Virtual Showdown: An Accessible Virtual Reality Game with Scaffolds for Youth with Visual Impairments

Ryan Wedoff[1], Lindsay Ball[2], Amelia Wang[3], Yi Xuan Khoo[4], Lauren Lieberman[2], Kyle Rector[4]

[1]Microsoft; [2]Department of Kinesiology, Sport Studies & Physical Education, The College at Brockport, State University of New York; [3]Human Centered Design & Engineering, University of Washington; [4]Department of Computer Science, University of Iowa

INTRODUCTION

Virtual Reality (VR) gaming is growing in popularity. However, VR games are not accessible to people who are visually impaired, because visual output is a primary cue for gameplay.

To address this problem, we designed a VR game call “Virtual Showdown.” Virtual Showdown is inspired by the accessible game “Showdown”, where people hit the ball against an opponent by using their hearing (see right photo).

Virtual Showdown uses voice, sound, and vibrations as cues for gameplay. We also designed two types of scaffolds to teach youth (ages 7-20) how to play.

We conducted a user study with 34 youth with visual impairments to test for acceptability of Virtual Showdown.

Wooden Showdown table with bat, ball, glove, and blinders.

RESEARCH QUESTIONS

1.How do youth with visual impairments perform in Virtual Showdown?
2.What are their body movement strategies during gameplay?

DESIGN AND IMPLEMENTATION

Virtual Showdown

- We changed real-world Showdown dimensions to ease VR gameplay:
  - Table smaller
  - Ball bigger and bouncier
- We tracked players with a Microsoft Kinect for Windows Version 2.
- We used spatial sound to convey the ball’s location.
- We used vibrations when the player hit the ball or moved their hand out of bounds.

Scoring:

- For each ball, a player could earn:
  - 3 points for scoring
  - 2 points for hitting the ball past the halfway point
  - 1 point for hitting the ball slowly
  - 0 points for missing the ball.

Scaffolds (in Levels 1-3)

- Verbal: We gave verbal hints, including a preview of the ball’s path, corrective feedback when the ball crossed halfway, and constructive feedback
- Verbal/Vibration: Same as verbal, except a handheld Nintendo Switch Joy-con vibrated with increasing intensity as the player moved their hand to the correct location to hit the ball

Debugging interface for Virtual Showdown. *not* used for gameplay

USER STUDY

We conducted user studies with 34 youth with visual impairments, where 15 played Showdown before. Participants played Virtual Showdown with both Scaffolds (order was counterbalanced). We conducted interviews after playing with each Scaffold. At the end of the study, we asked participants for their preferred scaffold and whether they wanted to play again (as a one player and two player game). We calculated the final score, final level, and ball outcome. We analyzed the quantitative results with several statistical tests including paired t-test, Wilcoxon Signed Rank test, Kruskal Wallis rank sum test, and Friedman test.

We labeled the video footage to determine how participants moved their bodies. We omitted one participant due to video recording error. We iterated on the codebook while three researchers independently coded 2 participants. Two researchers coded 20% of the remaining videos. We calculate agreement with Cohen’s Kappa, and removed categories with “poor” or “fair” agreement, and coded the rest of the videos with the final codebook (in table to right). We conducted open coding for the interviews.

Category	Labels	% agreement	Cohen’s Kappa
Holding Controller	Grasp Controller, Rest Controller on Hand, Pinch Controller, Hold with Two Hands	98%	0.95
Respond to Midpoint Feedback	Yes, No, N/A	95%	0.88
Amount of Attempts	Deliberate Attempt, Multiple Attempts, Free for All	92%	0.82
Type of Swing	Forehand, Backhand, Joust, Sweeping, Overhand, No Swing	93%	0.77
Other Hand	Idle, Feeling Boundaries and Goal, Resting on the Table	88%	0.73
Dominant Hand Height	Table, Torso, By Head	86%	0.72
Body Movement	Stationary, Movement within the Table, Movement outside of the Table	86%	0.68
More Attempts after Hitting the Ball	Yes, No	85%	0.66

Final codebook for labeling gameplay video footage.

RESULTS

Quantitative

- Regardless of Scaffold, participants with prior Showdown experience scored higher than those without.
- No other demographic factor had an effect on the score.
- Participants scored higher with Verbal Scaffolds than Verbal/Vibration Scaffolds.
- There were no learning effects in the study.

Qualitative

- Body Movement Strategies (n = 33 participants). At *some* point:
  - 32 participants held the controller with a natural grasp
  - All 33 participants responded to feedback when the ball crossed halfway, but 18 participants did not respond to this feedback
  - 25 participants made a single attempt at a ball, while all 33 participants made multiple attempts
  - Participants made many swings, including backhand (n=28), forehand (n=15), “jousting” or poking (n=16), back and forth sweeping motion (n=8), had no swing movement (n=20) (placed their hand a location to let the ball bounce off their hand)
  - All 33 participants had attempted to hit the ball after they had already hit the ball
- Responses to Conditions and the Game (n = 34 participants)
  - No clear choice of preferred condition
  - 33 participants wanted to play the game again and with friends
  - Participants felt the game was fun and allowed to be on a level playing field with sighted peers
  - Participants suggested improvements including making the hints optional; making the game online; making the game multiplayer; adding more music.

CONCLUSION

We implemented a VR game that is accessible to visually impaired youth. Then, we conducted an empirical study with 34 participants to find out the effectiveness of Verbal and Verbal/Vibration Scaffolds. We learned that Verbal Scaffolds and prior Showdown experience resulted in participants earning higher scores in the game. We found diverse types of body movements strategies during gameplay. We presented qualitative feedback on gameplay experience. We hope this work will help further research in VR and accessibility.