bluble

Technische Hochschule Ingolstadt

Virtual and Augmented Reality Applications

Final Report

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Prof. Dr.-Ing. Munir Georges
Joed Lopes da Silva
Dr. Andreas Löcken
Tamara von Sawitzky

Handed in by Group C 'bluble'
Luci Fischer
Lena Stütz
Carina Ziegler

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Content

Meta data

Luci Fischer

During my bachelor's degree program in Online Media, I already had my first touch points with computer graphics. In particular, I had the opportunity to learn 3D modeling and become familiar with the software Blender when my teammates and I created an animation film. However, game design and implementation were a completely new field for me, and Unity a new environment. Additionally, I had no prior experience with VR technology. Despite this, I was excited to apply my knowledge of 3D modeling to our team project and be part of designing and developing the application.

Lena Stütz

Due to completing the User Experience Design bachelor course at THI, I was able to bring some experience with creating technical 3D models in Autodesk Fusion 360, designing user interfaces with the Adobe Creative Cloud tools and programming in Java into the project. The bachelor course also included a virtual reality module, but it unfortunately fell in the first COVID-19 semester. Therefore, the practical could not take place in person, and we focused on the theoretical part of the module. Early in the project I discovered that scripting was the most interesting for me, so I mainly focused on this in the further course of the semester. In addition, I assisted with the user interface, sound selection and put all parts together.

Carina Ziegler

I have a bachelor's degree in multimedia and communication and have already worked with Unity before. I had courses on product visualization and game design. In the course 'product visualization' my teammate and I developed an apartment simulator where the user was able to walk through an apartment and change various things such as floors or furniture textures. In the course 'game design' my teammate and I developed a simple jump and run game with three different levels and objects that the player could collect which would influence them (I. e. change the player's speed, kill the player immediately). While focusing on modeling and coding in past projects, I discovered that designing the user interface was the most fun part for me. Therefore, I suggested mainly designing the UI for our project. In addition to that, I was part of developing the gameplay.

GitHub-Project

The latest status of the project can be found in the branch **main**, all the presentations as well as this report can be found in the branch '**presentations-report**'. In case of any errors in **main,** we recommend trying out the **'dev-lena'** branch to rule out any merge issues.
https://github.com/stuetz-lena/vr-language-learning
Due to file size restrictions on GitHub the final executable can be only delivered via Google Drive: https://drive.google.com/drive/folders/1oxnQ7I3SDbBUfkJ4ervWpOJqSb1bbnsy?usp=share_link.

Introduction

Our application 'bluble' is a VR add-on to a language course where players sort objects to optimize their grammar skills in a bold and colorful environment. It addresses students, who are learning a new language and searching for an additional way to practice what they have learnt in a conventional language course. Learning a new language – especially vocabulary – can be draining and boring. With our approach, we want to change the way of learning and transport our users in a new world where they can interact and play with their friends all while expanding their knowledge on a language. Our goal is to provide a useful tool that motivates students to work and revise outside of their course time to achieve sustainable progress.

1. Concept

1.1 Description of the project concept

After choosing the language, game mode and level – in our case German and 'Cooperation Training mode' – the player finds themself in an outer space environment. In the level 'Articles', that we implemented within the scope of this course, the player must drag bubbles with German words on crystals with the correct articles. The game will be played while seated to avoid motion sickness. The navigation works with one of the two controllers. With the trigger of the controller bubbles can be grabbed and pulled towards the player via the joystick. In this game mode, the goal is to correctly sort in as many bubbles as possible. As a little help for the player, they receive an audio output of the chosen word. By that, they may find the correct solution more easily and can improve their listening

and pronunciation skills. The final version of the game, we envisioned three different game modes: 'Cooperation', 'Competition', and 'Single player'. To offer a useful tool, the different levels in a final version of the app should cover more grammatical structures such as word types, spelling, or translating vocabulary. In addition to the three game modes, there are two sub modes. Each mode can be played in 'Training mode' and 'Exam mode'. While the 'Training mode' has no time limit, offers a second try for wrongly sorted items, and provides the right solution as well as hints, the exam style has a time limit of 90 - 120 seconds, and only provides 'right' or 'wrong' feedback. The words are taken from already known vocabulary according to the specific course. New levels covering different grammatical structures can be unlocked according to the progress of the player and course. Teachers and professors have the possibility to individualize the content by adding vocabulary they discussed with their students in class. This vocabulary is also added to already available levels and in 'Training mode' vocabularies which were often answered incorrectly are repeated more frequently to enhance the learning effect.

1.2 Personas and user stories

Before we started implementing our app, we came up with two personas and their user stories to help shape and define our features.

Persona 1 and user story 1: John

Figure 1: Persona John [Source: https://unsplash.com/de/fotos/t8yimzM2bEY]

John is a 24-year-old student from Brighton in the UK. He has a bachelor's degree in Computer Science from Royal Holloway, University of London and recently moved to Germany for his master's degree in

User Experience Design at Technische Hochschule Ingolstadt. He has German A2 knowledge as he already prepared for his studies abroad back in the UK. He is rather tech-savvy and generally likes new technologies. Through his interest in gaming, he also has some experience with VR.
To extend his German skills, he attends a pursuing language course that offers the VR extension 'bluble' alongside the usual lectures and exercises. With the app, he can practice the contents of the course at home. The difference to a regular course is that the VR app acts more like a video game due to the strong gamification aspect. Thus, John feels much more motivated to exercise his vocabulary or grammatical structures than he would if he had to practice them in the common way. Moreover, he can interact with his fellow students by working together in teams or competing against each other.

Persona 2 and user story 2: Jessica

Figure 2: Persona Jessica [Source: https://unsplash.com/de/fotos/IxnC_Zw_weE]

Jessica is a 37-year-old teacher from Munich, Germany. She has a master's degree in German linguistics and is a German native speaker. She is teaching German to non-native speakers at Technische Hochschule Ingolstadt and is very passionate about her job. Creating a fun and motivational environment for her students is of high importance for her.
Jessica offers a German language course with the VR extension 'bluble' to provide her students with a diversified experience instead of the standard and possibly dull learning routine as she noticed her students having trouble finding the ambition to practice at home. She observed that her students are much more motivated to do their exercises with the VR app, as it offers a new and different approach to learning languages. In addition, the grades of her students and time invested in revising the lecture content increased in comparison to her previous approach with common *exercises*. Moreover, she implemented a bonus system that is linked to the app usage. Students who receive a certain number of points while playing get bonus points that can be used to improve their grade in the final exam.

1.3 Game flow, user activities, and multi-user interactions

Our application 'bluble' works as the following:

The game takes place in a virtual reality environment with a purple, space-like theme, and 3D assets, accompanied by background music. Players can navigate the game using a controller while seated or standing, but movement in physical space is not required. The 'Articles' level's main objective is to help players practice using the correct articles for German nouns. Bubbles containing German nouns will be displayed in the VR environment and players must sort them in by placing them on the 3D crystal representing the corresponding article. The goal is to correctly sort in as many bubbles as possible.

Figure 3: Dragging bubbles [Source: own illustration]

Once the player puts the VR glasses on, the starting screen appears, and the user can launch the game by clicking on the 'Let's start' button. Afterwards, the selection of language, mode and level take place and a little tutorial introduces the gameplay. We decided on three modes: The multiplayer mode 'Cooperation' is a team play setting for practicing together with others. Furthermore, the mode 'Competition' can be selected to play against each other, and a 'Single player' mode is available as well.

The multiplayer mode in 'bluble' allows players to interact with each other through voice chat while playing. Players can discuss strategies and right solutions, give feedback, and encouragement to each other as they sort the bubbles. Additionally, players can pass bubbles to each other, allowing them to

work together at sorting them correctly. This mode is perfect for team players who want to improve their grammar skills together.

Besides, the game includes two sub-modes: 'Exam Mode' and 'Training mode'. In 'Exam mode', players have a limited time (90 - 120 seconds) and receive immediate feedback. In 'Training mode', there is no time limit, players have a second try for incorrect answers, receive hints, and have the correct solution displayed at the end of the game.

Since we want our application to be an add-on to the language class and as close to the content in class as possible, all words are taken from the already known vocabulary. Teachers can unlock different levels based on students' course levels and progress.

Once the player grabs a bubble, the written word is being read out too. This helps to avoid possible misunderstandings because of blurriness and helps to remember the pronunciation as well. In case the user needs further assistance, the 'B' button on the controller can be pressed while having a bubble selected to translate the German word into English or the players' native language. Hints can only be used once, and if the player made use of it the correct sorting is rewarded with only half of the points. After using the hint, the indicator above the bubble disappears.

The bubbles can be moved via the controller. The 'Trigger' button works as a tool to select an object. With the joystick, an object can be pulled or pushed closer or further away and by moving the controller, bubbles can be navigated towards the correct crystal.

As soon as all bubbles are sorted, the player receives an overview including the playtime and score. The player will have the opportunity to review their performance as all bubbles are displayed once again, this time with the correct solution, and in a green color if sorted correctly, or in red color if not. This feature allows players to identify their strengths and weaknesses and strive to improve their performance in the next round.

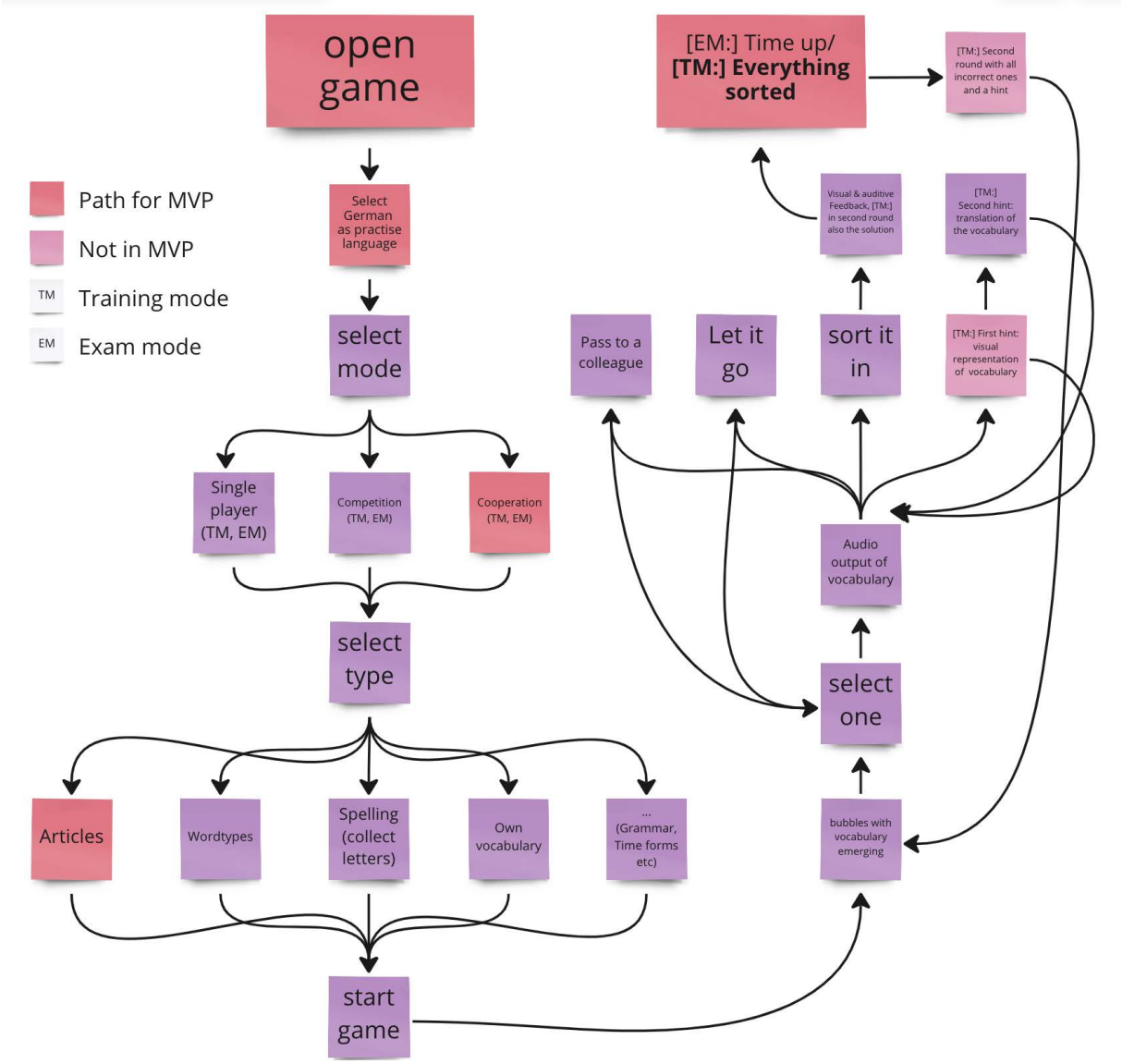

Figure 4: Planned game flow of the application [Source: own illustration]

2. Methodology

2.1 3D-Objects

For modeling the 3D objects, we used the software Blender. It is an open-access software with which we already had some experience. Therefore, the rocks, the UFO, and the little robot in our setting were 3D modeled by ourselves. Only the crystals with the articles on them were taken from the Unity asset store.

2.2 Game Logic & Scripting

Unity was used in version 2021.3.9f1 (LTS) as installed on the lab computers to avoid version conflicts. The scripting was done in the Visual Studio Code editor. For source control we used GitHub. To implement the multiplayer aspect, we used the Pun2 Framework from Photon[1]. An Oculus Rift with controllers was provided by THI and used for the project.

After getting familiar with Unity basics, Photon principles, and with the example project as basis, we started developing our game logic. Over the course of the semester, knowledge and experience with the technology stack improved which we all applied again in the end when polishing and improving the code multiple times. Especially determining which functionalities should be overtaken by the master only and which ones should be executed on all clients was gripping. Our final project includes twelve adjusted or newly created scripts with the following functionalities:

- *NetworkManager:* Manages Photon room and game status (start, pause, restart, quit); spawns and manages avatars, crystals, and robo
- *RigPosition:* Start position adapts depending on player amount
- *NetworkPlayer and PlayerName:* Name label translated to English and adjusted rotation
- *PhotonStatus:* Score added to the output
- *GameController:* Responsible for score, time and tracking of sortings; creates bubbles, determinants game end and shows results
- *BlubleDraggable:* Manages the bubbles and their reactions to user input (selecting, hints, sorting, leaving game area)
- *UserInterface:* Manages the UI by enabling and disabling the screens and sounds
- *RoboMaterialController:* Changes the material of the robo body in case of a correct sorting
- *RoboMovement:* Animates the robo body, head, arms, and floating
- *UfoMovement:* Animates the top ufo to float in circles
- *SpriteMovement:* Animates the sprites in the instructions to move vertically/horizontally
- *Rotator:* Rotates the icons of the crystals and bubbles

[1] https://www.photonengine.com

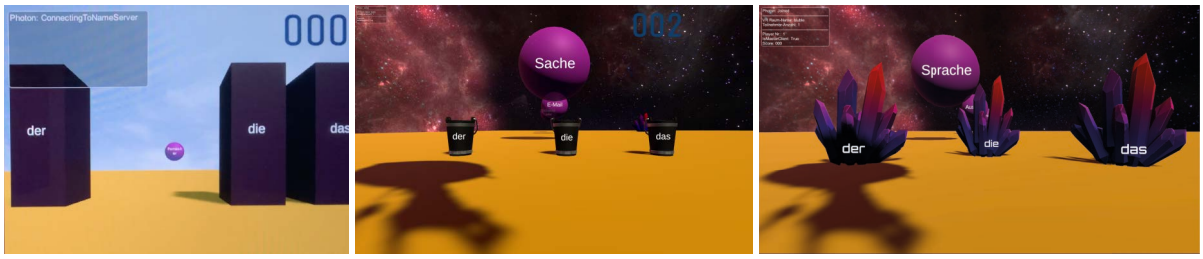

Figure 5: Evolution of game design [Source: own illustration]

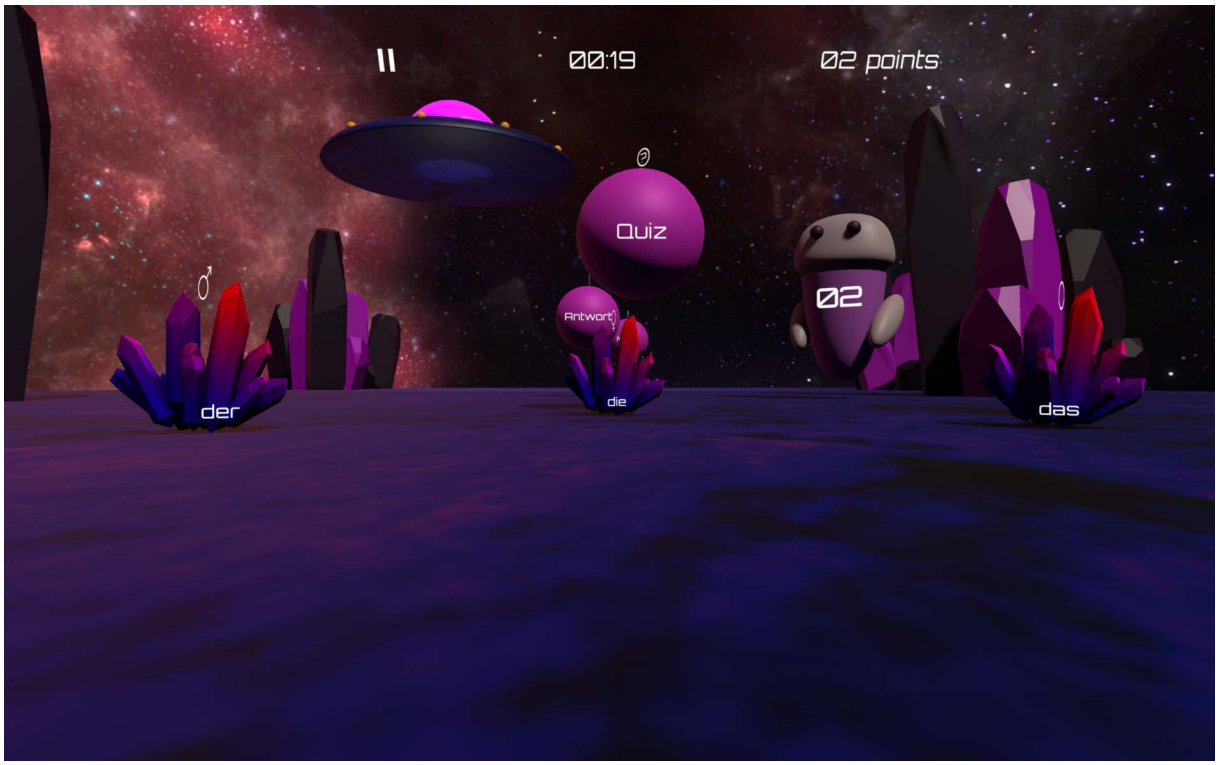

Figure 6: Final game design [Source: own illustration]

Figure 7: Animation of correctly sorted bubble [Source: own illustration]

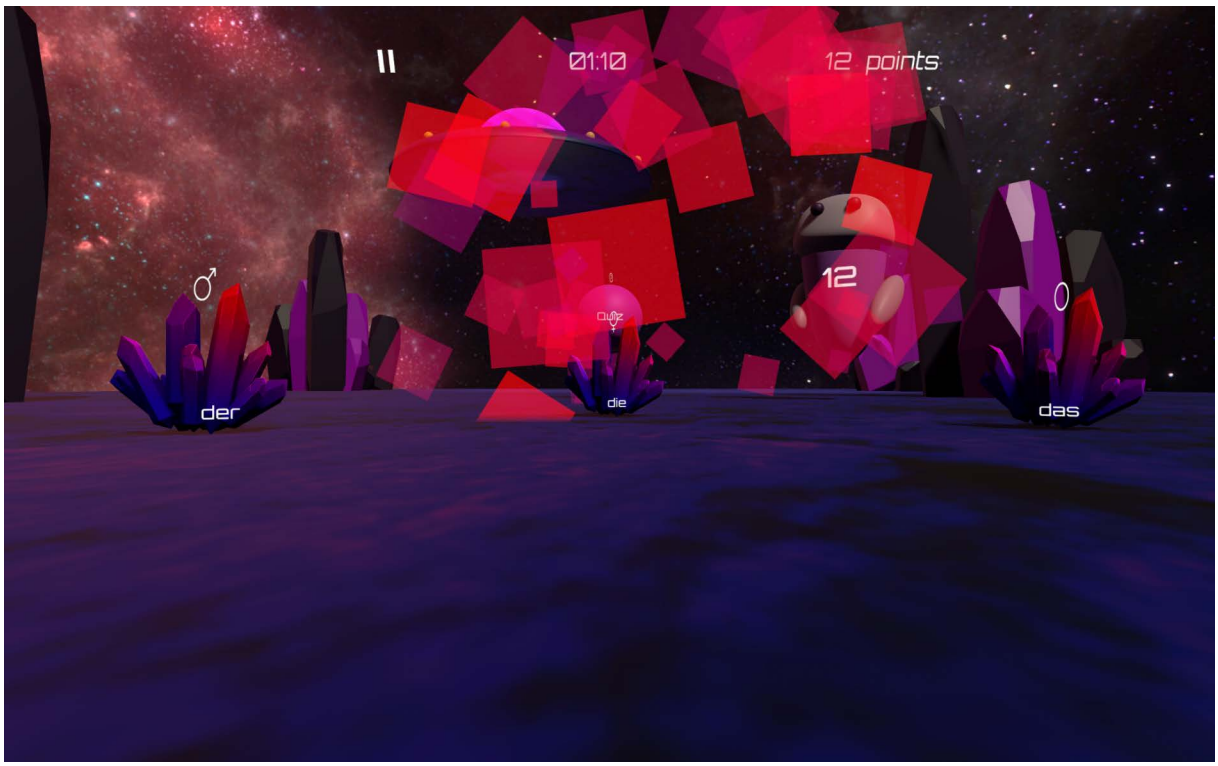

Figure 8: Animation of correctly sorted bubble [Source: own illustration]

2.3 Game & UI Design

Before implementing our game, we started with drafting a screen design and game layout as well as a color palette in Adobe Illustrator to achieve a consistent design approach. After our first presentation, we received feedback on how to design our game view. With the input that some surrounding would be appreciated, we discussed what kind of environment would be fitting for our app and features. We settled for a space themed environment in a dark purple, Milkyway inspired color scheme.

We wanted to keep our UI simple yet fitting for our space theme. As font we chose 'Orbitron' which we also applied to our progress reports and presentations. It's a sans-serif font with a geometric look. Our predefined buttons have rounded edges. A missing filling and colorful outlines give them a clean and modern look. After recognizing that some users may need assistance understanding how to play, we included a brief tutorial before the actual game begins. The sprites such as the buttons, image of controller, crystal, and bubble for the tutorial as well as the article signs (male, female, and neutral) were created with Adobe Illustrator. Another part of the UI is the head-up display. It consists of the play time, the current score, and a pause button. When clicking the pause button, the player is presented with the options 'Continue', 'Restart game', 'Review Tutorial', and 'Leave game'.

Evolution:

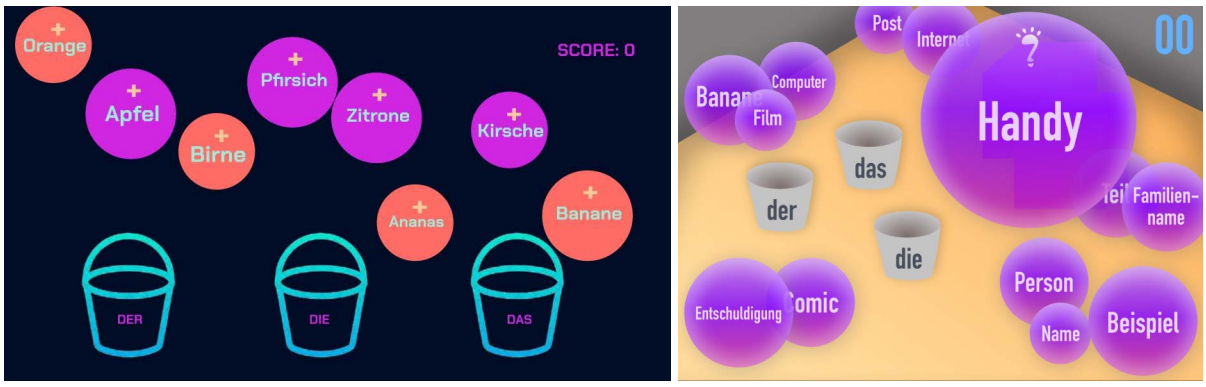

Figure 9: First sketches of the game design [Source: own illustration]

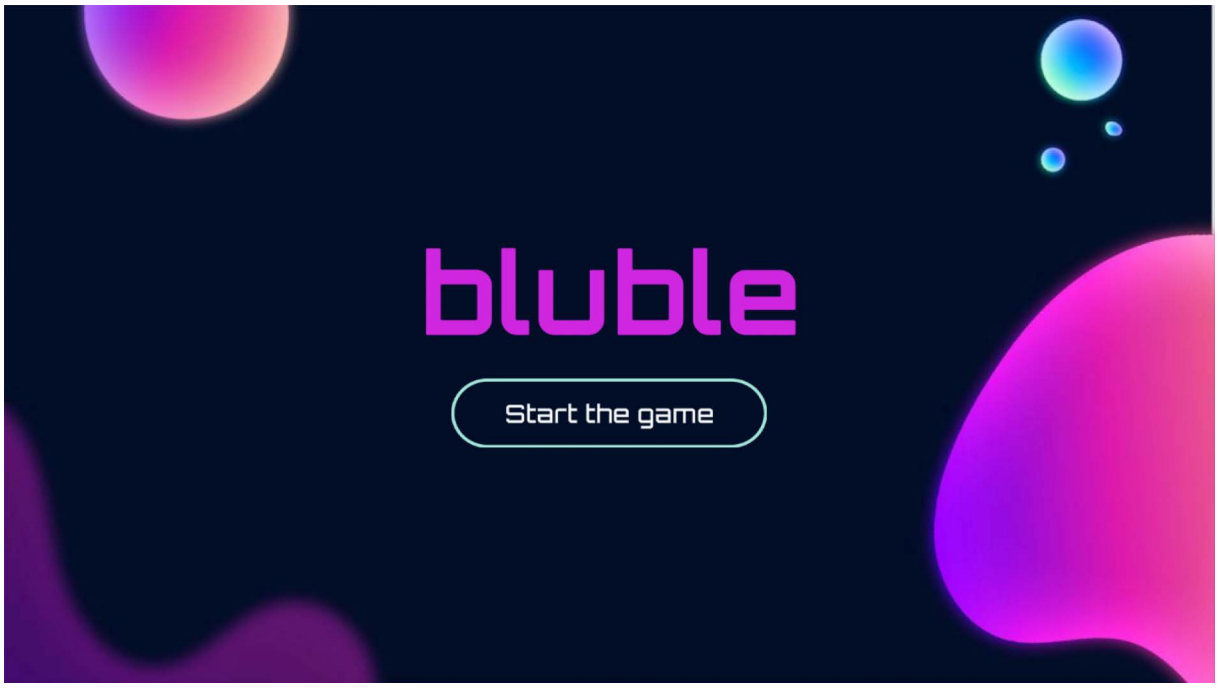

Figure 10: Initial UI design [Source: own illustration]

Figure 11: Final UI design in the VR application [Source: own illustration]

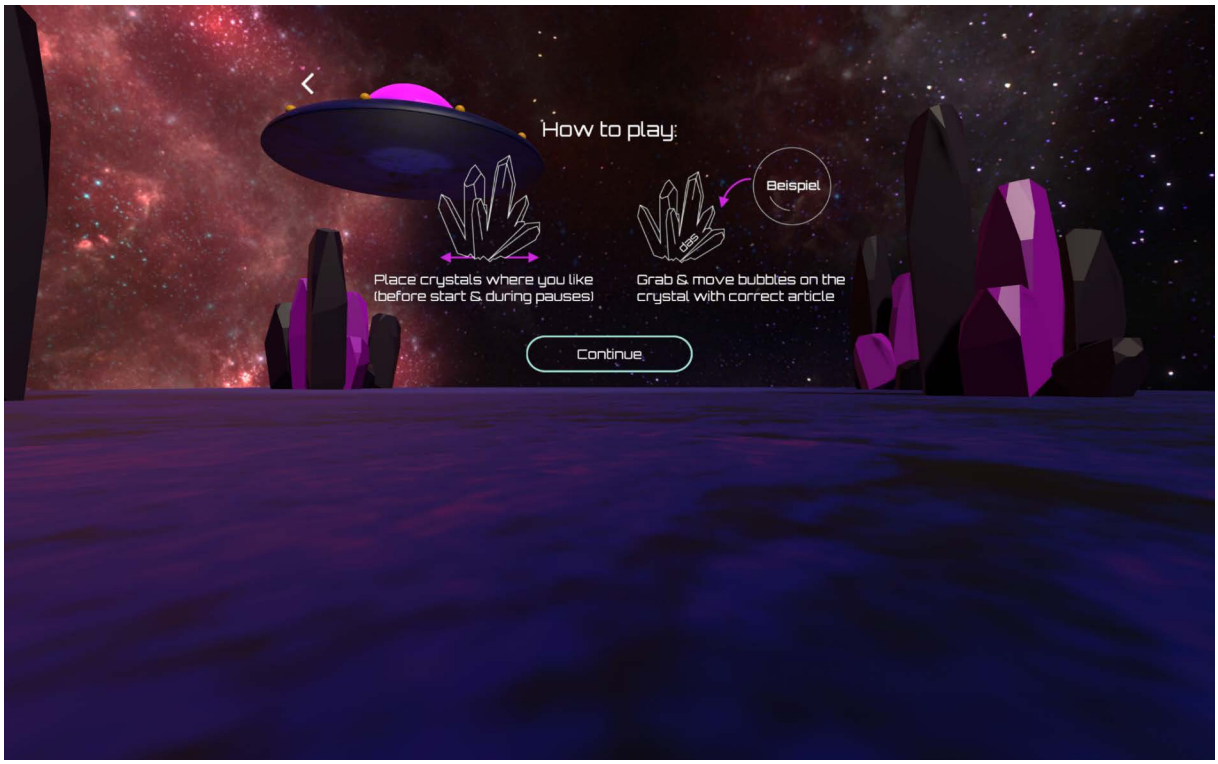

Figure 12: Tutorial interface in the VR application [Source: own illustration]

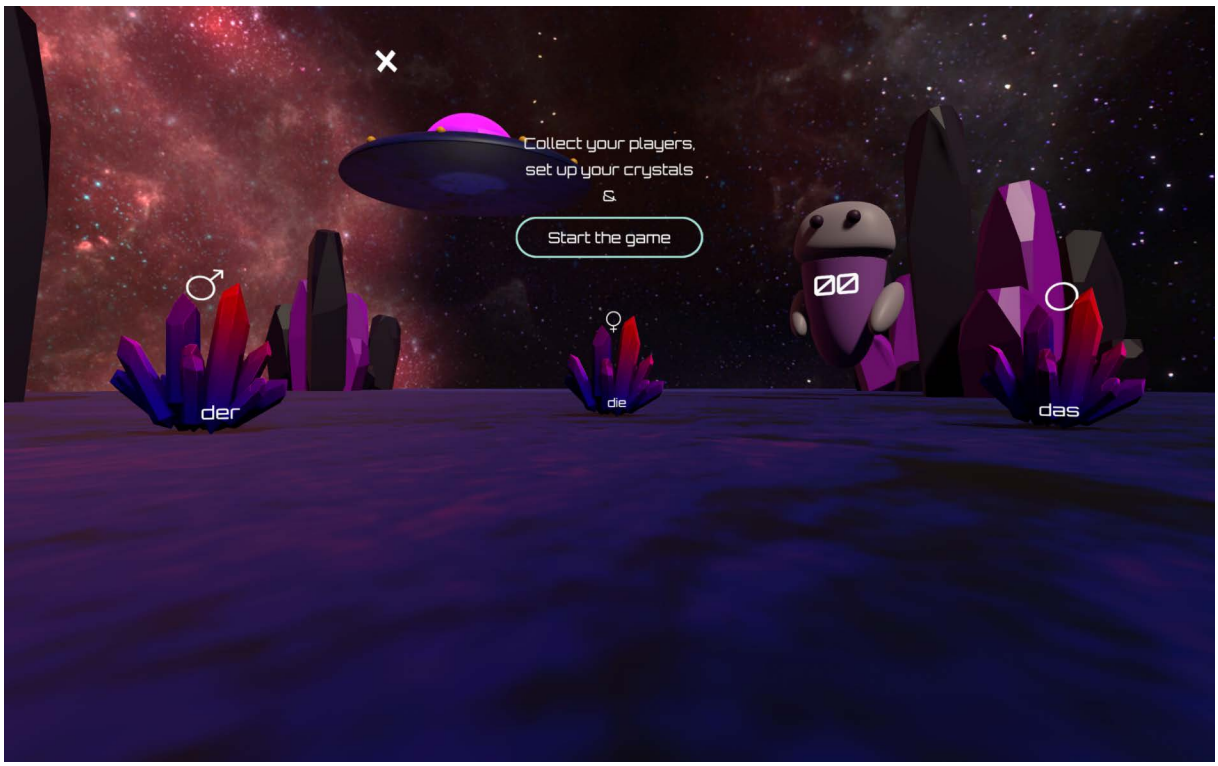

Figure 13: 'Start the game' screen in the VR application [Source: own illustration]

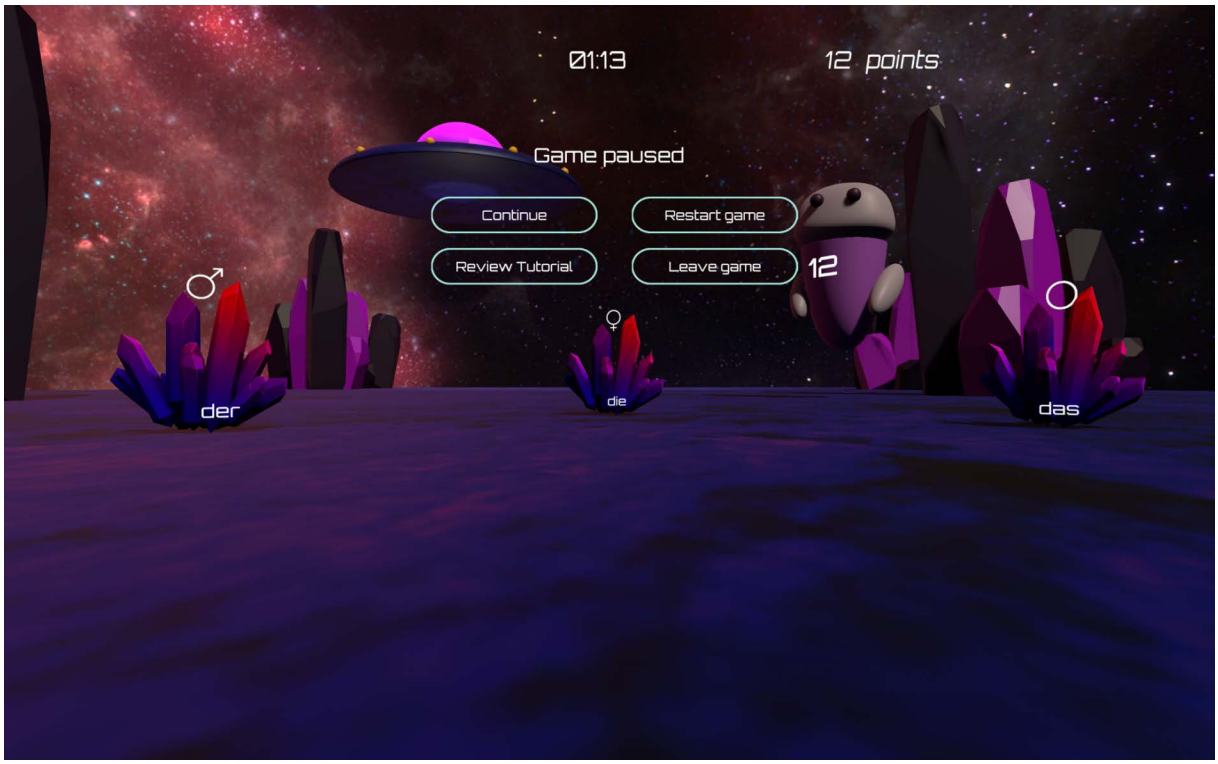

Figure 14: Pause screen in the VR application [Source: own illustration]

2.4 Text-to-sound converter

We have utilized a free online text-to-voice generator to generate audio files for the vocabulary words. The used vocabulary was taken out of the 'Motive A1-B1' course book which we received from fellow students completing the German A1 course. With the audio output, we wanted to facilitate the sorting in case someone has difficulties reading the word but also include the aspect of internalizing the correct pronunciation.

2.5 User study

Preparation of user testing

Through user testing we wanted to elaborate the general impression of our application. Therefore, we have created the hypothesis that 'Our VR learning application is fun to use and intuitive for the user'. The learning effect should have been tested as well, but regarding the given testing setting this was difficult to realize. A real learning effect is probably only noticeable with multiple usages over a longer time. For that reason, we wanted to mainly focus on intuitive usage and fun for our users.

For the user testing, we had chosen different evaluation methods. We had planned a usability evaluation where we wanted to encourage our users to think aloud when playing while we observed them. By measuring the playtime and score after each test run, we could give a statement concerning the learning effect to a certain extent. Through follow-up interviews with open questions, we wanted to find out about the general experience, willingness to use, and issues regarding the user experience. With additional questionnaires as the UEQ, we gained a quantitative measurement of the user experience and wanted to keep an eye on possible VR sickness symptoms.

User testing

During our user testing, five participants played our game twice. Three of them were native German speakers and two of them were non-native speakers with A1 knowledge of German. They played one of two different sets of words depending on their participant group. The order of words within the sets was randomized.

The user testing was run on the PCs in the VR lab at THI (G006). Due to time limitations, one of us focused on one test user each. After a brief introduction of our idea and the test itself, we adjusted the equipment to the user and conducted two test runs. We encouraged them to think aloud while playing and took notes in Microsoft Word on everything our test players mentioned or any issues we observed. To gain insights on the progress of our testers, we measured the score and playtime for each run. After completing the two runs, we posed interview questions, and they filled in the Motion Sickness Questionnaire and the User Experience Questionnaire.

3. Results of user testing

3.1 Observation & user feedback

In general, all test people stated that they liked our game because it was fun to play and they found the design, setting, and sounds fitting. One of our participants highlighted that playing was intuitive and that the general pace of the game was very good. We got the motivating feedback, that all of them would like to play the game again and use it as an addition to their in-person language course. However, the pre-condition for the native German speakers was of course that the game would be

available to learn a different language than their native language. Besides, it has been pointed out that the game provided a motivating gamification aspect for such boring chores as training vocabulary. Of course, we also got some feedback on what to improve over the next few weeks. The crystal structures with the articles 'der', 'die', and 'das', which worked as targets to sort the bubbles on, needed more spacing in the beginning. At that moment, they were a little bit too cramped together. The pulling of the bubbles was too slow for our testers. They suggested speeding up the movement to end up with a decent playing speed. Some participants also stated that the speed of the bubbles could be increased in general. After finishing the level, the user receives an overview of all the bubbles and whether they were sorted correctly. Here, an interaction with the bubbles was perceived as unnecessary and, in some cases, led to them disappearing in space before the correct solution could be reviewed. One of our testers also mentioned that it would be nice if the crystals with the articles were designed in different colors or accentuated with symbols so that they would be more distinguishable. Some also wished for more dark color accents, tuning down the music, and adding a pause and play button as well as a score with how many words one already sorted correctly. Those are also points that were already on our to-do list. The fact that the text is no longer readable as soon as the bubbles start rotating was also mentioned.

Besides the learnings on the improvements, we also wanted to hear about some suggestions on additional features. Our participants wished for a more detailed tutorial on the controllers in the beginning as well as a multiplayer competitive mode. Various difficulty levels and more grammatical structures were also mentioned. Moreover, multiple participants would find it helpful to have correct solutions displayed in case of a wrong answer and as already mentioned, the native German speakers wished for more languages. One participant also suggested that the words that were sorted incorrect should reappear again during the same run to increase the learning effect. They also wished for features such as an in-game currency in the form of a reward for daily playing and an export function to have an overview of incorrectly sorted words in a document. The points of showing the correct solutions and the availability in more languages were also already next steps on our agenda.

3.2 Run comparison

The following chart shows the comparison of the two game runs for all our participants.

Test participants	**P1**	**P2**	**P3**	**P4**	**P5**	**Average**
Points	+2	-	-2	+2	+8	16.4 vs. 18.4
Time in seconds	-20	+10	+6	-2	-8	1:1 vs. 1:16

Table 1: Comparison of two game runs for all participants [Source: own data]

Overall, a tendency for improvement is visible. For two players, the values worsened during the second run due to problems with the article indicators because they fell off the plane or sideways as well as due to the pace. But as mentioned earlier, we have not had the perfect test environment for a long-term test. Therefore, we would like to conduct another test focusing on the learning effect in the future.

3.3 Motion sickness

To test possible motion sickness, we decided on using the Motion Sickness questionnaire developed by Kim et al.[2]. None of our test people stated feeling a headache, fatigue, vertigo, and dizziness with the eyes closed. One of five participants felt a slight fullness of the head, blurred vision, and a slight general discomfort. 40% mentioned a slight eye strain, and 60% felt a slight difficulty focusing. However, the overall feedback from our participants was positive. The majority of users didn't have any issues regarding motion sickness.

[2] Kim, H. K., Park, J., Choi, Y., & Choe, M. (2018). Virtual reality sickness questionnaire (VRSQ): Motion sickness measurement index in a virtual reality environment. *Applied ergonomics*, *69*, 66-73.

3.4 User Experience Questionnaire

For the User Experience Questionnaire (UEQ)[3], the results for all scales were positive. Attractiveness and dependability were rated the highest with especially the values for the items 'pleasing' and 'meeting the expectations' standing out. The novelty and efficiency scales were rated lower but still positive especially for the items 'slow/fast', 'leading edge', and 'inventive'. The responses for 'slow/fast' were very mixed which also led to a low internal consistency for this value. In comparison to a benchmark data set, we received overall good to excellent values. Due to the mixed feedback for the speed and the qualitative comments about this, we wanted to have a look at that aspect again.

UEQ Scales (Mean, Variance & Alpha)			
Attractiveness	2,300	0,41	0,96
Perspicuity	2,200	1,58	0,91
Efficiency	1,550	0,42	0,56
Dependability	2,250	0,50	0,87
Stimulation	1,950	0,92	0,92
Novelty	1,250	1,53	0,74

Table 2: UEQ Scales [Source: own data]

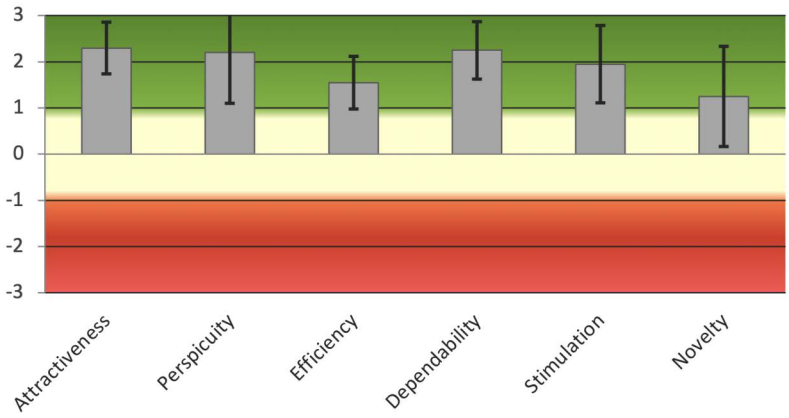

Figure 15: Benchmark comparison [Source: own data]

[3] https://www.ueq-online.org

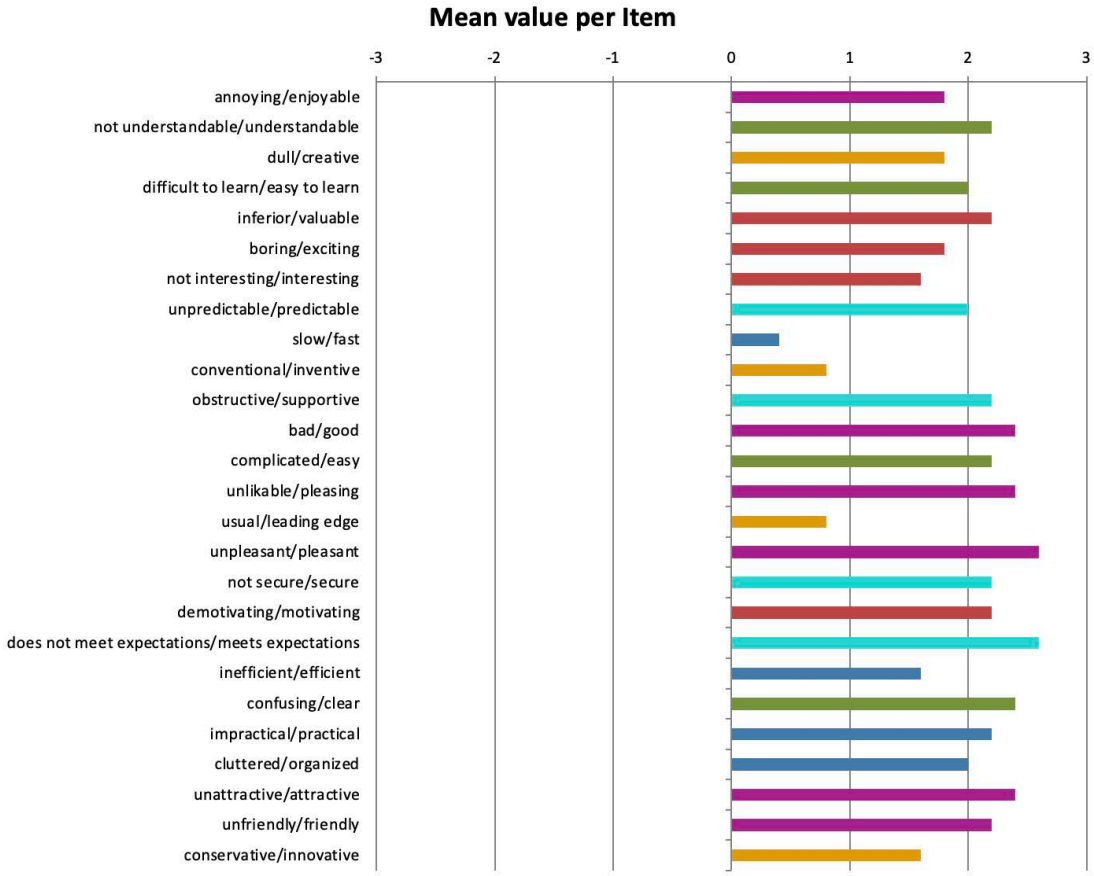

Figure 16: Mean value per item [Source: own data]

4. Discussion & Adaptations

4.1 Feedback adaptations

To improve the gameplay experience, we have implemented several new features in our application – based on our user feedback.

First, we have added features for pausing, quitting, and restarting the game. We have also implemented the user interface, to which we added a respective pause screen and tutorial to guide players through the game. Additionally, we have adjusted the environment by changing the floor color and adding the created 3D models with animations. We added icons to distinguish the different crystals and increased their label font size. To improve the gameplay mechanics, we have decided to add the ability to freeze the buckets during game mode and give players time to set them up in the beginning of the game. We have also frozen the result bubbles to avoid them getting lost in the virtual space and

removed Raycast targeting on non-draggable objects to avoid wrong affordances. Furthermore, we have increased the pulling speed and added higher invisible walls and a roof with colliders to prevent the bubbles from disappearing in the virtual space without returning. To avoid the bubbles and buckets falling through the floor, we changed the floor plane to a cube. To enhance the learning experience, we have implemented the vocabulary audio and added a particle effect as sorting animation.

In addition, bubbles that were not sorted will show up again to give players another chance to practice in case they needed some more time. Additionally, we have implemented a pass-over functionality, allowing players to exchange bubbles with each other in multiplayer mode to collaborate. Furthermore, we implemented one stage of hints. By pressing the 'B' button on the controller while having a bubble grabbed the player will once receive the translation of the vocabulary. A correct sorting of a word with a used hint only gives one point in the score opposed to two points for a sorting without using hints. For this feature and the emerging of the crystals and robot, we added additional sound effects. To provide a better multiplayer experience, we have made corresponding adaptations to the spawning of bubbles such as adjusting the amount, speed, and position of the bubbles to the number of players. We have also optimized the font size and hyphenation of the bubbles to make them more legible. Finally, we have done a general code cleanup and made several code improvements for correct functionality and stability.

Overall, these additions and improvements aim to enhance the gameplay and make the game more engaging, fun, and effective for learning. In a second, informal quick test with two participants the conducted adaptations received positive feedback. Concerning the multiplayer functionality, it was proposed to highlight the bubbles which are currently selected by a player in different colors, which was also implemented.

4.2 Practicability, limitations, and challenges

Practicability

When developing the application, we took several practicability considerations into account. For example, we avoided quick movements in the peripheral field of view to reduce annoying distractions. We also made sure all depth clues were applied on the bubbles, such as them being smaller, blurry, and covered by closer objects when further away, to create a sense of depth in the virtual environment.

Additionally, we made sure that dragging the bubbles had a smooth acceleration to avoid discomfort for players.

We also chose suitable gameplay mechanics such as opting for a seated operation and avoiding any artificial movement to reduce the likelihood of motion sickness. We used a ray to grab the bubbles instead of using hands, as we found that this helped preserve the sense of presence in the virtual environment. We also added sounds for actions to make them feel more realistic and to create an immersive experience for the players.

Limitations

Given the limited time and resources, we only implemented one mode, one language, and level. Within that level, we focused on an MVP approach, meaning that there is only one stage of hints, and no second round. The game is currently designed to work for only four participants and was only tested with two.

Challenges

We also faced challenges with the technology stack we used, specifically with Unity and Photon. For example, we had issues with spawned bubbles not being visible on other clients, and with the UI not being displayed on the headset. We also found that the readability of the UI was affected by the limitations of Unity and VR. However, we tried to mitigate these issues by adding audio output, increasing UI size and integrating it seamlessly in our environment. In addition, we ran into problems in the multiplayer mode concerning taking over the ownership of game objects and unregistered collider events on the master when the client was dragging the bubbles on the crystals. We were finally able to solve this via an additional RPC call, nevertheless it is still unclear why the position transmission via Photon seems to fail in that case while perfectly working the other way around.

Other occurring issues concerned the usability testing. It was difficult to measure time and score while also observing and assisting the participant. Therefore, it would have been better if we had managed to implement the UI beforehand. It would also have been beneficial to have two PCs and instructors per test, one to assist the user and lead through the test on one PC and one person to take notes, measure the score, and time on the other one. However, due to time constraints, we had to conduct the test in parallel.

4.3 Retrospective and future

Our vision for a fully developed version of 'bluble' would include the implementation of further levels such as syntax exercises, vocabulary training, and translations. Moreover, the elaboration of the pending play modes such as the competitive or exam mode would be on the agenda. Including more training languages as well as menu languages would address an even greater clientele. To offer a useful tool for teachers and professors, the possibility of having user profiles and statistics to check on students exercising time and progress would also be a great addition. By offering a teacher view, where teaching staff would be able to manually add vocabulary from their own courses and unlock levels, would give the possibility to personalize the learning process of students and their motivation to work with those topics even more. One feature that was proposed during the user testing as another possible addition was the option to add a repetition mode for all the words. With that, users would be able to extract their wrongly sorted words into a different play mode to revise them separately. Another idea would be a feature to share and customize word sets to create a more personalized experience. The 'Training mode' of the final implementation would also include a second stage of hints with a visual representation of the vocabulary before receiving the direct translation. To guarantee an even better learning effect, it would also come with a second round, where all the wrongly sorted words would reappear.

In our planning phase, some of the currently implemented features were planned differently. In the following list, we describe what we initially planned and how that feature eventually turned out.

- In our first project outline, we wanted the bubbles to spawn at once on different places all around the game field. Users would have to walk around or teleport themselves via controller to grab the bubbles. Later, we opted for bubbles that floated one by one towards each player. This way, we created a more active game play and immersive experience. Also, the seated operation was better to avoid motion sickness which was also confirmed by our test participants.
- During our first steps, we were thinking of buckets as objects in which the bubbles have to be sorted. After we established our space theme, the buckets became crystals to create a suiting atmosphere. The bubbles also pop when they hit the walls or crystals. The color of the resulting 'explosion' indicates whether the bubbles were sorted and if correctly or not.
- When thinking about the pass-over functionality we first envisioned to handle it via the UI or the press of a controller button. We eventually decided to implement it via an actual hand-

over (one player drags the bubble towards another and the other player grabs it) or by placing the bubble in front of the other player to make use of the 3D environment.

- We added a little robot to the 3D environment that also shows the current score and changes its body color in case of a correct sorting to further motivate the user.
- To ensure a long-lasting learning effect, we chose not to indicate the correct solutions directly after sorting but in a joint results overview in the end. This way, especially in the multiplayer mode students should be encouraged to discuss their solutions.
- After initially wanting to work with a long list of words, we reduced the bubbles to 13 per player. We wanted to keep the game entertaining and interesting and avoid the player from getting tired due to excessive play time.
- From previous projects, we were familiar with the workflow of implementing the UI as overlays. Due to the specific preconditions of VR and the goggles, we opted for integrating the UI within our game scene instead.

5. Summary

In summary it can be said that our main goal of implementing the 'Articles' level for the 'Cooperation Training mode' has been achieved and even surpassed in the end. Players can play different sets of words depending on player amount, grab the bubbles with the controller, and sort them to the corresponding crystal structure. The multiplayer aspect came with some issues. Especially spawning the bubbles on all clients took us a long time without any pre-experience and background knowledge about Photon. In addition, we run into problems with unregistered collider events on the master when the client was interacting with the bubbles. Fortunately, we were able to solve this eventually. Especially the positive feedback from users and their euphoric reactions while playing made us very happy and convinced us that we created a high value game for our target group. All in all, we are more than delighted with the outcome and would love to see a fully developed version helping students all around the world with learning new languages.

Appendix

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3rd-Party Sources

- Example project provided by THI via Moodle with the included assets
- Stylized crystal: https://assetstore.unity.com/packages/3d/props/stylized-crystal-77275
- Pixabay Sounds: https://pixabay.com/de/music/search/ (chill-abstract-intention-12099, bubble-pop-6395, notification-sound-7062, wahwahwahwaaaahahahahahaha-94669, whooo-105751, yay-6120, background-music-111bpm-26445, button-124476, interface-124464)
- SpaceSkies Skybox: https://assetstore.unity.com/packages/2d/textures-materials/sky/spaceskies-free-80503
- Orbitron Font: https://fonts.google.com/specimen/Orbitron
- Texture for the plane: https://www.freepik.com/free-photo/texture-background-with-grunge-stone-texture_31613231.htm (Colors have been altered)
- Word pronunciations generated via: https://voicemaker.in/