are not what users wanted even though they would like to have the features in the application. In that case we can conduct the contextual inquiry or semi-structured interviews with the designs we had created and gain more insights as to what is wrong with the designs. Then we can incorporate that feedback into the designs. As there is an ambiguity in the result, our research question might not have been answered fully and requires careful study.

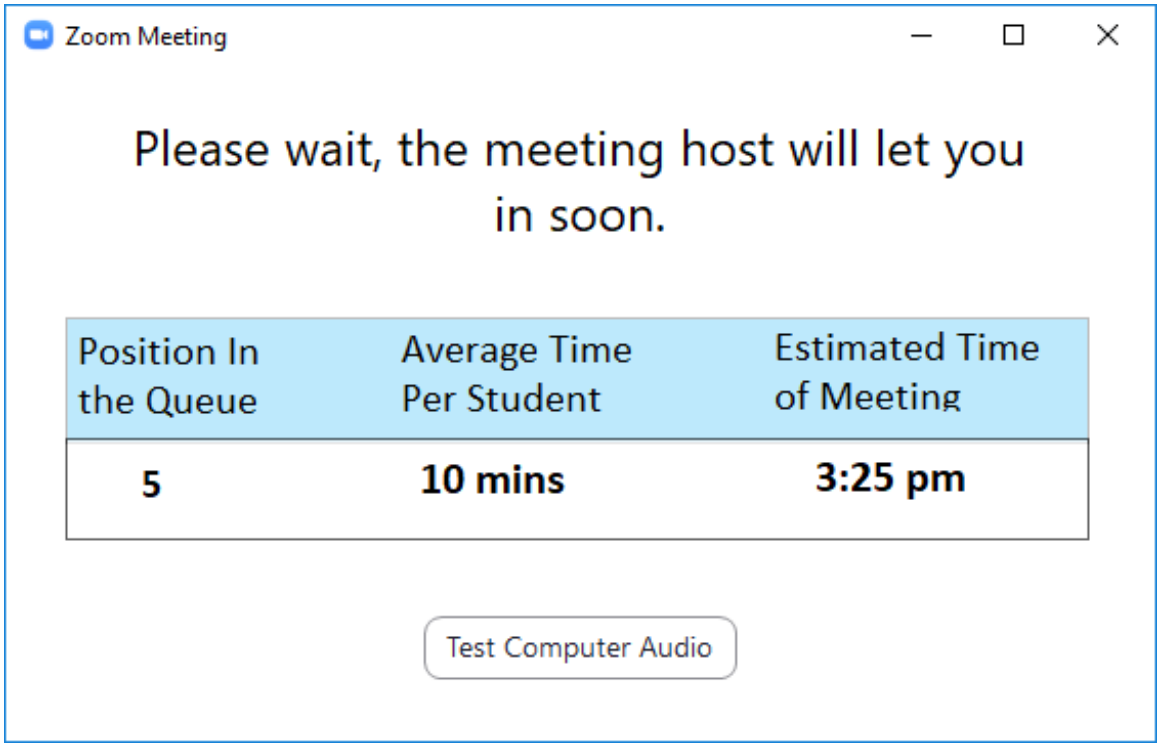

Figure 3: Student in the waiting room to join the office hour after the design changes.

Even though the results are not clear and contradicts each other, it is not a wise idea to implement these designs in the product. But these results can be used for further study and ask different questions to the users so that we can get better results next time.

Conducting the contextual inquiry with more students and TAs would have helped to gain more insights into the users behavior. Also, while designing we should have considered the results carefully and they have been incorporated wisely. Also, an intermediate study could have been conducted before getting the feedback online after incorporating the intermediate feedback.

Nevertheless, we have identified the design changes for the Zoom video conference applications to increase the effectiveness of the TAs office hours. So for the three scenarios, we had identified earlier, we have finalized the design as shown below:

- Scenario 1: Student joining the Office Hour

  We have added the features students wanted to see when join the waiting room in figure 3.

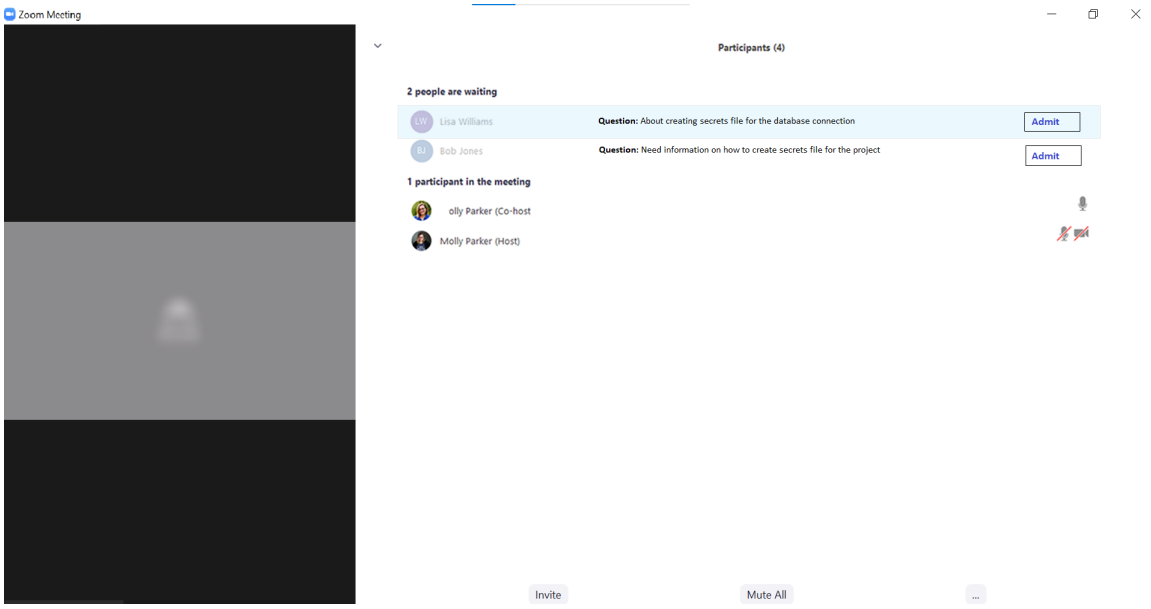

Figure 4: Participant's screen after the design changes.

- Scenario 2: TAs checking the participants to allow students to join the bridge

  We have added the features TAs wanted to see in the participant's screen in figure 4.

- Scenario 3: Student and TAs debugging the code together

  We have added the feature to share the code and edit for TAs and studnets in figure 5.

5.3 Related Findings

Firstly, We find that Social Translucence mentioned in [Erickson and Kellogg, 2000] plays a vital role in communication and collaboration tools. Even though the paper is outdated, we could reestablish the visibility ideas are fundamental in today's era. So we couldn't neglect these ideas in implementing the communication tools. Moreover, TAs and students find it challenging to communicate their opinions, especially in heavy programming courses. Students don't know what questions to ask and are clueless. A significant amount of study is required to bridge these gaps in computer science education.

6. Conclusion and Future Works

This work identified what design features students and TAs would like to see during TAs office hours via Video Conferencing Applications. Also, we created the prototype and produced it for user testing. Also, we incorporated the feedback and conducted secondary usability testing. We have presented the design changes for the video conferencing applications to optimize the effectiveness of the office hours. Also, we need to analyze how these

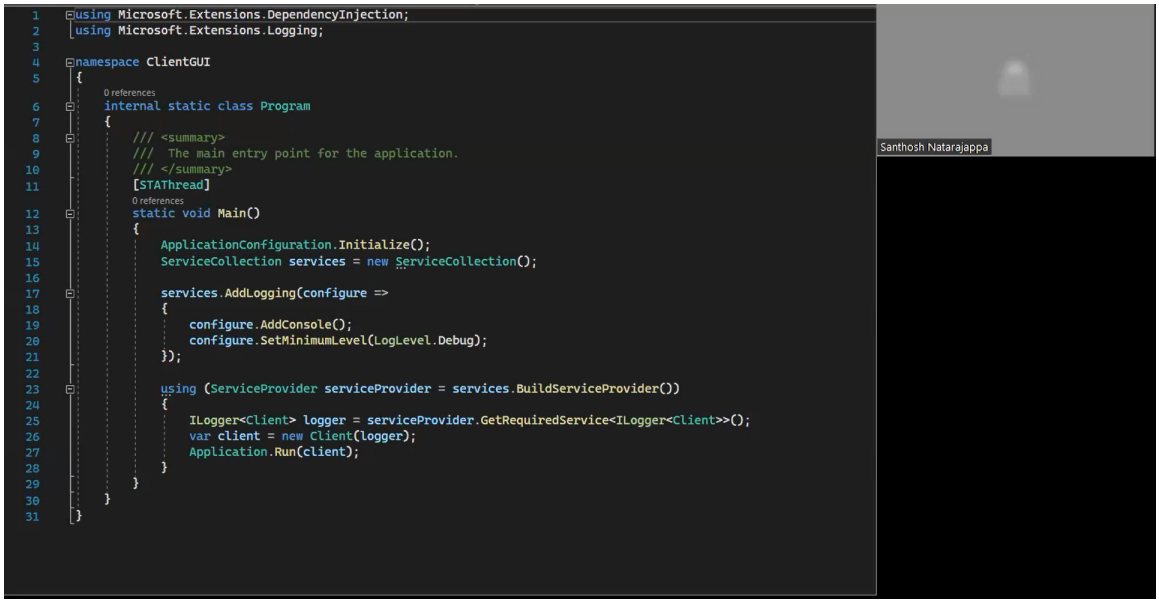

Figure 5: Coding sharing window.

changes will fare in the long run. Through our work, we have contributed in the below areas:

- How TAs office hours are conducted via video conferencing applications.
- What features students and TAs would like to see in a VC application during TA office hours.

In our methodology, we had some limitations where artifacts couldn't confirm what contextual inquiry has informed. Also, the user sample would have made some difference. So, in future work, we can consider conducting the contextual inquiry on more students and TAs, and also, we could have run the semi-structured interview before creating the artifact. Also, these designs aren't studied from feasibility or financial perspective. Moreover, more research is needed to understand student TA interaction in computer science education to understand if the creation of the software plays a role in the effectiveness of the TA office hours as some of the problems are fundamental to the process and knowledge rather than the software itself.

Acknowledgments

We wish to thank Prof. Wiese for the valuable feedback and guidance throughout this work; without that, this work couldn't have shaped into what it is now. Also, We would like to thank Jessica, Pranav, and Jared for their valuable peer feedback.

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