CS 564
Remote Collaboration Report

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Executive Summary

1. Research question and propositions	Overall RQ: What kind of challenges are CS students facing while collaborating remotely on research work during COVID? RQ1: What are the various channels and tools via which CS students facilitate remote collaborative research? RQ2: How has remote work been affected by remote collaborative meetings?
2. Units of analysis.	The meetings itself, encountered problems, Tools, CS students
3. Type of case study	*Exploratory.* The case study is inclined towards an exploratory analysis. We wanted to look at what challenges CS student researchers are facing while collaborating remotely, what tools they are using and how they are using them to facilitate in collaborative learning. Whether these tools have a positive or negative impact on the way they communicate, solve problems, carry out research collaborations, brainstorm on ideas, identify points of interest etc.
4. Data collected.	1) Observations during meetings regarding what tools these CS students use and what challenges they face 2) Semi-structured Interview regarding meetings
5. Code Set Origins	● **W**here our code set came from: We are following a top-down approach from a published theory, the theory of remote scientific collaboration (TORSC) [1]. Olson et. al developed TORSC based on previous research on collaboratories. TORSC states five categories of factors pertaining to the team, and their task management, which play a role in successful distance collaboration, such as (1) the nature of the work, (2) management, planning and decision-making, (3) common ground, (4) collaboration readiness and (5) technology readiness. Since our research study involves the observation and analysis of the process of remote collaboration, only a few of the codes listed in the referenced paper actually have relevance to our study. There are codes which are talking about the success and outcomes of remote collaboration and this aspect of the paper does not entirely lie within the domain of our study. Therefore, we decided to not include these codes in our codeset.

	• **Why** did we choose this code set? We chose this theory over others (such as Cognitivism, Collaboration theory) because the basis of this theory entirely coincides with our case. Olson's work specifically investigated scientists who are often remotely located and the complexity of their work, as well as skills and equipment they used to perform their research. In our project, we are also investigating how people (our population: Student researchers) are doing collaborative work and specifically want to look at how they are using specific tools and why.

1. Introduction

During COVID, students had to unexpectedly change their work environments and had to adapt to a different way of working. However in research, it is critical for students to communicate and collaborate. With everything being implemented online, the quality of remote collaboration is one of the important components that assures efficiency of the remote work system. Therefore, this study aims at analyzing the various factors of remote collaboration among Student researchers.

The theory of remote scientific collaboration published by Olsen et.al [1] coincides with our case study. Olson's work was specifically focused on scientists who are mostly remotely located and on their complexity of work, skills and equipment they used to perform their research. This matches with our project as our analysis deals with investigating how people are collaboratively working together. Their study states various categories, out of which there are five major factors that affect remote work. This pertains to team work, and their task management, which play a role in successful distance collaboration, such as (1) the nature of the work, (2) management, planning and decision-making, (3) common ground, (4) collaboration readiness and (5) technology readiness.

Since our research study involves the observation and analysis of remote collaboration, only a few of the codes listed in the referenced paper actually have relevance to our study. Codes which refer to the success and outcomes of remote collaboration does not entirely lie within the domain of our study. Therefore, we decided to not include these codes in our codeset.

Our study is an embedded single case study since we have only one case (remote collaboration) but multiple units of analysis(meetings, tools, students themselves) and is an exploratory study. Our case is "remote collaboration among computer science (CS) students" as it is an existing phenomenon in the current world. It is more common for CS students to be collaborating remotely; our case can represent the entire CS student population.

Our research question aims at understanding the challenges and adaptations that CS students are experiencing while collaborating remotely on research work during COVID. Towards that, we framed two main research questions:

1) What are the various channels and tools via which CS students facilitate remote collaborative research?

2) How has remote work been affected by remote collaborative meetings?

The theories corresponding to the nature of the work, management, planning and decision-making, common ground and collaboration readiness answers our research questions on how research students are currently managing to collaborate remotely, and whether they are able to do so effectively.

On the other hand, technology readiness and tool use point towards the usage of technological challenges faced while collaborating remotely. Our codes aim to capture the essence of what our RQ's are trying to figure out. Our Unit of analysis are the meetings itself, the encountered problems, tools themselves and CS students.

2. Case study design

Our data was generated from several interviews and observations, and each of these followed a certain methodology listed below:

We collected the data from:

(1) Observations during meetings regarding what tools these CS students use and what challenges they face. We observed various important factors like what new tools are being used for remote collaboration and how they are affecting research work, misunderstandings or repetition of any explanations, their body language if cameras are on, the intonation of the participants, features of tools being used (e.g., Zoom share screen.) The observations were focused on rich insights into collaborative meetings and how research collaborations proceeded and how participating members interacted with each other using certain channels of communication.

(2) We conducted Semi-structured Interview regarding meetings (Appendix A)

The interviews primarily focused on getting an in-depth understanding of how researchers collaborate and what they feel about the tools they are using, what challenges they face and why they prefer OR not prefer remote collaboration.

We transcribed our data and divided it into segments of conversational turns. Given below is a sample of 2 segments from our data.

An example of our questions:

(1) “How much time did you spend on collaborative meetings last week? Can you walk us through one of those meetings: what did you discuss, how many people were involved, how many projects were discussed, what communication channel / tools were used?”

(2) What do you think about team members being able to express themselves and speak up about their opinions during the meetings?

(3) What communication channels did you use the most? (Emails, messaging, video or audio.)

For coding our dataset we first coded a small piece approximately 5% of our dataset and calculated our agreement using the Jaccard score. Initially, the agreement was not above 80%. We then discussed our coding rules and how they coincided with the selections we made. This discussion gave us a deeper conceptualization of the codes and how they fit our data. In our successive iterations of a new 5% of the dataset, our Jaccard scores kept improving.

After four iterations, which made up 20% of our data, we had a Jaccard score of 84% after which we coded the datasets independently. Given below is a sample of how our data was transcribed, broken into conversational turns and segmented on the basis of the paper-”A theory of remote scientific collaboration” (Olson, 2008).

Segments: Conversation Turns	Segment number	Code 1: The nature of the work	Code 2: Common ground	Code 3: Collaboration readiness	Code 4: Management, planning, and decision making	Code 5: Technology readiness	Code 6: Tool use
: [00:03:03] No, we all look on the same thing. We don't divide and conquer at least. So what we do is we and prayer before meeting, I just tell them that. Okay. Hey, so we don't have our next meeting X on X date, and we will work on this. X XYZ activities. Do you guys agree with it? And they will say, yeah. Okay. Or they'll be like, you know what?	4						
No, maybe we should work on this as well. And like, okay, let's work on that as well. On the day of the meeting, we just work on everything together. Uh, we are not, so our group meetings are the only time when we all work together or not project. Um, I don't think we work on it separately. Okay. I see. So you mentioned that you use discord for your meetings.		1	1	1	1		
: [00:03:56] Why would, why do you use discord? Like why this particular communication channel, like, do you usually use this for messaging also? Like if you need to interact with them really quickly, like you said, deciding on a time.	5			1		1	1

3. Codeset and Coding

In order to capture the true essence of the research questions and how exactly does remote collaboration affect researchers, the impact it has on their work, the effectiveness and productivity issues/boosts they experience and to assess the overall sentiment of remote collaboration, we picked up 6 qualitative codes and defined precise rules for each one of them in order to gain rich insights from our dataset. Our coding rules were extracted from the research paper Olson et al. and we picked the below listed relevant codes as follows:

- **Code 1:** (Nature of work) -- Whenever sentences mention about working chemistry and how team members interact with each other, we assign this code. An example of a segment which comes under code 1 is “Let's say if I am in an in-person room and you're all my team members, and I just like, I'm ready to do this. Uh, Um, they, I do this, uh, sweet. I do this and I forget about the fourth member. And I just keep talking to you three people. Then the fourth person would feel dejected. I will probably not contribute as much as if it's the same with online too.”
- **Code 2:** (Common Ground) -- Whenever segments talk about collective progress, mutual knowledge and team members sharing a common management or working style, we assign the data point this code. An example of this could be “I would say online people who contribute more rather than doing offline. This is just based on what I've seen so far or based on my previous experience. And it's. Um, so here's the thing, right? It all boils down to work kind of team member. They are who's a leader or who is trying to guide the conversation on discussions and stuff like that.”
- **Code 3:** (Collaboration Readiness) -- Whenever sentences mention about the data and workspace sharing mechanisms, they are bucketed into this code. Code 3 could be exemplified by this segment: “You have to see which cause it is on which page is just, they didn't. Then when you're working on the same thing, you rather stream or share your screen and everyone works on the same thing. So most of the time I do the writing work and everyone is pitching their ideas. Um, and I keep making the changes in it.”
- **Code 4:** (Management, planning, decisions) -- Whenever team members spoke about effectiveness, roles, responsibilities, timelines or leadership, we assigned this code. An example of a segment which comes under code 4 is “It's that no one has different tools compared to the other person. And if that is not the best environment for collaboration, I don't know what else is. Okay. So for an in-person meeting, what.”
- **Code 5:** (Technology Readiness) -- As the name suggests, whenever participants mention the preference of a technology, they were assigned this code. An example of this could be “And you have easy access to materials. You had the same Google doc that you're working on. It's not. And then people, so one person has a board that it wasn't this not habit. It's not like that everyone has equal resources. It's, it's kind of inclusive. You know, you, you can all pitch in and do the same thing.”
- **Code 6:** (Tool Use) -- Whenever participants mention the usage of a tool and why they use it or prefer it over another tool, this code was used. “So, so as, uh, as you know, like, uh, I think

I've mentioned this before, but anytime there is a group project, the first thing I do is start a Google drive”

We decided to not use some of the codes as some of them were not directly relevant to the research questions we were trying to answer. And we ended up picking the codes which were best able to capture the essence of our study in the best way possible.

4. Results

In this section, we describe our findings to the Research Question 1 (RQ1)-what are the various channels and tools via which CS students facilitate remote collaborative research, and the Research Question 2 (RQ2)- how remote work has been affected by remote collaborative meetings. Then we discuss the co-occurrence matrix and the insights extracted from it.

4.1 Remote collaborative research tools

Before we did the case study, we had two hypotheses for the two research questions.

RQ1: What are the various channels and tools via which CS students facilitate remote collaborative research?

Hypothesis 1: Most students used Zoom for collaborative meetings.

Here is the result of RQ1, and how it integrates with the code. In all code sets, the code 2,5,6 could answer the RQ1, which is common ground, technology readiness and tool use respectively. Following these codeset, we extracted the information that could answer the RQ1 from our database (Appendix b), which the link was listed on the reference pages.

Code 2: Common ground	Whenever segments talk about collective progress, mutual knowledge, beliefs, and/or assumptions and team members sharing a common management or working style
Code 5: Technology readiness	Whenever participants mention the preference of a technology, Collaboration technologies provide the right functionality and are easy to use, Technology readiness also involves reliability. If the technology is unstable (as some research proof-of-concept prototypes can be), people will be unlikely to use it
Code 6: Tool use	Whenever participants mention the usage of a tool and/or why they use it

a) When CS students used technology to communicate, such as scheduling a meeting, the results and related evidence showed below.

*Participant 1 [Segment ID: 5]: "**most people use discord** these days.. mainly because it is kind of **easy to use.**"*

Discord was used by participant 1 because it was "easy to use".

*Participant 2 [Segment ID: 137]: "*Why do you use discord?- i've been using **discord** for a long time. I had to shift from discord and it was a hassle. Everyone had discord and prefered them because it's **popular** and most people use it. zoom is easy too. in discord you just have to hop in a general channel and it's **easy**."*

Discord was also used by participant 2 because of the long-term usage of the communication tool as well as its popularity and easiness.

*Participant 1 [Segment ID: 47&48]: "..Is there a reason why you choose Slack or like Slack specifically?"": ..Uh, it's just like my research group is a **Slack**. So pretty. Yeah. So **they're pretty active** there. So that's **what we got used to**."*

Slack was used by participant 1 because the other team members' active behavior on that platform. In addition, it was also their common communication tools.

*Participant 2 [Segment ID: 46]: "Yeah. So we do not use emails. We usually do **Slack** or zoom or zoom."*

Participant 2 had the same reason for using Slack as participant 1, it was also because they didn't usually have the email habit. Instead, they usually used Slack.

In the results, both the participant 1and 2 preferred to use discord and slack, which we didn't think about in the hypothesis. Furthermore, the results were integrated well with the rules of code 2, 5 and 6. For example, by looking at the bold font of the first segmentation, ID 5, the participant said "..most people use **discord** these days...mainly because it is kind of easy to use." Back to the "code 6-tool use", the rule is whenever participants mentioned their usage of a tool or the reasons, it could be the tool that they use. Therefore, the tool's popularity and convenience could influence whether the tools would be used or not. In this situation, the tool that they used was discord.

b) The participants gave various answers when the participants used technology to remote collaboration, such as Google products, Zoom, AtlasTi, Qualtrics and Overleaf. The evidence is as follows below.

*Participant 1 [Segment ID: 8]: "but anytime there is a group project, the first thing I do is start a **Google drive**...**easier for everyone** in the team… I personally like to do it when you're collaborating on something…."*

Participant 1 used Google products as priority to do their collaborative work because it was easier for all of their team members.

*Participant 1 [Segment ID: 6]: "Um, so yeah, and also it has this on zoom. **Zoom** is easy too, but you*

have to schedule the meeting. You have to invite everyone and all of that, but in this car you just have to hop onto the general channel. So it's, it's easy. Um, so yeah, that's why I think he meant, but discord, um, mainly because it is kind of easy to use."

Participant 1 used zoom to do their collaborative work because they had to schedule a meeting to finish their work. Though using zoom is not his/her favorite method to do the collaboration, they had no other choice in the COVID-19 time.

*Observation [Segment ID: 99]: ""The software they use are **Atlas.ti** and zoom. The meeting topic was design discussion.."*

*Participant 2 [segment ID 54&55&56]: "Okay. One second tools, meaning uh, okay, cool. **Atlas.ti.**"Put it in the chat and stop DPI. Okay. Atlas RTA.""Is this a software you guys **commonly** use?""**Yeah**, this is a software that we use for qualitative coding."*

This observation showed that the participants used Atlas.ti to do their collaborative research. The participant 2 mentioned that they used this for qualitative coding. Therefore, the reason that they used this tool might be to finish their CS research requirement.

*Participant 1 [Segment ID: 9]: ": Genderly **Qualtrics** is also kind of bulky gold funds is a lot more easier to qualify Qualtrics as more options than Google forms, but it. It heavily depends on the questions that we want to put in the Google form. Right. Um, I've been using quantics like for the past few weeks, that is the main reason I was like, Oh, maybe Qualtrics might be **easier**."*

This interview of participant 1 showed that they used Qualtrics to collaborate research. The main reason was that the tools were easier for them. Additionally, it was also because the tool has more options than Google forms.

Observation [Segment ID: 103*]: "A shares her screen and opens up the **overleaf** tool."*

This observation showed that the participants used overleaf to do their collaborative work. Since the tool is a format editor, the possible reason that they used it might be that it could help the participants write the report faster.

In these tools, using zoom is consistent with our hypothesis. The results also fit well with the rules of code 2, 5 and 6. For example, in the first piece of segmentation, ID 8, the participant 1 said "Google **drive** makes things **easier for everyone in the team**". Back to the code "5-technology readiness", the rule is whenever the participants mention the tools are easy to use." Hence, the google products made the participants' collaboration easier.

Overall, CS students used discord and slack to schedule a meeting when collaborating because of the tool's popularity and easiness. Additionally, they used various tools to do the collaborating study, such as Google products, Zoom, Atlas.ti, Qualtrics and Overleaf. The possible reason is that it was easier for them to finish the work as well as the common usage of the tools.

4.2 Remote work

RQ2: How has remote work been affected by remote collaborative meetings?

Hypothesis 2: Students preferred remote collaboration meetings to in-person meetings.

To understand how students have adapted to remote work and remote collaboration, we draw on three codes from the theory of remote scientific collaboration(Olson, 2008), namely “The nature of the work”, “Collaboration readiness”, “Management, Planning and Decision-Making”.

Code 1: The nature of the work	Whenever sentences mention about working chemistry and how team members prefer to work or make the work clear and unambiguous
Code 3: Collaboration readiness	Whenever sentences mention about the data sharing methods - How do they share the documents ? Come up with a meeting time?
Code 4: Management, planning, and decision making	Whenever team members are talking about effectiveness, roles, responsibilities, timelines. Any member exhibiting strong leadership qualities, Whenever a communication plan is in place.

We coded the interview transcripts and observations using these codes to answer our second research question.

Whenever participants mentioned working chemistry and how team members prefer to work, we linked it to the nature of work. In total, 47 instances were reported that linked to the *nature of the work* for remote collaborations. One instance was that our participants did not have a fixed meeting schedule every week because everyone’s available at a different time each week and prefer flexible hours. We saw this in both groups of students that we observed.

Participant 3 [Segment ID: 2]: “..everyone is available at a different time..having one calendar invite every week seemed a little bit, uh, problematic...if my team members were non-collaborative, then, uh, meetings can be the best way to bring everyone on the same page.”

Among work preferences, we wanted to see if team members turned on their cameras to recreate in-person meetings, however, our participants said they don’t prefer to have their videos turned on in longer meetings.

Participant 3 [Segment ID: 25]: “.. I don't want to see someone's face for six to seven hours...it would be nice. But at the same time, when you're working on a Google doc together, you're looking at the Google doc...You're not talking to someone face to face for like six hours or five hours.”

In another instance, our participant said that the collaboration features of the tools being used often cause increased contribution of members:

Participant 3 [Segment ID: 29]: "...if someone has an idea and you are continuously talking on a zoom call and the other person does not have an opportunity to pitch it, they will leave a text message right there, multiple ways of presentation right now."

Whenever participants mentioned collaborative actions such as coming up with meeting times, sharing data with each other, we linked that to *collaboration readiness* of team members since these actions reflect the motivation to work together, resulting in greater productivity. For example, in the instance explained above, one of our participants mentioned discussing meeting time availability of team members informally over discord. However, it was also stated that if one team member is not collaborative by nature, that is when *management, planning and decision-making* is required.

Participant 3 [Segment ID: 31]: "...one of the team members kind of dropped out...kind of non-responsive for the, from week two because he only attended one meeting of ours..most teams had four members and we had three members...I and my teammates had to do a lot of things..I saw people being online and not responding "

Organization of work in a distributed team is critical to the effectiveness of work. In larger groups, exhibiting leadership qualities become even more important. In our interviews, a participant mentioned that the use of breakout rooms by the project lead. Whereas, in smaller group meetings, they did not adopt a divide-and-conquer approach and preferred working on the same document while using the screen sharing feature of the application they are using.

Participant 3 [Segment ID: 4]: ".. we all look at the same thing. We don't divide and conquer at least. So what we do is we prepare before meeting."

In the following segment, we detail how remote collaboration could have both a positive and negative impact :

a) It is easy to collaborate together efficiently and reduces the working time

Participant 1 [Segment ID: 8]: "when you're working on the same thing, you rather stream or share your screen and everyone works on the same thing. So most of the time I do the writing work and everyone is pitching their ideas. Um, and I keep making the changes in it."

Participant 2 [Segment ID 70]: "...lesser, the number of people, um, the more close to physical communication it becomes."

b) Ease of access to resources

Participant 1 [Segment ID: 8]: "anytime there is a group project, the first thing I do is start a Google drive."

c) Objectives of the meeting are well planned ahead of time which leads to a clear outcome at the end of the meeting.

Participant 2 [Segment ID: 44]: "we always have a fixed agenda of what we are doing"

d) Among negative impacts, people get easily distracted in remote meetings

Participant 2 [Segment ID: 73]: - “I am definitely distracted when I don't have my video on, like, I just I'll just keep checking my phone...I do get distracted if I do not have my video on”

Participant 2 [Segment ID: 90]: “..people do not really have to be ... in an official setting for a meeting, they can be anywhere...even be hanging out with their friends and then be on a meeting...I feel it affects efficiency because like we're not there.”

e) Meetings with larger number of people become cumbersome

Participant 2 [Segment ID: 69]: ”Now with 10 people, it's a lot more chaotic and then it sort of also decrease people's time”

4.3 Co-occurrence Matrix and implications

	Code 1: The nature of the work	Code 2: Common ground	Code 3: Collaboration readiness	Code 4: Management, planning, and decision making	Code 5: Technology readiness	Code 6: Tool use	Total co-occurance
Code 1: The nature of the work	40	8	17	10	5	7	87
Code 2: Common ground	8	26	13	11	7	7	72
Code 3: Collaboration readiness	17	13	48	12	13	12	115
Code 4: Management, planning, and decision making	10	11	12	37	8	5	83
Code 5: Technology readiness	5	7	13	8	41	25	99
Code 6: Tool use	7	7	12	5	25	43	99
Total co-occurance	87	72	115	83	99	99	555
Total occurence of the code	40	26	48	37	41	43	

Fig. 1. Co-occurrence Matrix

After coding our data, we were curious to know if we are able to extract any patterns from our codings. So we decided to draw a co-occurrence matrix [2], having our codes replicated in its rows and columns(See Fig.1. Co-occurrence Matrix). Then we went over our coded data and counted the number of the times when each pair of the codes appeared in a single segment and summed up the numbers and created this table.

We realized that there are actually several data patterns showing up in this co-occurrence matrix. Here are the extracted patterns from the co-occurrence matrix.

4.3.1. The Extent of Collaboration Readiness

By taking a look at this matrix, we found out that when participants were talking about people issues, they usually mentioned aspects of the codes 2, 3 and 4 (Common Ground, Collaboration Readiness and Management)at the same time. It means that there is always a co-occurrence in these codes. We also can see that codes 5 and 6 (Tool Use and Technology Readiness) are totally different and have low co-occurrences with other codes except for code 3 which is collaboration readiness.

Collaboration Readiness has a strong relationship with all the other codes and that is interesting to us because it tells us that the collaborative culture in a group plays a significant role in the quality of a remote collaboration. We also can see it through the 67 total occurrences of Collaboration Readiness which is relatively higher than all the other total co-occurrences. If we look at the elements of collaboration readiness, we are able to see the reason:

Collaboration Readiness can include:

- The goals are aligned in each subcommunity
- The motivation to work
- Whether participants like or not to work with each other
- The trust among the team members
- Participant's sense of collective efficacy

For example, in the following segment, we can see that aligning goals with each subcommunity has a relationship with management because according to each subcommunity, people are assigned to different breakout rooms, planning and decision making:

<Segment 66, Code co-occurrence of 3 and 4, "*[00:08:39] So whenever it is 10 people, or more than 10 people meeting, it's usually something like we go around the table and then everybody gives their updates and then. Daily stand-up kind of thing. No, it's not a daily standup thing. It's like, you could say a weekly standup thing, but then we all work on different projects, which has, let's say for ATI, for example, in this class, it says with every project group had to give an, give a summary of what they did this week. … We first do that and then we each go to every breakout rooms, if anybody needs to talk to anybody else. Okay. Yeah. That's how we do this. High level overview and then it sort of any way comes down to three or four people meetings.*">

Another important issue to note is that this pattern doesn't have anything to do with the total number of each code because we have relatively similar grand totals for all the codes except for the Common Ground.

4.3.2. Technology Readiness and Tool Use

One of the other patterns in our co-occurrence matrix is that Technology Readiness and the Tool Use have highest co-occurrences and people usually talk about them at the same time and they do not refer to these subjects with other areas. Find the following segment as an example:

<Segments 47 and 48, Codes 5 and 6, ": [00:03:57] Is there a reason why you choose Slack or like Slack specifically? … : [00:04:04] Uh, it's just like my research group is a Slack. So pretty. Yeah. So they're pretty active there. So that's what we got used to.">

From this, we can see that the collaboration technologies that provide the right functionality and are easy to use, determine what tools are being used in the collaboration meetings. Also, we conclude that the Tool Use is determined by whether the participants are comfortable with the collaboration technologies and there exists an agreement among participants as to what platforms to use for communicating and collaborating.

For example, in one of our interviews, one participant told us that they preferred using Discord over Zoom because all of their team members were more comfortable with using it.

4.3.3. Nature of The Work and Collaboration Readiness

One of the other patterns that we can see in this co-occurrence matrix, is the relatively high number of the co-occurrences between the Nature of The Work and the Collaboration Readiness.
The Nature of The Work can include whether the work is ambiguous to participants or if the participants in a collaboration meeting can work somewhat independently from one another. So we can see how the motivation and trust in the collaboration is affected by the nature of the work. For example in the following segment, we can see that one of our participants is complaining about the issue with her teammate who is online but does not pay attention to our participant so she loses her motivation to work and is not able to work independently and has a low trust on her team member:
<Segment 23 and 24, Codes 1 and 3 co-occurrence, *"So this person, all of this was playing a game, but never was responding to assignment. He did not collaborate on any of the projects. So it was, yeah, it was very frustrating, but that's how it is. … If like, does it ever happen that you're in a collaborative meeting and like people's cameras are off, and then you ask a question and nobody answering, honestly I will lose my interest in the task.*">

The mentioned items were the results that we extracted from Fi.1. matrix. Although at first, we were hesitant if these kinds of tables can give us any useful results or not, however, the risk of analyzing one worthed the try and gave us some insights.

4.4 Rival Theories

As we were analyzing our interviews and observations, we figured out that we are facing some contradictions. In this section we will mention these inconsistencies.

4.4.1 Tool Use Rival Explanations

One thing that we figured out in our results is the preference of the tool use. For example, participant 1 told us that they preferred using Discord because it was “easy to use” however participant 2 told us that they preferred Discord because of another reason which is the long-term usage of the communication tool as well as its popularity. On the other hand, what we observed was that we figured out one of the team members had a dominant power over the whole group and she told us that she prefers Discord because she has all her chats and groups inside Discord. So our rival explanation is that this dominant power of this group member, made all the group members use this tool.

Another contradiction is that Slack was used by participant 1 and the reason for it is the other team members’ active behavior on that platform as she told us in the interview. In addition, what we were told in participant 2’s interview, they prefer Slack only because they are not used to using emailing tools.

The interview of participant 1 showed us that they used Qualtrics to collaborate research and the main reason for it is that they are more comfortable with it. A rival theory for this explanation is that it was because the tool has more options than Google forms.

4.4.2 Remote work Rival Explanations

From interview of Participant 1, we saw that cameras being off are preferred because they feel they get distracted when they have their cameras on. However we got a totally opposite feedback from Participant 2 who said that they get distracted easily when cameras are off. This shows two different explanations for one phenomena. Here is the reference:

Participant 2 [Segment ID: 73]: - “I am definitely distracted when I don't have my video on, like, I just I'll just keep checking my phone...I do get distracted if I do not have my video on”

4.5. Triangulation

In order to triangulate our results, we cross validated our findings using multiple sources.

4.5.1 Collecting data from different sources

To triangulate our results, we collected data from two different sources: Observations of meetings and followed that with interviews of one participant from these meetings. Both our

observations and interviews resulted in the same findings about the tools and channels used for collaborative work as well as how students have adapted to the new way of working. The observations gave us a “what” perspective and we derived the reasonings from the interviews.

4.5.2 Participant Validation

After we concluded our results, in order to make sure that we have correct understanding of what participants have told us in the interviews and we have a correct comprehension of what we saw through our observations, we decided to arrange a survey (See the “survey questions” in appendix C) including 10 number of our main results, stated in form of questions. We asked our three participants to fill this questionnaire and let us know if they agree or disagree with each of our conclusions. Also, participants were asked to leave us a short description in cases that they disagree with our conclusions. We have tried to avoid generalization and any hidden implication of information in our questionnaire.

4.5.2.1 Participant Validation results

After analyzing our triangulation data from the survey, these are our findings:

1. All of our participants agreed to the statements Q1, Q5, Q7 and Q10. This may not be a good feedback that we have got 40% complete validation from all the participants. Find the fully agreed statements below:

    - **Q1** - You have faced problems scheduling meeting times when collaborators are in different time zones.
    - **Q5** - You use google products because everyone in your group has access to it (through .edu accounts)
    - **Q7** - The channels you use depends on the type of meetings and the relationship between you and your collaborator
    - **Q10** - Zoom chat features often help shy people contribute more.

2. ⅔ of our participants agreed to the statements Q2, Q3, Q4, Q6 and Q8. This implies that we have most agreements on 90% of our findings(Except for Q9). Please find the statement descriptions and the participant feedbacks below:

    - **Q2** - You are more comfortable having your camera off for longer meetings. The disagreed participant explained: *“I like to see people face-face while communicating. I think it is important to maintain eye contact or look at someone when you talk. The other person might feel comfortable as well. I usually have my camera on except rare occasions (feeling sick etc). It also depends on the other person's comfort. If they don't switch it on, I don't like to keep it on.”*
    - **Q3** - In one on one meetings, you prefer to have the camera on. The disagreed participant explained: *“Depends on how well I know the person, and how I am feeling that day.”*

- **Q4** - You find it frustrating to collaborate with members who do not respond. The disagreed participant explained: *"I guess it is natural to feel frustrated when people are unresponsive. I'd rather prefer to have a reason rather than being ghosted."*
- **Q6** - You can make gestures to make the other members realize that you have to say Something. The disagreed participant explained: *"I don't really make gestures on zoom"*
- **Q8** - A meeting involving larger number of people requires more management strategies than smaller group meetings. The disagreed participant explained: *"It depends, sometimes if you have a good connection with the large group of people, it requires less strategy as it depends on mutual understanding"*

3. We got most of our disagreements from Q9's statement that ⅔ of the participants disagreed with it.
    - **Q9** - In remote collaboration, it is easy to collaborate together efficiently, while reducing the working time. The disagreed participants explained: *"I think sometimes this is true, but other times it is easier to collaborate if you are together in person"* and "*Not always, depends on the team*"

Please find the graph for the "survey results" in the Appendix C.

5. Validity and Concerns

5.1 Internal validity threat:

To ensure internal validity, we aimed to capture the real phenomenon as accurately as possible. We went to group meetings and observed participants and their conversations. One challenge was to not cause biased behaviour in participants because of our presence. To control for that, we all had our cameras and microphones turned off during these meetings. Another challenge could have arised from a biased sampling of participants. To control for that, our participants were all Computer Science research students but had various backgrounds. One was an undergraduate student, one was a Masters student and another was a student pursuing her PhD.

5.2 Construct validity:

A threat to construct validity would be to ask incorrect questions in our interviews. We mitigated that first observing meetings and then coming up with interview questions that would answer our research question. For example, if we observed a group using a certain tool, we asked them why they were using the particular tool in the interview.

Also, to avoid misinterpretation of the data, the entire team decided on the codeset explanations and two researchers independently coded our transcripts and after a few iterations, achieved a IRR (Jaccard index) of 84%.

External Validity: Since we only looked at three computer science students, our results might not be generalizable to other students. However, we tried to get perspectives from students from three different backgrounds.

Reliability: Reliability refers to the degree of replicability of our research. To ensure replicability, we provide our dataset, which contains our observation notes and also describe our methodology in detail. We also believe that using the TORSC [1] paper's codeset increases reliability of our analysis and results.

6. Conclusion

This exploratory study implies that when working with remote teams, CS students used slack and discord for scheduled meetings, which was inconsistent with our hypothesis. The reason for using these tools was that the tools themselves are more popular or easy to use. In meetings, they used a variety of different tools, such as Google products, Zoom, AtlasTi, Qualtrics and Overleaf. The reason they used those tools was to make team collaboration more efficient, or the tool itself has more functions and so on. Among those tools, only zoom was consistent with our hypothesis. In addition, remote collaboration has positive and negative effects. Specifically, it was easy to collaborate together efficiently and reduces the working time, ease of access to resources. Objectives of the meeting were also well planned ahead of time which leads to a clear outcome at the end of the meeting. Among negative impacts, people get easily distracted in remote meetings. Meetings with a larger number of people also became cumbersome.

Furthermore, we also used the Co-occurrence Matrix to analyse our results. We found out that when participants were talking about people issues, they usually mentioned aspects of the codes 2, 3 and 4 (Common Ground, Collaboration Readiness and Management)at the same time. Additionally, technology Readiness and the Tool Use have highest co-occurrences and people usually talk about them at the same time and they do not refer to these subjects with other areas. Lastly, there was a relatively high number of the co-occurrences between the Nature of The Work and the Collaboration Readiness.

In our project, the difficulty we encountered was the use of the co-occurrence matrix. At first, we were hesitant if these kinds of tables can give us any useful results or not, however, the risk of analyzing one worthed the try and gave us some insights. Therefore, the future research has the following directions. Since it is mentioned that the impact of remote collaboration on CS students, both bad and good, how to change the bad impact in the future, or as a CS student, how to develop other related programs or methods to improve their study and lives.

7. References

[1] Olson, J. S., Hofer, E. C., Bos, N., Zimmerman, A., Olson, G. M., Cooney, D., & Faniel, I. (2008). A theory of remote scientific collaboration. *Scientific collaboration on the internet*, 73-97.

[2] Nanni L, Brahnam S, Ghidoni S, Menegatti E, Barrier T (2013) Different Approaches for Extracting Information from the Co-Occurrence Matrix. PLoS ONE 8(12): e83554. https://doi.org/10.1371/journal.pone.0083554

[3] Leydesdorff, L. (2007). On the normalization and visualization of AUTHOR co-citation data: Salton's Cosineversus the Jaccard index. *Journal of the American Society for Information Science and Technology*, *59*(1), 77–85. https://doi.org/10.1002/asi.20732

Appendix A

Interview questions

Appendix B

Database

Appendix C

Survey Questions

Survey result

Survey raw data