Usability Evaluation on Artifact Affordances in Collaborative Virtual Reality

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***Abstract*—Our case study describes a user experience (UX) analyses of a previously understudied domain, social virtual reality (VR) systems. This surfaced various areas in need of improvement for our users and the usability of the system within a collaborative, multi-user virtual environment. We found that a recurring pain-point for users was the vague presentation of the artifacts that they had to identify or understand to successfully complete a group activity. Our team adapted established usability methods in a new domain and identify opportunities for developing new design features to solve user understanding with contextualization aids. We hope this case study can help support future research in best practices for VR UX analyses and research.**

***Index Terms*—Graphical user interfaces, Human computer interaction, User centered design, Virtual reality**

Introduction

Our research team piloted a virtual reality (VR) experience of learning communities (LC) within our university's Freshman Year Seminar (FYS). FYS help freshmen (year 1) students better acclimate to their new college environments [5], [8]. Our university offers LC and non-LC versions of FYS, where the former places extra emphasis on interacting and collaborating with classmates and the latter does not [11]. Pairing FYS with LC has shown to yield greater positive short- and long-term outcomes for participating students [9], [10], yet a regular percentage of incoming freshman have scheduling conflicts that prohibit them from attending in-person LC meetings. Recent statistics from our university show that 30.71% of incoming freshman attend non-LC FYS which have no formal peer interactions, and need a viable alternative. For these reasons, we decided to explore how virtual offerings of LC FYS experiences compare to more traditional, physical, in-person LC FYS experiences.

Our intention was to make nearly identical virtual versions of the physical LC activities to make a fair comparison. Review of publicly available LC curricula revealed that nobody had previously created VR collaboration activities to date, resulting in our team recreating physical LC activities for VR. To scope our work, we only selected activities that could be reasonably replicated in the study's VR environment, Facebook Spaces—a social VR platform capable of allowing up to four remote users to interact with each other through conversations, writing tools, playing cards, dice, and static 3D models.

After we completed running our VR activities, we began to review participants' activities recorded within the virtual spaces. We quickly realized that we had an extensive amount of user data, and decided the best way to analyze both our curriculum and user interactions was to apply usability evaluations. Since we were unable to find any established user experience (UX) research methods specifically regarding VR in practice or literature, we adapted UX research methods from established areas. We applied these UX research methods to conduct a full usability analysis on one specifically chosen VR collaboration activity to establish a baseline of application and best practices for future work in this domain. This paper presents a case study outlining the methods we used to collect and analyze our VR user data for a socialization activity.

Related Works

Current work in this domain is still exploratory and focuses mostly on understanding the effects of the design features on social interactions [6]. While significant to social VR as a growing field, this research does not address the usability and effectiveness of content in social and collaborative VR. Qualitative methods used by researchers range from autoethnographic [6] to qualitative interviews [2]. Shirram explores the opportunities in VR ethnography by placing the observer in VR with the participants [7]. Researchers that compare the usability of VR between different platforms record participants usage from outside VR rather than record in-VR usage for further analysis [3]. Case studies represent another area of interest, with researchers testing attitudes and potential uses for social VR [4].

Method

This case study revolves around observations we made of a controlled experiment exploring the viability of VR as a LC collaboration tool. This experiment included a control group and two experimental groups: a physical group and a VR group. Subjects in all groups were required to self-report their exam and final grades throughout the semester, along with weekly reports tracking their academically-related social interactions with classmates, which included any instance where they provided or received help to/from a fellow student about any class material. Our physical and VR group participants also attended weekly collaborative training exercises for eight weeks during university common hours (a consistent day and time throughout the semester where courses are not scheduled) to keep a regular time for all activities. Collaboration training consisted of a predetermined group activity for the day, and included up to four participants, as that is the maximum group size supported by Facebook Spaces. Both physical group and VR group collaboration training consisted of the same task, with the main difference being the interaction method (i.e., the environment). Physical group participants met in a small room with a desk and chairs and worked on the collaboration training exercise facilitated by a researcher. Virtual group participants met in a large research lab and were separated physically. They worked on the collaboration training exercise within the VR environment (see Figure 1), which was facilitated by researchers stationed next to each participant who could each watch the virtual interactions on separate computer monitors in real-time.

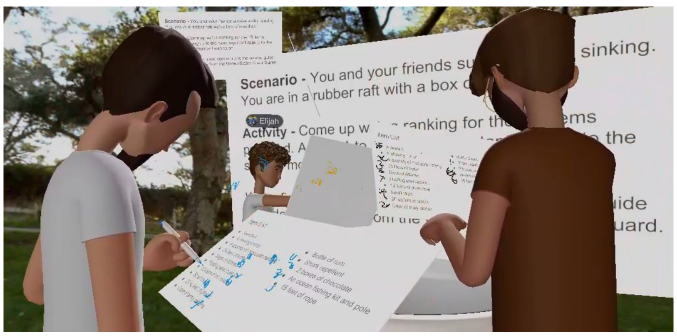

Fig. 1. Virtual Reality Implementation of a collaboration activity.

As mentioned previously, due to the lack of existing LC content for VR, we adapted physical collaboration activities to provide a reasonably similar experience for our VR group within Facebook Spaces. Both the physical and VR content informed the design of the other. For example, due to the limited resolution and space for text within the virtual world, we reduced the amount of overall text instructions for both experiences. Having this concise text allowed participants from both groups to read less and get started on tasks faster. Finally, the maximum of four participants imposed by Spaces also affected he maximum size of our physical group. The activity that we decided to conduct the usability study on was Lost at Sea, which presents the group with a list of emergency supplies that they must rank the importance.

Video Pseudo-Ethnography

To facilitate data collection, we used the built-in video recording feature in Facebook Spaces by having a designated session leader place a virtual camera above and behind their avatar within the the VR environment to capture the interactions. We had 6 group videos of this activity in VR, each lasting between 34 and 48 minutes. Two researchers worked independently from each other to code themes from this set of videos. After the first pass through all the videos, the researchers compared themes, worked again independently to reanalyze the videos to fill in gaps from the first pass.

Affinity Diagrams

Each researcher then listed each of their themes on individual post-it notes. These were then placed onto a whiteboard where they were organized using the affinity diagram process [1] to discover emergent categories. Overlapping themes were combined and the remaining themes were clustered into larger groupings (see Figure 2).

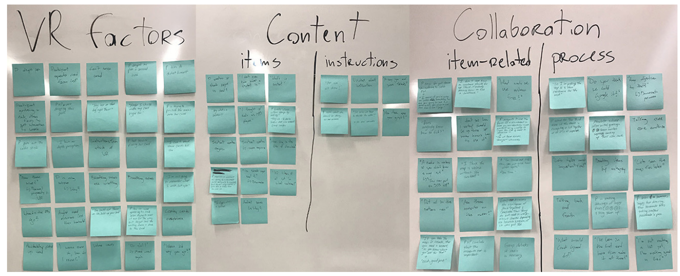

Fig. 2. Affinity diagram whiteboarding activity.

Three main themes emerged from the analysis. First, there are some significant limitations of the VR both as a medium for delivering content, and as a fairly new technology for users. Second, some issues are related to content as in the structure of the activity, presentation of the content, task complexity, and unclear flow between tasks. Third, there are factors that affect collaboration, such as group dynamics, personality clashes, and inadequate conflict resolution skills.

Experience Maps

Mapping participants' thoughts, actions, and feelings throughout the length of the activity gave us insight into our users' perspectives (see Figure 3). This process allowed us to apply additional structure to the insights we extracted from our affinity diagram. At this stage, our goal was to create a document which would allow us to point to specific places on the activity's timeline where we could talk about pain points, observations, and future ideas. Major sections of the timeline included reading instructions, user ranking of items, and final scoring.

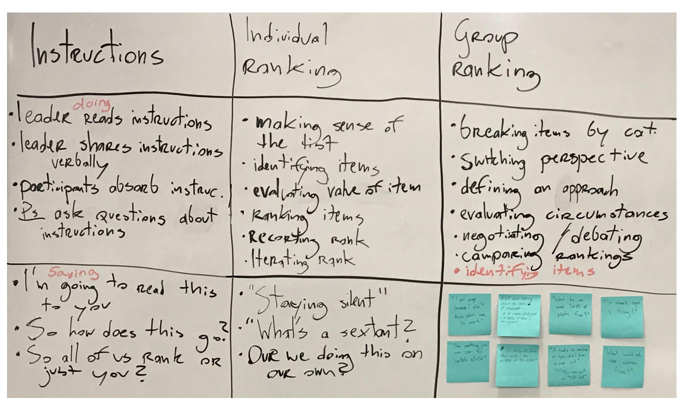

Fig. 3. Experience map organization of our ethnographic notes.

User Personas

The next step in the process of organizing the observational findings was extrapolating user personas from the behaviors, personality types, and recorded participant dialogue. User personas are crucial for Human Centered Design; a practice which requires user feedback and observation to design the best possible user experience. We formed these user personas based on how these students behaved as users in VR and participants in the group activity. Based on our observations, we created personas to represent a common personality types, accompanied by related comments or behaviors (see Figure 4). Personalities include assigned names and attributes. Comments and behavior collected by observation were assigned to the most relevant persona.

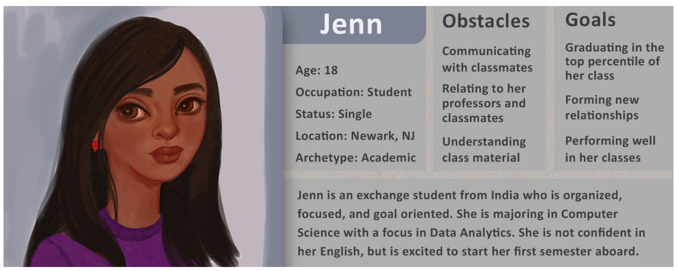

Fig. 4. User Persona Profile of the introverted academic.

RESULTS

Problem Scenario: What is This Object Called Sextant?

Watching the VR participant interaction videos, our team noticed a common situation that occurred after they read the list of objects. The navigation object known as a *sextant* stumped most of them. The extroverted participants would ask out loud what this object was, while the introverted participants would disengage from the activity. In either case, these participants could not make an informed decision and their collaboration quality suffered. This information is summarized into a problem scenario for the persona, Jenn:

- Jenn reads a list of objects she is asked to rank.
- Jenn does not recognize the object called sextant.
- Jenn is too shy/afraid to ask others for help.
- Jenn socializes less and guesses the object ranking.

Problem Statement: User Has No Context of an Object

This allowed us to focus our attention on two separate, but intertwined domains: our users and the problems they face. The intersection of those areas gave us detailed insights into how our users experience virtual collaborative spaces. As our UX analyses nears completion, we state this understanding of our users in the context of the environment and the challenges they face with a problem statement:

- User unfamiliar with instruction or content.
- User hesitate to ask for help on object unfamiliarity.
- Group collaboration suffers based on this reluctance.

Activity Scenario: Object Called Sextant Offers Context

To find solutions to this problem, we use our persona, Jenn, as a lens to understand possible solutions. A pattern that stands out to us was the repeated misunderstanding of the content by our participants. Our experience suggests that the single, most impactful improvement we can make, is bridging this gap between the content and our users. If we look at the example task of ranking a set of objects by their usefulness in an emergency situation, then an object that offers contextualization to users expected to rank it is offered as a potential solution. We phrase this as an activity scenario for Jenn:

- Jenn reads a list of objects she is asked to rank.
- Jenn does not recognize the object called a sextant.
- Jenn is too shy/afraid to ask others for help.
- Jenn interacts with an object.
- Object presents information that describes it.
- Jenn understands the object and moves on with the activity.

UX Design Solution: Object Contextualization Features

What we found was central to most of the activity conflicts was the vague presentation of the objects which participants had to understood to successfully complete the activity. There were no visual aids to give these objects or their use any context which also presented major issues for non-native English speakers. Our design solution arrived at implementing a card catalog (see Figure 5 and 6) for object contextualization as it meets the necessities of immersion, easy one-hand interactions, and in-depth contextual information. The user may activate this menu at any time they need to understand an object by squeezing down the off hand trigger, while holding the object in question. In the future, when VR headsets have facial cameras, an AI algorithm may activate the card catalog when it recognizes user frustration.

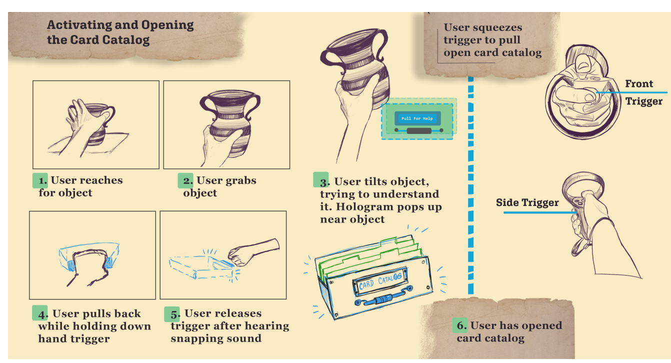

Fig. 5. User flow of activating and opening the card catalog.

The card catalog offers three categories of contextual information which include origin, purpose, and how to use. An AI algorithm would search the internet to find the most relevant information to fill out the card for each of these categories, which would offer a level of context to help connect the meaning with the user for an in depth understanding. Once the user has pulled back a small distance, a hologram of the card catalog box transitions into a solid object with three tabbed cards, each labeled with the corresponding information: origin, purpose, how to use. The user may leave the box stable in mid air at whatever height is most comfortable for her/him and when the user is ready to close the menu, they are simply cued to make a pushing motion. The card catalog condenses with the pushing motion and snaps out of the scene (see Figure 7).

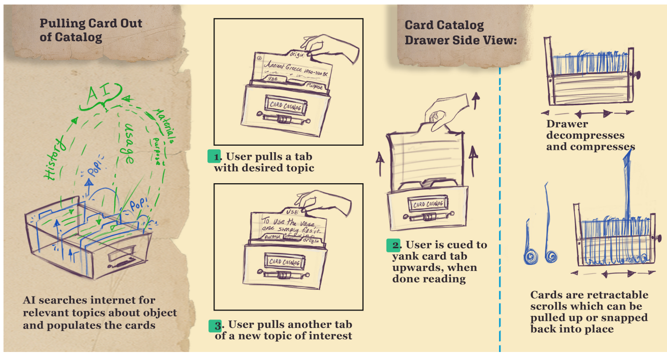

Fig. 6. User flow of pulling card out of catalog.

Discussion

Our case study described the use of usability analyses in a previously understudied domain, and surfaced areas in need of improvement within collaborative multi-user virtual environments. The most rectifiable issues are directly related to content presentation. Understanding the content is critical to activities of all categories, and any obstacles that user has to overcome do not contribute to better results in collaborative training. We are confident that using smart objects to improve the contextualization of content will bring improvement by reducing observed issues.

Depending on the context of the activity, there are different ways to define what understanding of an object means. Users understanding of an object could mean recognition by name, understanding functions, familiarity with objects history and origins, among many others. Observing user behavior is a suitable method for analyzing the usage of the application since users are often unaware of some of their actions and would be unable to explain their behaviors when asked directly. With that said, some of the motivations behind their actions are unclear, and future studies should include qualitative methods to limit the possibility of incorrectly interpreting user behavior.

Future Work

It will be necessary to conduct a study that explores different levels of object understanding based on a variety of presentation methods. Participants would be surveyed on object recognition by exposing them to lists of object names, images, and 3D models. Results of this study would either confirm the level of information necessity for user recognition of objects. Depending on the specific application using 3D models can be difficult and costly to implement, so allowing an alternative content presentation options are beneficial to the development of new educational applications without higher cost or over-engineering where it would not lead to better outcomes.

Study Limitations

Limitations to the generality of our findings may include parts of our videos' audio being unintelligible, either as a result of the volume issues, or participants talking over one another. These issues are compounded by the lack of accurate non-verbal communication that would allow the analysis to decipher some meaning from otherwise unusable data.

Conclusion

This research gave our team new insights in applying UX analyses to multi-user collaboration within a VR environment. We were able to adapt established usability methods in a new domain and identify opportunities for developing new design features to solve user understanding with contextualization aids. We hope this case study can help support future research in best practices for VR UX analyses and research.

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