



Collaborating in Virtual Reality: Exploring the Impact of Visualization of Activities on Social Modes of Co-construction

Ching Guo¹

Supervisor(s): Marcus Specht¹, Nesse van der Meer¹

¹EEMCS, Delft University of Technology, The Netherlands

A Thesis Submitted to EEMCS Faculty Delft University of Technology,
In Partial Fulfilment of the Requirements
For the Bachelor of Computer Science and Engineering
June 21, 2023

Name of the student: Ching Guo
Final project course: CSE3000 Research Project
Thesis committee: Marcus Specht, Nesse van der Meer, Ricardo Marroquim

An electronic version of this thesis is available at <http://repository.tudelft.nl/>.

Abstract

Background. The advancements in Virtual Reality (VR) technology have opened up new possibilities for studying human dynamics and conducting experiments in immersive environments. To gain insights into collaborative learning and how it can be enhanced, an experiment was conducted to investigate the effects of visualizations of activities in VR on social modes of co-construction, which is to what extent learners refer to their partner's contribution.

Methods. A maze, specifically designed for collaboration, has been chosen to use for this study and visualization tools such as laserpointing and vision cones were made available for certain sessions.

Results. The findings from this maze experiment did not provide conclusive evidence regarding the impact of visualization tools on social modes of co-construction, mainly due to the limited comparison material available. An interesting finding however, is that sessions with visualization tools tend to have more distracted participants compared to the absence of them.

Conclusion. Further research is needed to examine the relationship between visualization tools and social modes of co-construction, as well as to explore whether the observed distractions are specific to the participants in this study or representative of a bigger spectrum. By addressing these aspects, we can gain a better understanding of the role of visualization tools in collaborative learning and uncover strategies to mitigate any potential distractions they may introduce.

1 Introduction

As technology continues to advance, the realm of Virtual Reality (VR) has seen tremendous growth, with ever-increasing levels of sophistication. Today, VR has progressed to a level where it can simulate a lifelike environment, enabling individuals to explore new places and experiences without the need for physical travel. This remarkable capability of VR has opened up new avenues of exploration, enabling us to study the effects of various scenarios that may be difficult or impossible to replicate in the physical world (Cipresso et al. 2018). As Burda and Coiffet (2012) suggest, VR offers a powerful tool for learning by mediating collaboration among users in a shared virtual space. With its potential to facilitate collaborative learning, VR offers a unique opportunity for conducting experiments and studying the dynamics of human interactions in a safe and controlled environment.

As such, this paper intends to answer the following research question: "Do visualizations of activities have an effect on a group's level of social modes of co-construction while collaborating inside Virtual Reality?"

The research question revolves around two variables: visualization of activities (independent variable) and social modes

of co-construction (dependent variable). In this context, visualizations of activities refer to rendering the actions and activities of users visible to each other in the virtual world, which may not be perceivable in the physical world. Social modes of co-construction, on the other hand, refer to the extent to which learners refer to and build upon their learning partners' contributions during collaboration (Weinberger and Fischer 2006).

Framework of Social Modes of Co-Construction

The framework of social modes of co-construction involves rating participants' utterances on a scale of 1 to 5, representing different modes of interaction and collaboration (ibid.). These modes include:

1. **Externalization:** Learners externalize what they know (to explain their perspective).
2. **Elicitation:** Using learning partners as a resource by asking questions, receiving information from them in the process.
3. **Quick Consensus Building:** Learners accepting the contributions of their learning partners, not because they are convinced, but in order to be able to continue discourse.
4. **Integration-Oriented Consensus Building:** When (individual) learners operate on the basis of the reasoning of their learning partners, i.e. showing a willingness to revise or change their own views in response to their partner's arguments.
5. **Conflict-Oriented Consensus Building:** By facing critique, learners may be pushed to test multiple perspectives or to find more and better arguments for their positions.

In Section 3.4, a comprehensive explanation will be provided on the utilization of this framework in this study. This framework will serve as the main tool for deriving the results and answering the research question.

2 Related Works

Linton et al. demonstrated that learning is more effective in a group setting compared to an individual setting (Linton, Farmer, and Peterson 2014). This highlights the significance of collaborative learning over individual learning. However, one might question the connection between virtual reality (VR) and collaborative learning. In fact, VR provides a unique opportunity to create experimental environments that encourage collaboration (Mütterlein, Jelsch, and Hess 2018). These environments can be used to study the effects of collaborative learning on a large scale without compromising privacy or safety (Mayer et al. 2023). By using VR, we can design immersive settings that facilitate collaborative learning experiences.

The focus on social modes of co-construction comes from their role in shaping the dynamics and outcomes of collaborative learning (D. W. Johnson and R. T. Johnson 2014). Positive interdependence among group members is needed for effective collaboration. By assessing how frequently and

deeply group members refer to each other’s contributions, we can gain insights into the degree of interdependence and the overall group dynamics.

Moreover, the visualization of techniques is another key aspect of this paper. Research by Wuertz et al. on the use of gesture tools in Dota 2¹ emphasized the importance of visualizations, such as pings, as essential gesturing tools that contribute to group success (Wuertz, Bateman, and Tang 2017).

While using visualization techniques in real-world settings, such as laser pointing in public spaces, may attract attention and be met with skepticism, the same gestures in VR are more readily accepted. Conducting our research on the impact of visualization of activities in VR allows us to gain valuable insights into how VR technology influences collaborative learning, providing a unique perspective that is not easily achievable in the physical world.

3 Methodology

In order to examine the impact of visualizations of activities on social modes of co-construction, it was essential to create an environment that facilitates such visualizations. To fulfill this requirement, Nesse van der Meer, the research supervisor, developed a VR maze. This VR maze offers a distinctive context where participants collaborate to navigate and successfully exit the maze (Meer, Brinkman, and Specht 2023 Manuscript in preparation).

Ethical approval has been obtained to record the audio during the experiments, enabling the application of the framework of social modes of co-construction to evaluate participants’ utterances. Given the project’s tight time constraints, conducting the experiment within the provided maze was chosen as the optimal approach. The subsequent sections will provide further insights into the maze setup, its utilization in the research, and the data collection and analysis process.

3.1 Participants

The recruited participants for this research project consisted of students personally known to the team members. However, it was important that the participants were not acquainted with each other, as previous research has shown that friendships can have a positive influence on collaboration (Hanham and McCormick 2010). Additionally, certain requirements were set for the participants, including:

- Participants should not be colorblind.
- Understanding of English required.
- Not prone to motion sickness or claustrophobia.
- Must communicate with others via NL or ENG.

In virtual reality (VR), some users may experience symptoms of motion sickness, commonly known as VR sickness or cybersickness (Chang, Kim, and Yoo 2020). Additionally, considering the confined nature of the maze environment, individuals might also feel a sense of claustrophobia when entering the VR space. To mitigate potential risks such as participant discomfort, health issues, and the need for rescheduling data collection, it was important to ensure that partici-

pants did not have a tendency towards claustrophobia or motion sickness. By screening for these conditions, the team aimed to maintain a safe and uninterrupted experimental process while prioritizing the well-being of the participants.

In preparation for the experiments, participants were asked to complete consent forms and a questionnaire to gather information about their previous experience with VR, as this factor could potentially influence the research question. The consent forms and questionnaire can be found in Appendix A. As the ethical approval for the consent forms was required, the supervisor who obtained the necessary approval took full responsibility for conducting the experiment and their name was specified in the consent forms.

3.2 Materials

Ethical approval was obtained to collect and utilize specific data from the participants. The approved data collection included audio recordings, screen recordings, task performance logs, and questionnaires. The questionnaires focused on participants’ previous experience with VR and their situational awareness. Please note that situational awareness is not a primary focus of this paper and will not be further examined. The supervisor was responsible for acquiring the ethical approval, and due to the approval limitations, only the aforementioned data types were processed and used for this research.

3.3 Experiment Set-Up

The research experiment involves a maze designed for three color-specific players: yellow, red, and blue. Each player is only able to see their respective color within the maze. The objective is for the players to navigate through the maze by solving passwords and following specific routes. Communication among the players is crucial to share their findings and progress effectively.

For instance, as depicted in Figure 1, the yellow player can only see the yellow parts of the password. To decipher the complete password, it is essential for the participants to communicate their individual observations.

Furthermore, the maze features markings on the ground that are visible only to the corresponding color. In Figure 2, the yellow player can only see the yellow markings. In this figure example, each player will be pointing in different directions. By communicating and discussing the correct and incorrect signs they observe, the players can collectively determine the correct path. The maze design therefore fosters collaboration among participants, encouraging them to work together closely to navigate the maze successfully and reach the exit.

The maze experiment consisted of two sessions, with each session involving two groups, each consisting of three participants. Each group was assigned to complete one control group session and one experimental group session. In the experimental group session, participants had access to vision cones and pinpointing, as illustrated in Figure 3. The vision cones enabled participants to observe the views of other participants, while pinpointing involved using a laser pointer. These visualizations of activities served as the focus of this

¹A multiplayer online battle arena (MOBA) video game

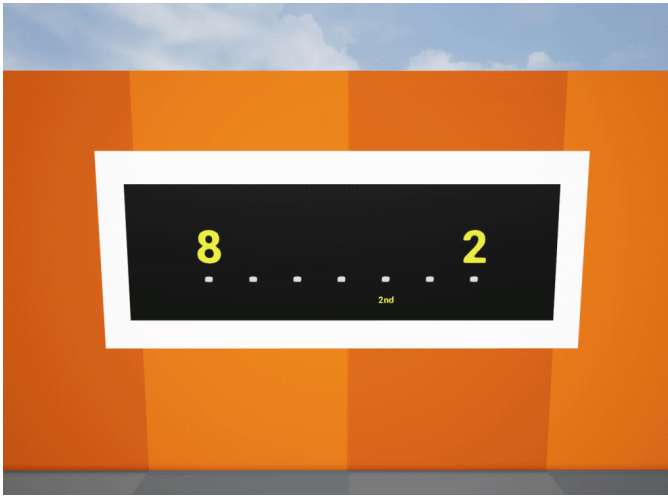


Figure 1: A glimpse into the perspective of the yellow player

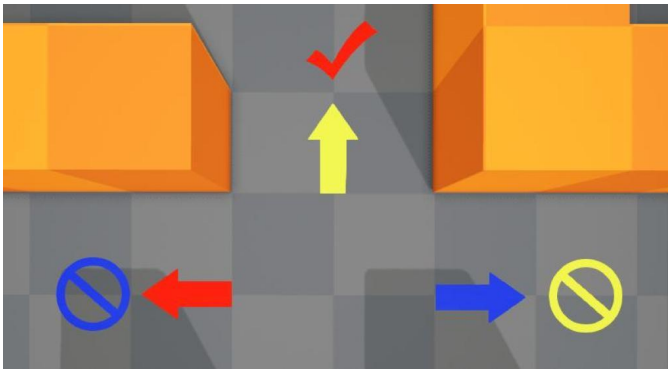


Figure 2: The players of different colors will indicate different directions. Through effective communication, the players will discover that the correct path is straight ahead.

experiment, as this paper aims to explore their impact on social modes of co-construction.

To minimize the impact of a potential confounding factor, which is the player getting accustomed to the experiment, a minimum delay of one week was introduced between the two sessions of each group. This break aimed for the participant to "forget" the gameplay and approach the second session with a fresh mindset. Additionally, slight changes to the maze design for the control group and experimental group session were implemented to further reduce the influence of familiarity. These steps were taken to ensure that the results reflected the effects of the experimental conditions as accurate as possible.

The groups were assigned different session orders: the first group started with the control group session, while the second group began with the experimental group session. This allowed for the examination of the influence of visualization of activities on social modes of co-construction. The study aimed to explore the potential positive effect of visualization on collaborative processes, hypothesizing that it enhances social modes of co-construction.

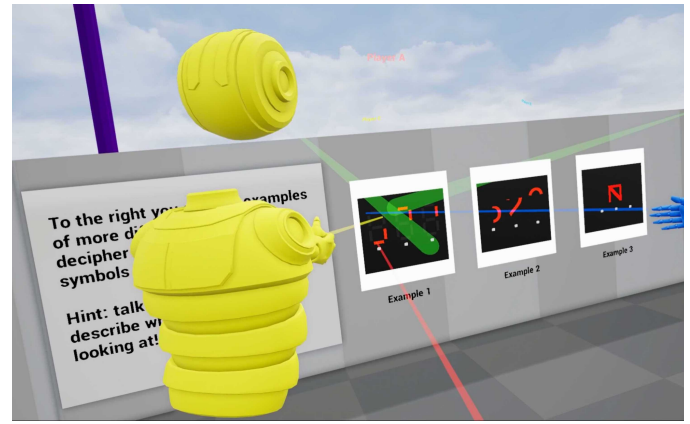


Figure 3: Experimental Group: The ability to use vision cones and pinpointing

3.4 Analysis of Data

The primary focus of data analysis for this paper was the audio recordings obtained from the experiments. These recordings were transcribed to facilitate the application of the social modes of co-construction framework, described in Section 1.

To maintain consistency in the encoding process, team members carefully reviewed a section of the transcript. Since the previous application of the framework differed from the VR maze context described in this paper, there were instances where the utterances did not fit precisely into one of the pre-defined ratings. Therefore, consensus among team members was necessary to determine the appropriate rating for each utterance.

Each team member independently rated 100 lines of a transcript and carefully analyzed any differences in their ratings. Based on this analysis, encoding rules were made to maintain consistency across the transcriptions. In addition to the framework, the following rules were implemented:

- Remembering collective contribution, such as recalling a deciphered password, was rated as a 4.
- Cut-off sentences, off-topic talk, and irrelevant answers were rated as 0.
- Relevant answers to questions, including confirmations and assistance, were given a rating of 3. This rating recognizes that when participants respond to questions, they are actively supporting collaboration and helping the group make progress, which ultimately falls into quick consensus building.
- Utterances reflecting hesitation or opposition towards another's contribution were rated as 5, as they demonstrated a higher-level reflection and alternative beliefs.

These rules were designed specifically for this project and may not be applicable in all cases. They were developed to ensure consistency and to prevent team members from getting caught up in constant questioning of the appropriate rating for each utterance.

4 Results

The study's results include graded transcripts based on the framework of social modes of co-construction. All four transcripts were carefully evaluated, rating individual utterances by each participant.

4.1 Grading the Transcripts

To provide a better idea on how the framework of social modes of co-construction was applied to the transcript, see Figure 4.

Red	I have a checkmark straight ahead.	1
Yellow	I have a number here. It's from a code?	1
Blue	I have a number as well.	3
Yellow	A seven, first number.	3
Red	Me too.	1
Blue	The last number is a one.	1
Red	The middle is a four.	1
Yellow	Seven-four-one?	4
Blue	Yep.	3
Red	Okay.	3
Yellow	So where do we have to go? Where was the ...?	2

(a) A simple conversation between the participants and the corresponding social modes of co-construction.

Blue	I think there is something we didn't try on this side. Is there like- yeah, there is a door like further ahead.	1
Yellow	Yeah, but it's just an arrow pointing at us.	5
Blue	But did we look inside that corridor? Like maybe there is something ahead of this?	5
Yellow	I'll check.	3

(b) A more in-depth conversation between the participants where thoughts between the participants clashed.

Figure 4: Example of the grading of participant's utterances using the framework of social modes of co-construction.

In Figure 4a it can be seen that Red initiates the conversation by mentioning that they see a checkmark. This act of externalization earns them a rating of 1, as they are expressing their perspective. The conversation then progresses as Yellow adds their observation, also receiving a rating of 1 for externalizing their viewpoint.

Blue then says that they see a number "as well". This indicates that they not only remembered what the other participants mentioned, but also provided a response based on that information. The key point here is that while Yellow externalized their observation without explicitly acknowledging Red, Blue's use of "as well" in their statement demonstrates their recognition of what both Red and Yellow said. As a result, Blue got graded a rating of 3 instead of 1. Similarly, when Red responds with "Me too.", they are referring to Blue's mention of seeing a number, and indicating that they also have seen one. Hence why Red got graded a 3 as well.

As the participants continue to externalize their thoughts, Yellow pieced the code together by their information and therefore got a rating of 4 on "Seven-four-one". The other two players express their agreement, receiving a rating of 3 since they accept and acknowledge Yellow's contribution. The conversation concludes with Yellow eliciting input from the other participants on where to proceed next.

In Figure 4b a more in-depth conversation unfolds between Blue and Yellow. Blue proposes an idea that Yellow appears to oppose, despite initially responding with "Yeah." Yellow

demonstrates hesitation by pointing out that the arrows do not align with the direction suggested by Blue. However, Blue counters this argument by suggesting that there might be something beyond the indicated arrows and proposes investigating further. The conversation concludes with Yellow ultimately agreeing to explore the suggested direction.

4.2 Results of the Grading

After evaluating all four transcripts using the same rating criteria, two main measurements were obtained: the participation score and the average social modes of co-construction.

The participation score indicates the number of lines contributed by each participant, giving us an idea of their level of involvement. This score is also used to calculate the social modes of co-construction (SMOCC) score. Figures 5 and 7 show the participation scores of Group 1 and Group 2 respectively. Figures 6 and 8 provide the SMOCC scores for individual participants and the group as a whole. These scores were acquired by adding up the ratings each participant received and dividing them by the number of lines they contributed, as well as adding the SMOCC scores of the participants and dividing it by 3 to get the group score. The term "0-adjusted" refers to the number of "on-topic" lines, excluding any off-topic discussions and lines that were rated 0. In Figure 9, you can find the calculation of the on-topic conversation ratio. This ratio is obtained by dividing the total number of participants' lines by the 0-adjusted lines and then multiplying it by 100.

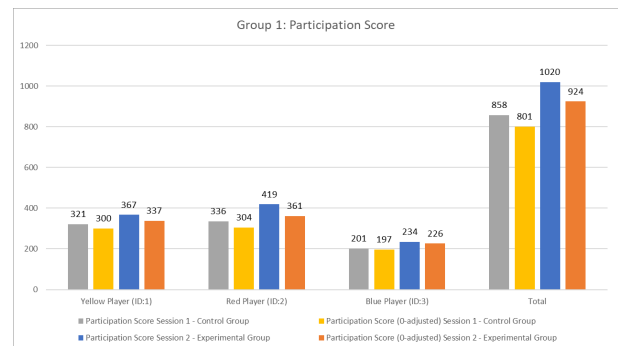


Figure 5: Participation Score of Group 1

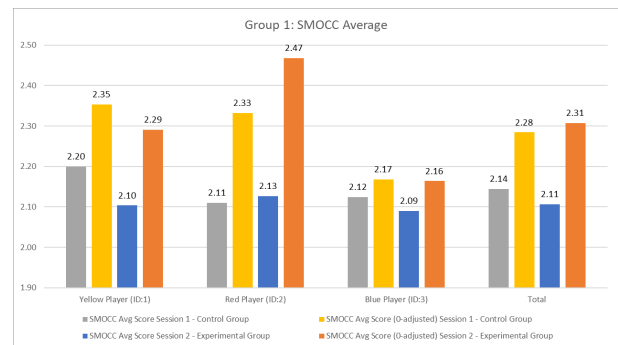


Figure 6: Social Modes of Co-Construction Score of Group 1

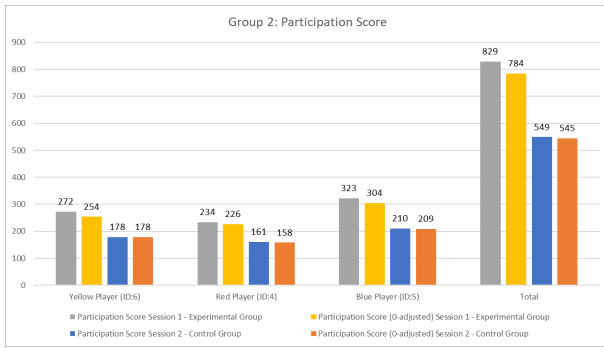


Figure 7: Participation Score of Group 2

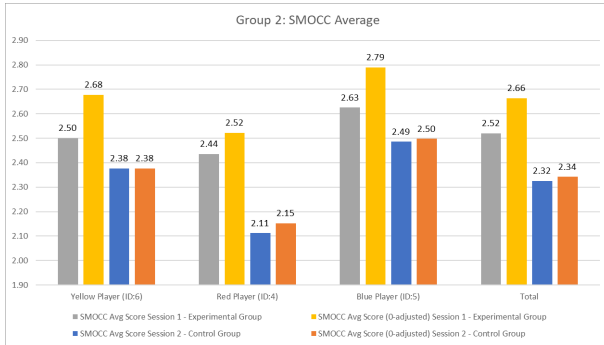


Figure 8: Social Modes of Co-Construction Score of Group 2

5 Discussion

Based on the results presented in Figures 5, 6, 7, 8 and 9, the impact of visualization of activities on the group's social modes of co-construction score will be examined. An analysis will be conducted on the social modes of co-construction scores for both groups to determine if any confounding factors may have influenced the results.

5.1 Analysis of Results

Let us examine Group 1 in greater detail, the group that started with the control group session. Initially, there was an expectation of a higher social modes of co-construction (SMOCC) score in their second session as part of the experimental group. Unexpectedly, when considering only the average SMOCC score without accounting for the 0-adjusted score, the SMOCC score was actually lower. Nevertheless, when we examine the 0-adjusted SMOCC score, the group achieved only a slightly higher score (+0.03) during their experimental run.

It is worth noting that the increase in the 0-adjusted SMOCC score was more pronounced in the second run compared to the first run. If we calculate the ratio of non-adjusted talk to the 0-adjusted talk, we find that the group had a 93.36% on-topic conversation during the first run as the control group, while this slightly decreased to 90.59% during the second run as the experimental group. This observation raises the question of whether the availability of gesturing tools can introduce additional distractions.

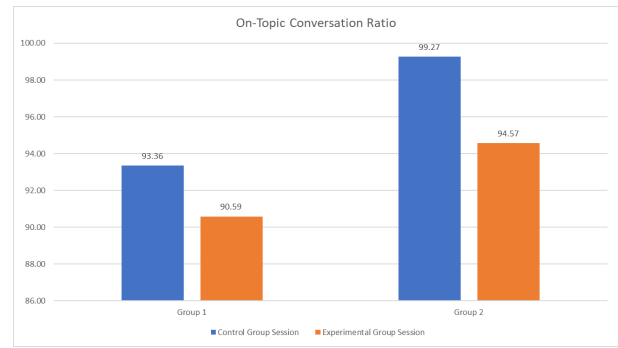


Figure 9: On-Topic Conversation Ratio for Both Groups

In a related study, it was found that task difficulty correlates with the level of distraction experienced by individuals (Sörqvist and Marsh 2015). As tasks become easier, concentration tends to decrease. This leads to the question whether the presence of gesturing tools in the maze gameplay makes the tasks easier, potentially causing participants to become less focused on completing the assigned task.

Group 2 further supports this hypothesis when considering the ratio of on-topic talk. In their first session as the experimental group, they achieved a score of 94.57% for on-topic conversations. However, in their second session as the control group, they achieved an outstanding score of 99.27% for on-topic conversations. This on-topic ratio also explains why there is a higher 0-adjusted SMOCC score in their first session compared to their second session, as the ratings are more significantly impacted by the decrease in the number of lines in the first session.

In contrast, Group 2 experienced a more significant change in their SMOCC score compared to Group 1. Being the experimental group first and then transitioning to the control group, it was expected that their second run would yield a lower score. This expectation held true for both the SMOCC and the adjusted SMOCC score. However, the extent of the score change is not substantial enough to conclude that the lack of visualization tools directly results in a lower SMOCC score. It's important to note that this paper only experimented with one group in this specific order, and chance or coincidence should also be considered. It is possible that this particular group obtained a lower SMOCC score, thereby supporting the hypothesis.

Likewise, Group 1, despite having a slightly higher SMOCC score after accounting for off-topic talk through 0-adjusted conversation calculations, actually contradicts the hypothesis of achieving a higher SMOCC score with the presence of visualization of activities. Coupled with the fact that our sample size was too small, the results are not statistically significant enough to conclude that the presence or absence of visualization of activities directly correlates to a higher or lower SMOCC score.

5.2 Limitations

The results were based on the participant's amount of lines and their SMOCC ratings. These two variables are however very subjective. Differences in transcription methods among

team members have led to variations in the number of lines attributed to each participant in the transcript, thereby impacting the SMOCC score. Transcribing techniques varied, with some team members separating instances of talking over each other into separate lines while others opted to transcribe complete sentences, prioritizing clarity over strict adherence to the order of speech.

Furthermore, despite the team's efforts to establish clear grading rules for the transcripts, individual team members may still have slight variations in their perceptions and interpretations. Each team member brings their own unique viewpoint, which can influence their rating of certain lines based on their personal understanding. While the team aimed for consistency, it is inevitable that differences in perception arise due to these subjective factors.

Despite having access to video and audio recordings, it is impossible to fully grasp the participants' thoughts and intentions. Our perceptions are derived solely from these recordings, and there may be nuances and subtleties that escape our understanding. Consequently, our ratings are based on our interpretations within the framework of social modes of co-construction.

Additionally, it is important to recognize that this study only examined two specific groups. These groups cannot be considered representative or standard. It would be inappropriate to draw definitive conclusions about the research question based solely on the results of these two groups, especially considering the limited impact of these results. The study would greatly benefit from a more diverse range of comparison material to provide a broader context and strengthen the ability to address and substantiate the research question.

6 Responsible Research

Good and trustworthy research is based on the five widely supported principles in the Netherlands Code of Conduct for Research Integrity: honesty, scrupulousness, transparency, independence and responsibility (Conduct for Research Integrity 2018). In this section, each of these principles will be explored upon to see if the research conducted for this study is of high enough quality.

Honesty

The results of this study is based on the grading of the transcripts using the framework of social modes of co-construction. Since this grading is highly subjective, one might find different results when applying this framework. This variation arises from individual differences in interpreting and applying the rating criteria, leading to potential differences in outcomes. By no means is the approach and rules set for this framework definitive or universally applicable. They represent the specific methodology chosen for this study. Alternative approaches may exist, and different perspectives on rating criteria may yield distinct findings.

Scrupulousness

Multiple iterations of Research Plans were carefully crafted and refined before commencing the actual research. Moreover, this study has been overseen by a Supervisor during the

whole project to see if it has been on the right track and if it does not contain unscientific methods.

Transparency

The Methodology section provides a comprehensive explanation of the data acquisition process, and in the Results section an extensive answer is giving to how the data has been processed. Prior to participation, all participants were provided with informed consent forms, and the ethical approval for conducting this experiment was obtained. No extensive dialogue, besides the ones mentioned in this report, has been given but can be requested if necessary.

Independence

This study was completed as a bachelor thesis project and had therefore no political or commercial nature. This research was done out of personal fulfillment and guidance were provided by experienced and knowledgeable professors with a strong foundation in scientific principles.

Responsibility

The well-being and safety of the participants involved in this study were prioritized, and proactive measures were taken to prevent any physical harm. Participants were provided with comprehensive information about the study, ensuring that they were well-informed and aware of what to expect. I am pleased to report that all participants are currently in a safe and secure condition. If that was not the case, full responsibility would have been assumed.

Conclusion

This research have been carefully guided by professors with a scientific background and has tried to be as honest, scrupulousness and transparent as possible. It was not backed by any political or commercial nature and would have taken full responsibility for the participants if the experiments went wrong.

7 Conclusions and Future Work

Looking back at the research question, "Do visualizations of activities have an effect on a group's level of social modes of co-construction while collaborating inside Virtual Reality?" the answer can be inferred as "yes" based on the specific experiment conducted. However, it is important to acknowledge that this conclusion is derived from the findings of only two test groups. Each group sought to investigate the influence of visualizations on social modes of co-construction (SMOCC). The results indicated that the presence of visualizations increased the group's SMOCC score, whereas their absence led to a decrease. It is important to recognize that these score differences were marginal and insufficient to draw definitive conclusions in a broader context. To provide more substantial evidence and thoroughly address the research question, future studies should incorporate a more diverse range of comparison material. This would allow for a more comprehensive and well-supported understanding of the topic.

Exploring the motivations behind using visualizations in different circumstances is an idea for future research. By understanding why we choose to visualize certain activities and what drives those choices, we can enhance the effectiveness

of visualizations. This investigation would provide valuable insights into the reason why visualizations could impact social modes of co-construction.

Another idea is to look into the difference between a contributor and the referral to contribution. In the social modes of co-construction framework, there is a strong emphasis on referring to another contribution. However, this raises a question that aligns with our intuitive understanding: Why do we tend to assign a low score to an enthusiastic contributor who actively elicits and shares their thoughts, categorizing their actions as externalization or elicitation, which are considered the lowest ratings in the framework? Conversely, why do we rate an opportunist who merely replies with "yeah" to sustain the conversation higher, categorizing their behavior as quick consensus building? To shed light on these dynamics, it would be valuable to examine the correlation between a contribution and the subsequent referral to contribution, given that a referral only occurs after someone has contributed beforehand.

An interesting finding in this study was that the visualization of activities resulted in more off-topic conversations compared to their absence. Additionally, the experimental group, which had access to visualization tools, showed a higher jump in 0-adjusted SMOCC scores during their session compared to the control group, which did not have access to such tools. A motivation towards this finding could be that the visualization tools made the maze easier in which as a result the contestant got distracted due to the lack of difficulty (Sörqvist and Marsh 2015). To explore this further, a possible idea for future research is to create a more challenging maze during the experimental group session. This would help us understand whether the visualization tools still cause distraction or if their effects diminish when faced with a more demanding task. By investigating this aspect, we can gain deeper insights into how visualization tools, task difficulty, and their impact on social modes of co-construction are interconnected.

Ultimately, a definitive answer to the research question cannot be provided due to the insufficient amount of material and evidence to provide a conclusive claim. Nevertheless, it is my hope that the findings presented in this study will serve as a source of inspiration for future researchers, enabling them to enhance their investigations based on these results and the aforementioned motivations. Additionally, I have included suggestions for further researchers, aiming to provide subsequent researchers with valuable insights to establish a conclusive response to the research question.

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Appendices

A Consent Forms and Experience with VR Questionnaire

Virtual Reality Experiment

Participant ID:

Please answer each of the below questions by checking the correct box(es). If prompted, also write down any answers.

Q.1: What is your gender?

- Male
 Female
 Other: _____

Q.2: What is your age?

Q.3: How often per week do you play video games?

- Never
 Rarely
 Sometimes
 Regularly
 Often

Q.4: On which of the following platforms do you play video games? (Multiple answers allowed)

- Computer (Windows, Mac, Linux)
 Laptop (Windows, Mac, Linux)
 Mobile phones
 Tablets
 Mobile game consoles (e.g. Nintendo 3DS)
 Game consoles (e.g. Nintendo Switch, PlayStation 4 / 5, Xbox One / Series X, etc.)
 Other: _____

Q.5: Have you ever experienced Virtual Reality before this experiment?

- Never
 Rarely (once or twice)
 Sometimes
 Regularly
 Often

Q.6: Do you own one or more Virtual Reality devices and if so, which one(s)?

- No
 Yes, namely: _____

Q.7: Did you face any significant issues while experiencing Virtual Reality (and if so, what kind of issues)?

- No
 Yes, namely: _____

Q.8: What are your thoughts on usability of the Virtual Reality application? Was it easy or difficult to use and control? Please elaborate your answer.

Q.9: What are your thoughts on collaboration with your group members when using the Virtual Reality application? Was it easy or difficult to work together? Please elaborate your answer.

Q.10: Are there any other thoughts you would like to share regarding the experiment and/or the Virtual Reality application?

(a) Experience with VR

Study information for Experiment #01: Effects of Visualization of Actions on Social Modes of Co-Construction inside Virtual Reality

Purpose of this research

In this study, the effect of Virtual Reality on collaboration between group members will be studied as part of the PhD trajectory of Nesse van der Meer, PhD candidate at the Delft Technical University. As a participant, you will be asked to collaborate with two other participants to solve a selection of tasks while inside Virtual Reality; only by collaborating and communicating together will you be able to make progress. In total, the experiment will take approximately 60 minutes, of which 30-35 minutes will be spent in Virtual Reality. We will explain the rest of the experiment in detail after you have finished this consent form.

Benefits and risks of participating

By participating in this study, you will contribute to research on collaborative learning. As the team already will have explained, this study requires you to return in approximately one week to repeat the experiment; upon completion of the second session, you will receive a reimbursement for your participation and time.

Please be aware of the following risks:

- **Physical safety:** To prevent any physical injuries or accidents, the team behind this study will make sure that you and your group members have sufficient space to safely interact inside Virtual Reality without hitting anything or each other. We do however ask you to try and be aware of this while participating by not actively walking / running around and / or actively swinging your arms and legs.
- **Claustrophobia:** While the Virtual Reality experience is not meant to induce claustrophobic responses, those who are sensitive to claustrophobia might still experience it as such. If you have a history with claustrophobia, please inform us right away. If you experience claustrophobia during the experience, please make sure to inform our team so we can help you accordingly.
- **Motion sickness:** Some experience motion sickness (i.e. dizziness) while using Virtual Reality. If you have a history with motion sickness (either because of Virtual Reality or other reasons), please inform us right away. If you experience motion sickness during the experience, please make sure to inform our team so we can help you accordingly.

Procedures for withdrawal from the study

Please be aware that you have the option to quit your participation in this study at any time and will face no negative consequences for doing so. If you wish to withdraw from the study during the experiment, you can state this to the team responsible for the study. In case you wish to withdraw outside of the experiment, please contact us, using the contact information below, within one month of signing this informed consent. Please know that, as a participant, you also have the right to request access to and rectification or erasure of any personal data collected during this experiment within that month.

Collection and usage of personal information and data

During the experiment, audio will be recorded to register your communication with your fellow participants. This audio recording will be stored privately and securely and will not be shared publicly at any point. The recordings will be transcribed at a later stage and analysed for the purpose of this study (i.e. how Virtual Reality influences your communication with your group members); your identity will be anonymized in these transcripts. Additionally, recordings will be made of your screen while inside Virtual Reality. To clarify: you will not be recorded physically, but your avatar and activities inside Virtual Reality will be recorded through your point of view. As such, you will not be identifiable in these recordings. These recordings will be stored privately and securely and will not be shared publicly at any point. As with the audio, these screen recordings will be analysed to study collaboration between you and your group members. During the experiment, certain information regarding how you and your fellow group members solve collaborative tasks will be logged. This information will not be usable to identify you. After the experiment, you will be asked to fill in a questionnaire. This questionnaire will ask you about certain points related to the experiment, as well as your past experience with video games and Virtual Reality and personal information such as your gender and age. Again, this data will not be usable to identify you.

The collected data will be used only for research purposes, including publications intended for scientific and academic audiences (e.g. academic papers) and only the research team will have access to the data. All data collected during this study will be archived for a period of 10 years, in accordance with the VSNU guidelines.

Contact details

Nesse van der Meer
 Phone: 06 44 02 04 78
 E-mail: nessvdmeer@gmail.com

(b) Consent Form 1/3

**Consent Form for Experiment #01: Effects of Visualization of
Actions on Social Modes of Co-Construction inside Virtual Reality**

Please tick the appropriate boxes

Yes No

Taking part in the study

I have read and understood the study information dated and I have been able to ask questions about the study and my questions have been answered to my satisfaction. Yes No

I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason. Yes No

I have read, understood, and agreed to the following study details: Yes No

- The goal of this study is to examine how Virtual Reality affects collaboration between group members.
- The study will take part in two sessions. The first will take approximately 60 minutes and will take place approximately 35 minutes in Virtual Reality. The second will take place approximately one week later and will take approximately 60 minutes as well. Both will require you to be physically present at the location of the experiment.
- At any time during or after this study, the researcher will answer any questions you have regarding the study or your data which is collected.

Risks associated with participating in the study

I understand that taking part in the study involves the following risks: Yes No

- **Physical safety:** To prevent any physical injuries or accidents, the team behind this study will make sure that you and your group members have sufficient space to safely interact. You are aware that we ask you to be cautious of this during the experiment.
- **Claustrophobia:** While the Virtual Reality experience is not meant to induce claustrophobic responses, you are aware that if you experience claustrophobia during the experience, you should inform our team so we can help you accordingly.
- **Motion sickness:** While the Virtual Reality experience is not meant to induce motion sickness, you are aware that if you experience motion sickness during the experience, you should inform our team so we can help you accordingly.

Use of the information in the study

I understand that information I provide will be used for writing publications intended for scientific and academic audiences. Yes No

I understand that personal information collected about me that can identify me will not be shared beyond the study team. My responses will be treated confidentially and my anonymity will be ensured during the data analysis. Hence, the study results cannot be linked back to me as an individual. Yes No

Future use and reuse of the information by others

I give permission for the (1) audio recordings during the experiment, (2) screen recordings of my interaction inside Virtual Reality, (3) performance data related to collaboration inside Virtual Reality and (4) questionnaire data that I provide to be archived in a SURFdrive cloud storage provided by TU Delft so it can be used for future research and learning. Yes No

I understand that the collected data will be used only for research purposes, that only the research team will have access to the data and that all data collected during this study will be stored for a period of 10 years, in accordance with the VSNU guidelines. Yes No

Signatures

Name of participant [printed] _____ Signature _____ Date _____

Please provide an e-mail address below on which you, the participant, can be reached during the analysis phase of this experiment. Your e-mail address will only be used in case of an error (e.g., an error regarding the data provided) that requires further contact. Your e-mail address will be deleted as soon as this phase of the experiment is completed and the e-mail address will no longer be required.

E-mail address of participant _____

I, the researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Researcher name [printed] _____ Signature _____ Date _____

For further information, please contact:

Nesse van der Meer
Phone: 06 44 02 04 78
E-mail: n.vandermeer@tudelft.nl