DEPARTMENT OF INFORMATICS

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Master's Thesis in Informatics: Games Engineering

Communication and Interaction Methods for Virtual Courses

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Kommunikations- und Interaktionsmethoden für virtuelle Lehrveranstaltungen

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I confirm that this master's thesis is my own work and I have documented all sources and material used.

Munich, 15. October 2021 Maximilian A. Mayer

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Abstract

During the Covid-19 pandemic, education has been taking place mainly online by facilitating video conferencing tools and learning management systems. Often, courses were merely transposed from the offline setting into the online world, without notion of the vastly different requirements that online education poses. The results have been fatiquing for learners and especially social interaction between students was inhibited. This thesis presents an exploratory approach towards online education by leveraging the effects of a proximity based interaction system for virtual learning environments. The aim is providing a social space that encourages frequent interaction by design. The core question revolves around how the features of a virtual world can enable stronger sense of community through fostering regular and rich interactions. In addition, the contribution of proximity to shaping the space for engaging, but safe conversations is to be assessed. Based on theoretical foundations of virtual worlds, an online multiplayer prototype was developed with Unity3D. By applying a game design oriented approach, an immersive virtual campus was built, which defines the interaction space in which students can converse through live text and voice chat. This environment steers players' positioning through purposeful virtual facilities and regulations on communication channels. Meaningful collaborations are performed through embodiment in customizable characters, which allow players to develop a sense of identity. Proximity indicators around every player act as a measure of distance and inherently support contact with other users. In contrast, the proximity system also affords awareness of other users and their personal boundaries. These features contribute to creation of social presence and community.

Contents

1. Introduction

The ongoing exceptional situation that began in 2020 has strongly affected world's matters in all regards. After the World Health Organization (2021) declared the Covid-19 virus spreading a worldwide pandemic, the world shut down travels across and inside countries, openings of shops, working at job offices or social life in order to prevent further infections. Amongst the most severely impacted fields is the education sector, be it primary school, high school or any higher education such as universities. In March 2020, Bavaria's ministry for healthcare closed all schools of the state for one and a half months for the first of multiple times to come (Bayerisches Staatsministerium für Gesundheit und Pflege, 2020). During the closure, pupils were prohibited from entering any educational facility due to concerns of further spreading of the Corona virus. The first reopening concept was proposed by the ministry of culture at the end of April 2020 for a return to in-presence teaching. Over the course of the years 2020 and 2021, closures repeated for a couple of times and yet a complete return to normality has not been possible (Anders, 2021).

As a replacement for personal *face-to-face (F2F)* education, schools and universities sought for alternative options that would mainly focus on online teaching supported by learning platforms, video conferencing tools and study forums. At first, hurriedly taken measures overwhelmed unprepared schools in Germany. A representative study surveying roughly 500 teachers in May 2020 came to the conclusion that 83 percent of teachers did offer online curricula, but only one third of them considered their schools to be prepared for the situation (Eickelmann, 2020). They criticized that wholesome online teaching concepts, which would coordinate material and teaching distribution amongst pupils, were missing. Throughout the first months of online education, especially personal contact between teachers and students posed to be a serious issue. Just roughly a third of teachers pointed out, that they were able to stay in contact with all of their pupils. Another study commissioned by the Robert Bosch Foundation confirmed these troubles (forsa, 2020). Teachers rarely used explanation videos and even less video conferencing for communication. As a result, the majority of teachers doubted that homeschooling would be effective because of missing bonding and monitoring possibilities. Many instructors lowered their expectations of study progress during that year.

These studies further revealed that schools were digitally unprepared, teaching staff was inexperienced in usage of digital tools and large communication gaps existed between teachers and students (Eickelmann & Gerick, 2020; forsa, 2020). The current PISA study and earlier OECD releases already foreshadowed the problem of teachers' digital competence falling behind over the years (OECD, 2015; OECD, 2020). As counter measures in times of Corona, Voss and Wittwer (2020) recommend improved usages of digital tools such as cooperative forms of study, e.g. online discussions, and regular conversational knowledge exchange. Moorhouse (2020) adapted an initially offline-held course to an online course partly held synchronously and asynchronously. Synchronous in this case means that communication between instructors and learners happens in real-time (Kuo et al., 2014), whereas in an asynchronous setting all participants are physically and temporally apart (Rapanta et al., 2020). While session materials, like annotated PowerPoint presentations and voice-over narration, were stored and available anytime online on a learning management system, teaching was conducted in one hour real-time live sessions by video conferencing software. Efforts by other teachers to engage students online with live streaming technology included platforms like *Skype*, *Google Duo*, *WhatsApp*, *Hangouts* and the popular *Zoom* (Oliveira Dias et al., 2020; Serhan, 2020).

In an interview with Jacob Chammon, chairman of the Forum Bildung Digitalisierung (Forum Educational Digitalization) he stressed that keeping contact with students is the biggest, but most essential challenge during lockdown (Kuhn, 2021). Most often he recognized classes being transferred in a one-to-one manner from offline to online. This resulted in strictly teacher lead lessons through video conferences and a work sheet load that repeated itself every day (forsa, 2020; Kuhn, 2021). Collaboration from various locations on one paper, brainstorming together or virtually visiting knowledge spaces such as museums are ideas Chammon mentions, that haven't been put into practice yet. A lot of these are known issues that come hand in hand with distance education. Some of them surveyed in years before Covid-19 include lack of interaction, absence of collaborative learning environment, poor course design or low technological affiliation (Milheim, 2012). Generally, communication in computer-mediated settings are regarded as less personal and persistence in distance education programs is usually lower than in F2F settings (Rovai, 2002). Hodges et al. (2020) conclude that in an emergency time like this, none of the institutions' rapidly initiated educational substitutes can be a proper replacement for a robust educational ecosystem. In comparison to long-term research about online education, current instructional delivery resembles what they call *emergency remote teaching*. Instead, past experiences in asynchronous and synchronous educational content need to be leveraged in combination with new experiences of emergency remote teaching and contribute to the development of future wholesome educational concepts.

1.1. Project Goal

This thesis is an explorative study of possible future ways of online education based on current technological trends and insights gained from the Covid-19 pandemic. It aims at developing an education platform that focuses on communication and community delivery. Whereas most educational institutions look towards web conferencing or learning management systems at the moment, there are severe issues emerging. A survey by Adnan (2020) found student motivation, lack of F2F interaction and missing possibilities of socialization as detrimental factors against online education. A very recent study by Fauville et al. (2021) that explored causes of web conferencing, a term they coined *Zoom fatigue*, also raised several issues. Especially negative for women is the fact that one's camera image is being displayed to oneself, which causes anxiety through constant urge of reflecting on one's looks. Moreover, excessively staring at other user's faces on screen and the attempt to maintain eye-contact are stressful. While in regular interactions non-verbal cues are used naturally, in front of a video it becomes very tiresome and hard work. This induces high cognitive load on the user side and makes video-conferencing fatiguing. The authors explicitly suggest the usage of video-free meetings or more asynchronous communication tools.

With the noted issues in mind, promising platforms that allow users to join a virtual world as an avatar have recently seen increase in popularity. Especially during the pandemic, a trend has caught on and undergone further testing in education (Kuklinski-Rhee, 2021; McClure & Williams, 2021; Yoshimura & Borst, 2020). Applications include for example *Mozilla Hubs*, *Gather.town*, *Wonder.me*, *Remo* and many more. The general premise of those is the creation of a social online environment that people can join, communicate and collaborate, or just hang out at. Its idea is bringing together people in a more social way than what is possible with common video conferencing tools. Nevertheless, this is the standard approach at the moment for synchronous group communication (Steinicke et al., 2020). While tools like Zoom, Microsoft Teams or Skype have been existing prior to the pandemic, recent virtual worlds might be able to approach the social issues caused by the Covid-19 pandemic more explicitly. The settings of deployment are various. Synchronous group communication is nowadays necessary in education, at work or even for bare social gatherings of friends whose importance has risen ever since meetup regulations have been in place.

These concepts, however, are in fact not that new. With technological advancements in networking and computer computational power, Dickey (2003) brings forward that at that time *three-dimensional (3D)* virtual worlds were already trending. Applications included situated learning, collaboration through communicative tools embedded in the worlds or general resource and information provision. Distance learning centered on both synchronous and asynchronous communication through these worlds was already a factor being reviewed just shortly after (Dickey, 2005b). Even earlier Dillenbourg (2000) deemed *virtual learning environments (VLEs)* an interesting concept with potential for future applications. They are designed information spaces that have an explicit representation. This representation can vary from textual to 3D immersive worlds which is similar to how Dickey (2003) referred to them. Most importantly though, Dillenbourg et al. (2002) underlined that these virtual spaces are also social spaces that foster interactions among participants.

Latest software applications available fit into these definitions for virtual worlds. There are simple *two-dimensional (2D)* installments, e.g. Gather.town or *Rambly*, that have a 2D video game atmosphere. Some have a more simplistic approach by utilizing geometric shapes as spacial orientation, like Wonder.me, Remo or Teamflow HQ. Then there are also fully immersive 3D worlds that might be enjoyable on desktop or in *virtual reality (VR)* with head mounted displays, such as Mozilla Hubs or AltspaceVR. All of these include a representation of the user in form of an avatar. That avatar might solely be a profile picture that moves around, a 2D, pixelated character, or a fully customizable 3D human model. In addition, many facilitate a so called proximity chat. This system describes how users are able to communicate only with others that are close depending on certain measures (Zuo et al., 2015). In 2D and 3D worlds this could be the distance that users' avatars are spatially close to each other. That way, larger groups of users can be split into smaller chat circles similar to how an in-person social gathering would naturally split (Viegas & Donath, 1999). This feature is also suitable for enriching video games (Gibbs et al., 2006) and has been leveraged e.g. by the first-person shooter video game *PlayerUnknown's Battlegrounds (PUBG)*. Another example is the video game *Among Us* that became famous in 2020 as a result of players searching for a multiplayer socializing game during the pandemic. It received a community modification that included a proximity chat, which enables players to talk to others that are close to one's character (Delfino, 2021). The central goal behind proximity based chats is spatially localizing the conversations and, thus, improving the contextualized experience of participants in the online world (Viegas & Donath, 1999).

The goal of this thesis is the development of a similar online virtual world prototype that sticks to the definition of Dickey (2003). It should offer a 3D world that can be explored by the user with a customizable avatar, which will be their representation and way of self-expression. It should allow for the possibility of interactive communication amongst players. In addition, the game's focus should be implementing a proximity chat approach in order to enable spatial group forming. The specific aim of this virtual world is the creation of a VLE that demonstrates opportunities for students and instructors in future online education. Besides, it will especially explore ethical questions that arise throughout the development process and document advantages and disadvantages of realizing theory in game structures. The application will be approached from a video game developer's view and draw upon game design and creation knowledge for a different perspective on the problem. As all named application scenarios of virtual worlds overlap in many regards of research on social and communicative aspects, this work will build upon general theory about virtual worlds and use it as a foundation for development. The software can afterwards be used to assess effectivity of its features in user studies and show whether predicted behavior matches the surveyed.

1.2. Research Questions

Throughout the development process there are different questions guiding this study. As a starting point, it is necessary to collect fundamental information about virtual worlds which will serve as a basis for designing the prototype features. It is in question, which unique characteristics of virtual worlds may offer positive effects on the educational process. By looking at past and recent examples not only of virtual worlds, but especially

VLEs, an overview of application areas needs to be collected. As the concept of VLEs is not a new one, there are many former studies reviewing their usage in the education sector. These could give insights into potential challenges and how to approach them, but also about affordances that are yet to be drawn upon. As the technology itself is taking large steps in current times, ideas and features of applications available at the moment might also outperform former ones. Integrating experiences from them into the development of the prototype will serve a better understanding of the overall diversity of applications. The first guiding question is therefore:

1. What are key features that define virtual worlds and, more specifically, virtual learning environments and how can they affect online education?

In order to tackle the social issues of community, an emphasis will be put on the virtual world design. As mentioned by Dillenbourg et al. (2002), the space could either be one, two or three-dimensional. It should explicitly support social interaction and improve the process of virtual teaching. It is likely that communication depends on the interactions evoked by the world. For example, online fairs bring together people by imitating booths of companies within a virtual environment where users meet (e.g. *MeetYoo* or *Easy Virtual Fair*). Likewise, for educational purposes chat members could be placed in a topic related world that has been specifically designed for this occasion (Kuhn, 2021). It is interesting to know, whether common encounters in this space between participants can create a feeling of familiarity and help translate real life habits into virtual space. Will having a quick chat when passing by or silently listening to the speaker while sitting next to each other create stronger memories than regular conferencing apps? Designing this *game space*, as in the environment that defines space and traversing mechanics, with its looks and interactions becomes crucial. In the end, the game space determines how interaction and proximity will take place and work out. Due to the close connection to game development, a game design approach will be established:

2. What are design criteria for game spaces and how can community interaction be supported by it?

In connection with game space, the inclusion of a distance based proximity chat induces several further usage scenarios. A clear concept for proximity awareness and feedback needs to be thought of and developed. Furthermore, the proximity feature might be a possible solution for the issue of communication amongst a large group of people. Currently available programs already use separate chat rooms that participants can be sent to in order to split up discussions (Moorhouse, 2020). This breaks the crowd into smaller subsets while still keeping everyone within the same session. Implementing proximity could more naturally lead the way to weakening boundaries of getting to know someone in the crowd. On top, proximity might be a strong supporting factor for generating user interaction within the virtual world. Still, one must not forget that critical questions about personal distance also arise. How large is someone's own private space? Can participants be restricted from coming too close? How can communication be limited to trusted people? These ethical questions have to be covered in this topic as well:

3. What role can proximity take on in a virtual teaching situation and how can it be designed in a safe way?

Now that there is an interactable and traversable space that defines proximity and its interactions, the final topic to shift attention to is the expression and representation of oneself in this space. Depicting participants in a group chat has traditionally been taking place by simply listing all call members one-dimensionally, just how Zoom or Skype do. As a replacement in virtual space, the utilization of avatars should be discussed. These might provide an opportunity to more freely present oneself in the digital space (Falloon, 2009). Besides interactions driven by proximity, there are more interactions that can be based upon the avatars. Countenance and gestures can be imitated by avatar's facial or full body animations. In combination with the game space, social interactions could regain character similar to real-life ones. Yet, with the introduction of avatars, one should not neglect potential ethical aspects that might be at harm. How do avatars have to look like for everyone to feel well represented or how could avatar interaction be abused? These questions about avatars lead to the final guiding topic:

4. How can avatars improve self-expression and representation of virtual world participants and what are possible pitfalls?

2. Methodology

This chapter shortly introduces steps taken from literature review to the conceptual phase of prototyping up until actual development of the application.

Literature Review Hodges et al. (2020) mention the long history of online teaching and its experiences. Thus, this thesis focuses on teaching in virtual environments and looks into their theoretical foundations first. In chapter 3, previous studies about virtual worlds, classrooms and learning environments are covered for an overview of research. These are compared with related applications and set into context of the theoretical basis. A review of common theories concerning social issues and formation of community in online learning is given. Moreover, avatar usage is a crucial topic that is evaluated for further steps in design and development of the game prototype. The manifold approaches of former applications help defining a suitable avatar look that can withstand common issues.

Review of Applications on the Market After theoretic research, a short analysis of currently available video chats and proximity applications revealed use cases and goals. The applications under review were based on a collection of 42 websites put together by the technologists Simpson and Zuegel (2020). This compilation found public interest after the US-American technology magazine *Wired* used it as a basis for their research (McCulloch, 2020). The list was extended slightly by own research of available proximity chat apps. After a rough examination of about 50 different software programs and their internet presence, each one received a tag that indicates its importance to the topic of the thesis. This rating is based on scope, features and applicability of the chat platform. The information summary was done in Microsoft Excel and can be found in Appendix A. Applications that are not available for testing or of any interest to this thesis were left out from the table. Highly important ones were revisited in a more thorough examination including testing a demo. In connection with theory, features were considered for inclusion into this thesis' own chat application.

Decision on Technological Components For the developing environment, which was used throughout the development phase, a game engine had to be chosen. A video game engine is the fundamental program that offers a framework and interface for handling code and assets and which inherently determines the basic structure of a game. The decision also needed to be based on the targeted platforms of the virtual world. It was decided in favor of *Unity3D* due to its ease of deployment onto over 20 different platforms and wide range of community support (Unity, 2021). For implementation and testing the Unity version 2021.1.7 was used as primary tool. In addition, for the world design and creation, 3D models from third-party creators were necessary because time constraints did not allow for self-produced art. These assets had to be available under a Creative Commons license so that the final application would be publicly shareable. All used assets visible on any image of the application in this thesis are either part of a Creative Commons license or of the public domain. After choosing an engine, the second important decision was choosing a networking high-level API. Each game engine comes with different options out of which a suitable, which would fit the expectations of a multiplayer centered chat world, had to be selected. Due to its support for hundreds of players and *Massively Multiplayer Online Game (MMO)* scale, as well as client-server architecture, Mirror Networking was used for this thesis' application (Mirror, 2021).

The development phase occupied the largest part of this thesis as it represents the foundations that can be reiterated on afterwards. Development resulted in a final virtual world chat application that can be tested and evaluated in the future. A discussion on potential up- and downsides that have been discovered during testing will summarize and judge the features. Ultimately, theory and practical work are put down in this thesis paper.

3. Virtual Learning Environments

In the early 2000s the development of virtual worlds was far enough to support first educational studies in research. Amongst the earliest virtual worlds in learning, *River City* by Dede et al. (2004) and *Quest Atlantis* by Barab et al. (2005) were arguably very popular. These researchers found their applications, which can be counted as so called *Multi-User Virtual Environments (MUVEs)*, to be successful in supporting children's play combined with academic learning. Work by Dede et al. (2004) showed that MUVEs may be able to increase learners motivation towards achieving learning goals. MUVEs were deemed to be great mediators for group problem solving and the improvement of 3D location tasks. Therefor, a necessity is variety in scene design and complexity for learners to maintain interest (Finkelstein, 2006). Another even earlier adopter was *Whyville*, which started operations in 1999 (Dieterle, 2009). These applications were the origin of the term VLE that represents virtual worlds in an educational context. In 2009, over 100 universities in the United States had already seen the potential of *Second Life (SL)* and rented virtual land to give their own lectures for students. They created additional lecture spaces referencing their real campuses, but also offices or music stages (Baker et al., 2009). VLEs are an expansion that developed from the concept of virtual worlds which will be first assessed and defined in detail in the upcoming paragraphs.

3.1. Virtual Worlds

Virtual World is a term that has changed and developed over the years with the evolution of computers and ever new possibilities. It is also a term that can often be confused with many other, quite similar ideas that describe a close, yet different concept (Ball, 2020). Therefore, it needs to be differentiated from its predecessors and technologies that share the same foundations. To clarify unique characteristics, this chapter shortly unfolds the history of virtual worlds and will then give a clear definition for virtual world itself.

3.1.1. History of Virtual Worlds

Multi-User Dungeon (MUD) The first link in the evolution of virtual worlds were MUDs, short for *Multi-User Dungeon* (Dourish, 1998). The initial version, developed and released in 1979 by Richard Bartle and Roy Trubshaw, was a multi-player adventure game that allowed players to move through a textual virtual world (Bartle, 1990). Dourish (1998) explains that the spirit of the game lay in the player-player interaction, which was possible by networked play. This consisted of cooperating for puzzle solving or fighting against each other.

MUD, Object Oriented (MOO) A follow-up development of MUDs were so called MOOs. They were first developed by Stephen White and insofar a huge leap as it employed internal data extensibility and a clearer focus on social aspects like conversation and co-creation of worlds (Dourish, 1998). In MOOs users were able to change and expand the virtual world for the first time (Livingstone et al., 2008).

Multi-User Virtual Environment (MUVE) As the next evolutionary step, Dieterle (2009) names MUVEs. These "enable multiple simultaneous participants to access virtual contexts, to interact with digital artifacts, to represent themselves through "avatars", to communicate with other participants and with computer-based agents, and to enact collaborative learning activities of various types" (Dede et al., 2004, p. 1). Finkelstein (2006) adds that communication can occur e.g. by text, animated gestures or movements, or audio transmissions. The key feature of MUVEs are the persistence of the world which means that its social and material changes will continue existing, even for other players (Barab et al., 2005). Some famous examples listed by Dieterle (2009) are Quest Atlantis, River City and *MOOSE Crossing*.

Massively Multiplayer Online Role-Playing Game (MMORPG) While MUVEs were especially popular in the educational sector, the video game sector soon developed their own version in form of MMORPGs. The most prominent example is *World of Warcraft (WoW)* which had millions of active players during its high times (Achterbosch et al., 2008). Chen (2008) mentions that for this game social aspects went as far as players creating their own norms and rules that the community needed to follow. *Star Wars Galaxies* was known for its completely player-driven economy for items and character equipment. And *City of Heroes* introduced highly customizeable character creation which allowed users to define their outfits as well as facial features (Achterbosch et al., 2008).

Second Life (SL) On the contrary to MMORPGs, there is SL, a platform founded and launched by Philip Rosedale in 2003 and operated by Linden Lab. While MMORPGs are games which incorporate social aspects, SL is a social space that can have games within. It doesn’t have goal-driven rules and is as such not a game (Berge, 2008). Rosedale’s platform offers an immersive 3D world in which players can meet with their avatars, communicate, play and create new content together, such as clothing or buildings. It also includes an in-game currency and economy that is tradeable with real US dollars. This money can be used to buy goods and services that other players offer within the world (Berge, 2008). It further allows players to join social groups and attend events, music performances or lectures (Baker et al., 2009). Thus, this application is rather a world simulating real-life online and providing a space for social community interaction.

Metaverse The final and recently much talked about instances of virtual worlds are *Metaverses*. At *SIGGRAPH 2021* representatives of Epic Games, Roblox, NVIDIA and Unity came together to outline their idea of a new internet in shape of a metaverse.

The term metaverse initially stems from Neal Stephensons' *Snow Crash* released in 1992 (Berge, 2008). The sci-fi novel spins a story around a 3D world in which people try to escape the real world and find their happiness in digital activities where everything seems possible (Gent, 2021). The metaverse visionary Ball, who recently released a series of articles about the topic, states that it is hard to envision what a metaverse will be (Ball, 2020; Ball, 2021). He describes metaverses in seven bullet points: it needs to be persistent, synchronous and live, be capable of infinite participants while still providing a sense of presence, have a fully functioning economy, be spanning digital and physical world, offer interoperability of content and be created and operated by its own inhabitants. In contrast to previously mentioned variations of virtual worlds, Ball is yet unsure whether metaverses will have a single user representation such as an avatar or not.

3.1.2. Features of Virtual Worlds

The term virtual worlds grasps several features that can be found in above mentioned explicit examples. It can be understood as a generalization, a foundational concept and definition that might apply fully or partly to its instances. Dickey (2003) describes these worlds as a desktop virtual reality that offers networked connection for multiple players. Similarly, Schroeder (1996, p. 25) stipulates both virtual environments and VR as "a computer-generated display that allows or compels the user (or users) to have a sense of being present in an environment other than the one they are actually in, and to interact with that environment". The difference to virtual worlds is that they depend on the collaborative multi-user experience and, opposed to VR which allows "being there", virtual worlds give the opportunity to "be there together" (Schroeder, 2008, p. 2). If that sensory experience of a place or space was non-existent, then definitions were meaningless and anything could be a virtual world, even text-based MUDs, Schroeder (2008) argues. A key factor, besides the social presence of other players, is the visual representation of worlds which allow players to imagine another world than they are in at that very moment. Due to technological improvements over time, this older definition of virtual reality is not up to date anymore, however. Today, there are indeed virtual worlds that can be experienced with VR goggles such as *AltSpaceVR* and *Mozilla Hubs*. Schroeder (2008) claimed that VR has not been applied to persistent online social spaces compared to virtual worlds, which is a necessary feature of these. But concurrent user support of virtual spaces is granted in recent VR virtual worlds, too.

The three main features of virtual worlds stated by Dickey (2005b) are an interactive 3D space environment, users that are being represented as digital avatars and an interactive chat environment that allows all users to communicate with each other. While interactivity, 3D environment and the social aspects are given, in comparison to Schroeder (2008), Dickey's characterization lacks the aspect of persistence. Due to these differences in explanations and a missing agreed-upon, clear definition, Bell (2008, p. 2) tried to combine all aspects in one sentence: "A synchronous, persistent network of people, represented as avatars, facilitated by networked computers." Each of these five points was elaborated further in detail by Bell (2008) which, on top, the next paragraphs will give examples about.

Synchronous Virtual worlds need to accommodate synchronous communication between users. Synchronous means that users can interact, e.g. through exchanging live messages, with each other at the same time. An action or message by someone will be visible or audible right away by all other users that have access to that action or message. Martin and Parker (2014) explain that synchronous systems allow real-time communication transmitted via internet among multiple users and can be applied in various situation. These include especially, but not limited to, meetings and seminars, lead discussions, presentations and demonstrations. Synchronous communication does also apply to other real world applications like chats or teleconferencing. These applications use textual or vocal transmissions, of which usually at least one is also integrated into the virtual world (Dickey, 2005b). Nowadays, this would also include video, as used in any videoconferencing app or current examples of proximity-based chat apps. Dillenbourg (2000) questions what synchronicity actually means in the context of online communication. He poses that often responses in a synchronous online environment take much longer than it would take to answer an e-mail. In vocal communication, even a short delay is noticeable and disturbing to the conversation. In written communication, delays are accepted due to the notion of time it takes to type an answer on the keyboard. He comes to the conclusion that synchronicity is not a matter of actual time that goes by, but dependent on a subjective feeling of time that participants share amongst each other. As a result, a virtual world needs to set implicit communication rules that will be acknowledged by all users (Dillenbourg, 2000).

Exclusive to virtual worlds is the notion of "space, distance and co-existence of other participants" (Bell, 2008, p. 3). This is something usually found in real life spaces which is now replicated in the digital world. At the same time, players come together and collaborate, e.g. in SL, and start creating a sense of their virtual environment. They visit the same space and exchange opinions about it, even though they are from everywhere around the world (Berge, 2008). This does not mean that asynchronous communication is completely absent from virtual worlds. Asynchronous communication can be exemplified by electronic mail or forums (Dillenbourg, 2000). A user can leave an information for someone else who does not have to actively be engaged at the same time. They will be able to reply later once they become engaged. An example in virtual worlds are messages left on walls in SL which other users can see when they log in.

Persistent The environment that every user virtually traverses in a digital world has to continue existing and it cannot be paused. Even after a player leaves the world, it can still be accessed by other players. These players will also find elements of the world that previous players have affected, thus, they become actors themselves in this dynamic world. In SL, new buildings and spaces might have been created by others that are now newly visitable, while one's own digital home still remains. Persistence also covers changes that are not limited to the environment. New equipment acquired by befriended players will be visible after the player has stayed absent for a longer time for example in WoW. Similarly, a player's level and statistic values might have increased and are persistently seen by all other users of the game (Chen, 2008). This differentiates virtual worlds from video games like *Super Mario Brothers* where game progress is limited to the influence of one player only. One counterexample to persistence even within MMORPGs is illustrated by Achterbosch et al. (2008). Quests, which are tasks in the world that players can accept, are usually available for everyone. Even though one player finishes a task that was given by the computer, this quest still remains for others to clear as well. This is a limitation of content creation as developers would not be able to refill the world as quickly as players finish tasks.

Network of People The most important factor that was also covered by Schroeder (2008) and Dickey (2005b) is the community of people that interact with each other and the persistent environment. Participants form social groups that can just be expressed as being friends within SL or they can join larger assemblies of clans or guilds to work together in quests e.g. in WoW (Chen, 2008). Though, Bell (2008) notes that even if participants do not decide to actively engage, their existence and presence alone influences others and the environment. This makes them part of the world nonetheless. The difference between virtual worlds and online games such as MMORPGs lies in the intention of the application, says Schroeder (2008). Virtual worlds' intention is providing an online space for socializing whereas games usually have a primary goal, for example defeating a final boss. But he mentions that online games do contain social features and are, therefore, a subset of virtual worlds, too.

Represented as Avatars Avatars can be any digital representation of a user that is more comprehensive than only a label or name. This includes even simple textual descriptions of characters in MUDs (Bell, 2008). But it can also be expressed in two or 3D graphics. This could be a profile image of oneself in *Teamflow HQ*, though a *Facebook* profile is not an avatar. In addition to being graphical, it has to be able to interact in the virtual world and it needs to be controlled by a human player synchronously. A Facebook profile won't act and doesn't have so called "agency" of its creator (Bell, 2008, p. 3). In Teamflow HQ the user moves their representation around a 2D space and enters rooms, hence, the avatar acts as a "user-controlled puppet" (Bell, 2008, p. 3). This goes so far that communication exhibited by the user will be presented and understood by others as if they came from the avatar itself. With technological advances, avatars, especially in 3D, became more and more customizable. In WoW, players can choose between different races that have different looks during character creation (Chen, 2008; Ducheneaut et al., 2009). And *City of Heroes* allowed for endless visual configuration of characters as mentioned (Achterbosch et al., 2008). This fourth feature of virtual worlds described by Bell (2008) is one of higher importance and will be further discussed in section 3.5.

Facilitated by Networked Computers The last point listed by Bell (2008) differentiates virtual worlds from social settings in the reality. Also, it enables two other features, namely persistence and network of people. Bell draws comparisons to the board game *Dungeons and Dragons*, which is categorized in the pen & paper genre. He states that networked computers are capable of storing data of communication and interaction of participants that would never be realizable with simple notes. The networking function also extends the global factor. Players from all across the world are able to participate at the same time which creates an unimaginable scale of worlds. The complexity and persistence attained through it cannot be rivalled in any other way.

Looking at the history of virtual worlds, one can now compare features that the individual evolution steps included. About the question, if MUDs were virtual worlds, Schroeder (2008) disagrees with Bell (2008). Bell explicitly states that *MUD-1* was indeed a virtual world due to it having textual avatars, persistence, social engagement over network and synchronous communication. Schroeder does not seem to attest MUDs enough sensory experience of space because of its sole textual character. Taking sides with Schroeder, it can be argued against Bell that the first real version of *MUD-1* might not have been a virtual world from the start, as it hadn't been connected to ArpaNet before spring 1980 (Bartle, 1990). This would render Bell's own fifth feature invalid as only people in the local network had access to the game. In the end this discussion may be too fastidious as all other instances of virtual worlds contain the by Bell (2008) described features, and some will even try to extend them in the future (Ball, 2020).

3.2. Features of Virtual Learning Environments

After having taken a look at the features of virtual worlds, which form the foundation of VLEs, the next paragraphs will dive deeper into common aspects of VLEs. The features of VLEs can be best presented by going through an early specification done by Dillenbourg (2000). He splits his description into seven characteristics that all VLEs share. From the start, he makes clear that not every educational website will automatically be a VLE and neither is a *virtual campus* equivalent to VLEs. It is rather that virtual campuses can be a subcategory of VLEs, which are conceived as broader.

Designed Information Space At ground level, VLEs are designed information spaces. On one hand side they offer information such as knowledge that learners want to acquire. That knowledge was produced by many authors and is stored and accessible in an educational context. The critical issue is, how the information is labelled, sorted and maintained as more and more knowledge fills the internet. Thus, the space needs to be designed and organized by its creators as a foremost principle.

Social Space Secondly, VLEs are social spaces, which is an important concept all literature agrees upon (Baker et al., 2009; Berge, 2008; Dalgarno & Lee, 2009) and that is also an inherent part of virtual worlds (subsection 3.1.2). VLEs become a social space once there is "social interaction about and around the information" (Dillenbourg, 2000, p. 5). This communication is performed by synchronous or asynchronous contact and, in more detail, can happen one-to-one, one-to-many or many-to-many. McBrien et al. (2009) extend this concept by stating that these could be learner-learner, learner-instructor and especially in VLEs learner-content, but also learner-interface interactions. At that exact moment, when members of the world recognize representations of someone else being interested in information, which the world is representing, that space becomes inherently social itself (Dillenbourg, 2000). Dillenbourg describes this as *notion of space*. This concept will be further evaluated later in this chapter.

Explicit Representation About Schroeder (2008) and Bell (2008) arguing over which representation is viable for virtual worlds, Dillenbourg (2000) believes the whole range from textual to 3D graphics to be sufficient. Towards a settlement, he determines that the key issue is not the representation itself, but how learners conceive the environment. If they feel imparted by a textual virtual space, then that proves it has an explicit representation. Still, visuals account for a number of factors such as motivation, support of navigation within the world, rousing interest in the environment and awareness of information, such as who is currently where. The world could be designed like physical rooms and provide the user with a sort of order they can adhere to. All these mechanisms have an impact on the interactions of learners within this world.

Students as Actors What VLEs are trying to achieve is more than just delivering information that it contains to the learner. Students can upload and share their work in that exact same space, made accessible to all other learners. This could be informal notes, homework or opinions. It could also be computer programs or graphical objects that users worked on together in a group (Dillenbourg, 2000). This can go as far as students changing even the environment itself, which is possible for example in SL. This makes students more than active, it lets them be contributors to the space and, thus, actors in the social environment. A study by Dickey (2003) showed that learners helped other learners in case they did not understand the topics or came in too late for class. Instead of interrupting the teacher, learners would share their knowledge and actively bring themselves up to date. This idea follows a constructivist approach (Jonassen & Rohrer-Murphy, 1999), that became prevalent at the same time as new distance education tools were being developed (Dickey, 2003) (see subsection 3.4.1).

Not Restricted to Distance Education Dillenbourg (2000) underlines the importance of VLEs for F2F education that is being delivered in physical presence of teachers and learners. It often gets connected solely to distance learning, of which it is a necessary part. But it should also be seen as a possibility for coexistence of both learning methods - in presence and remote. Due to limitations of each application, making use of the other in parallel can foster intrinsic motivation and support general learning.

Integration of Multiple Tools In relation to physical learning environments that offer "courses, resources (libraries), formal communication (boards) and informal communication (cafeteria, ...)" (Dillenbourg, 2000, p. 10), VLEs have to provide these facilities in a virtual way. Means of information, communication, collaboration, learning and management need to exist, which the idea of *environment* includes in its name, so Dillenbourg states. Functions found in real life will have to be copied and made available within the online space, too. In the end what should be achieved, is a technical integration that ties together with the pedagogical integration inside the application. In practice, an example would be being able to work on a document and calling for the teacher's help, who would be informed by the system about the issue.

Overlap with the Physical Environment In the end, there still remains a strong connection between VLEs and the physical environment. Non-computerized resources such as physical books, instruments or specific tools stay relevant. While firefighter training can be done with training softwares, the execution in case of fire will be done in reality. Dillenbourg (2000) mentions also activities like field trips or role playing as physical goods that will stay part of reality. It can be argued that even those can easily be done virtually nowadays, like museum trips. However, Dillenbourg anticipated that boundaries will be obsolete. In his opinion the key is the integration and not separation of both worlds.

3.3. Affordances of Virtual Learning Environments

Dillenbourg (2000) was sceptical about whether VLEs would automatically achieve greater learning success. He reminded of the difficulties of putting possible positive effects into practice, but attested VLEs great potential if applied in the correct setting. Obeservations by Dillenbourg showed that the pedagogical context is crucial for courseware to have high effectiveness. The scenario in which the VLE is integrated, how strongly the teacher is involved, time, technical infrastructure and more conditions influence the successful outcome. As a result, there are several *affordances* pointed out. This is a term frequently seen in learning theory and utilized for the description of potential positive effects that VLEs contain for online learning (Dalgarno & Lee, 2009; Dickey, 2003; Dillenbourg, 2000). Originally the term dates back to Gibson (1977), an environmental psychologist who studied the relationship between perceiver and the perceived environment (Dickey, 2003). Dickey believes that the opposite of affordances are constraints of the learning environment. Both contribute to the opportunities for construction of VLEs. Dalgarno and Lee (2009), who have researched characteristics of 3D virtual environments, defined five different affordances for VLEs, which depict theoretical learning benefits especially in favor of 3D VLEs. They make clear that it is not the technology itself which provides advantages, but it facilitates the learning process. These five points will be outlined in the following paragraphs and supported by Dillenbourg (2000) and Dickey (2003).

Enhanced Spatial Knowledge "3D VLEs can be used to facilitate learning tasks that lead to the development of enhanced spatial knowledge representation of the explored domain" (Dalgarno & Lee, 2009, p. 18). 3D environments allow for positioning and maneuvering in all three dimensions which helps discovering objects and the environment in much greater sense than other alternatives would. Therefore, spatial knowledge acquisition of the environment can be supported better than e.g. mere perspectives of photographic images could. Looking at the issue from the opposite angle, users can also exhibit troubles with sorting information in a non-spatial representation like the internet. 3D VLEs offer an approach of "first-person, non symbolic experiences" (Dalgarno & Lee, 2009, p. 21) where information is connected to spatial information. Because of well developed spatial cognitive abilities of humans, 3D information representation can potentially increase exploration efficiency and understanding of users. This, in return, leads again to improved spatial cognition. Additionally, with current developments in technology like 3D scanning applications, models in 3D come closer to photorealism while providing additional dimensionality. For example, in 2020 the Cologne Dome was scanned by drones that created a 3D model which would then be used to study the architecture for potential repairs. Inspections would have posed a severe obstacle otherwise (Frädrich & Reschke, 2020). Such simulations allow learners to experience possibilities and difficulties which relate to real life instances.

Facilitating Experiential Learning Tasks Many of those experiences available in a VLE are simply not possible or impractical to implement in reality, may it be cost factors or time constraints. Dalgarno and Lee (2009) mention physical simulations as an example for knowledge domain supported learning in which students can develop an understanding of representations of dynamic behaviors. Weather forecast is one of those difficult tasks that require high calculation power, but are better simulated digitally than in real life. Their spatial representations again foster the learners potential spatial knowledge gain (Dalgarno & Lee, 2009). Other risky applications listed by Dalgarno and Lee are nuclear power plant training or astronauts' repairs in space. It cannot be afforded for these crucial tasks to go wrong in an emergency situation and mocking might be too expensive. Hence, training in 3D VLEs is a great alternative.

Increased Intrinsic Motivation Barab et al. (2005) found their VLE *Quest Atlantis*, which employs a 3D environment, to include the affordance of children and teachers undertaking further challenges due to intrinsic motivation. With *Quest Atlantis* creating an immersive and collaborative experience that is shared amongst participants in real-time, Barab et al. (2005) declare these features as the cause of engagement. The inclusion of achievable goals advocates user decisions and, thus, higher engagement with the environment as well (Rieber, 2005). Dickey (2011a) adds that the notion of game patterns and mechanics or a narrative in VLEs seems to support learner motivation. Dalgarno and Lee (2009) also note the importance of flow, which is a concept developed by Csikszentmihalyi (1990) that found wide application in the context of video games.

Flow describes a person's state when they are caught in an equilibrium of abilities and challenge that is especially compelling. High fidelity and a natural interface of VLEs bear the affordance of reaching the flow state and becoming immersed in the environment (Dalgarno & Lee, 2009).

Knowledge Transfer to Real Situations The fourth affordance of Dillenbourg is the advantage of 3D VLEs of enabling learning in contexts which leads to an improved knowledge transfer for real-life situations. When knowledge and skills are set in relation to fields of applications by modelling an explicit application environment, then learning is expected to be more effective. Because of higher levels of visual and sensory realism and feedback in 3D VLEs that is similar to the reality, experiences will be more readily applied when transferred to real-life situations (Dalgarno & Lee, 2009). Dickey's study about supporting a 3D modelling course with a VLE, for example, allowed learners "to become embodied in the learning content and context" by being represented as 3D objects themselves (Dickey, 2005b, p. 448). These findings are based on the *Situated Learning Theory* by Lave and Wenger (1991) and Brown et al. (1989) which basically states that *situated learning* needs "authentic contexts, activities, and assessments coupled with guidance based on expert modeling, situated mentoring, and legitimate peripheral participation" (Dede et al., 2004, p. 161). Dede et al. considered MUVEs after their research on River City as promising contributors to study environments for situated learning.

Richer Collaborative Learning Finally, Dalgarno and Lee (2009) account enhanced collaborative learning as the most important affordance of 3D VLEs. Learning in collaboration and carrying out tasks together exceeds the effect of just being able to communicate with each other. Especially tasks towards a combined goal that are shared amongst participants in VLEs can foster collaborative experiences. Dickey (2005b) showed that in the VLE *Active Worlds (AW)* spatially distanced learners were able to effectively collaborate on a shared objective. Using VLEs as course support, interviewees of Dickey managed to increase popularity of courses and the proper application of learner's skills. In her prior study, Dickey (2003) had still complained about a lack of collaborative tools such as whiteboards which was due to limitations of that specific AW world used. Furthermore, in a survey conducted by Livingstone et al. (2008), the top rated feature of SL was voted to be the collaborative whiteboard. On the contrary, Dillenbourg (2000) dampens expectations about collaborative learning as he thinks it is over-hyped. Effectivity boils down to how rich and engaging interactions between group members, as such collaborators, are. Dalgarno and Lee (2009) agree that collaborative success heavily depends on how indispensable the individual's contributions to the group are. In the end, it is the designer's task to create virtual environments whose structure support collaboration on tasks and communication between members (Dillenbourg, 2000).

Conclusion

Virtual worlds and VLEs have been covered extensively in literature, as has been illustrated. Their affordances for online education appear manifold. It seems that the general focus of advantages lies on a social level, specifically on collaboration, group forming and the constructivist idea that learners become actors themselves in these worlds. However, the correct application of technology and proper world design are crucial for successful online teaching. In the following chapter, this thesis will dive deeper on how learners altogether can benefit from the social aspects of virtual environments.

3.4. Oneself and Community in Context of Educational Theory

An important topic that has been touched on e.g. in section 3.1.2 and section 3.3, but not evaluated in general, is how online learning can benefit from community building and its process. In fact, in an online distance learning setting, Palloff and Pratt (2007) regard the formation of learning community as the differentiating factor to traditional offline teaching. "Key to the learning process are the interactions among students themselves, the interactions between faculty and students, and the collaboration in learning that results from these interactions" (Palloff & Pratt, 2007, p. 4). By using a medium for interaction between groups over a longer period of time, these groups will start forming a community (Dillenbourg, 2000). This progress is slowed down, however, by the use of online tools compared to F2F interactions, but it does appear in the end, according to Dillenbourg. He sees the key value of communities for education in their culture that they form on their own. Borrowing from Dillenbourg (2000, p. 21), this is exemplified by how physicians not only study medicine, but also have to learn specific expressions or language and adapt to physicians' values. Palloff and Pratt describe this more deeply as a sense of belonging to the group which only emerges through creation of shared values and identity. For understanding the event of community forming, the authors developed a model that describes all necessary factors (Figure 3.1). It is based on an extension Palloff and Pratt (2003) created from an original concept by Preece (2000). Preece described that in order for online communities to be able to emerge, four fundamental features were necessary: *people, purpose, policies,* and *computer systems*. This first idea did not include online communities in a learning setting yet. Palloff and Pratt (2003), thus, added two more features, namely *collaborative learning* and *reflective practice*. After streamlining the concept, Palloff and Pratt (2007) now list three groups of causes for community formation, *people, purpose* and *process*, and believe that the outcome of "well-constructed, community-oriented online courses is *reflective/transformative learning*" (Palloff & Pratt, 2007, p. 17). Each group consists of few elements that play a bigger role in the full picture.

Purpose is the goal that a community has uniquely agreed upon. It is influenced by guidelines that instructors and learners set up for their own group. A community itself is in charge of negotiating and mediating rules that every member of the community is

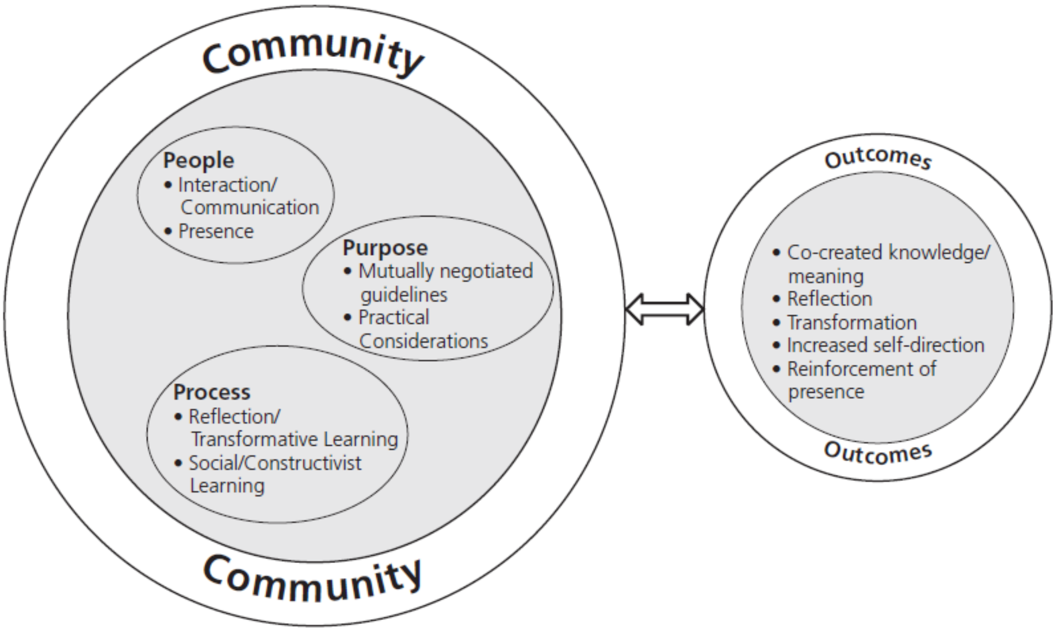


Figure 3.1.: Elements of community-based online learning and their outcome. Source: Palloff and Pratt (2007, p. 18)

supposed to follow. These rules define "how the community functions, what it believes, and the ways that is supports different activities" (Jonassen & Rohrer-Murphy, 1999). An example would be the communication contract that Dillenbourg (2000) deems necessary for all matters of communication as described in section 3.1.2. Another instance of guidelines is the agreement on minimum participation standards between instructor and learners to set a basis for discussion. Finally, practical considerations include e.g. size of group, how the group can provide safety and security or concerns about time (Dillenbourg, 2000; Palloff & Pratt, 2007). This section strongly resembles Dillenbourg's idea of culture which is formed by language, norms and values that all members share amongst the community.

People are critical, as without them, no interaction or communication were possible, which is defining for a community. Including collaboration and teamwork, like the way it is done in VLEs in section 3.3, helps raising interaction and communication and contributes to higher levels of community. Most valuable are the experiences that are created throughout the whole group instead of just between one participant and the course facilitator (Palloff & Pratt, 2007). Closing the cycle, conversation and discourse are in return the drivers of efficient collaboration and social negotiation (Jonassen & Rohrer-Murphy, 1999). Milheim (2012) applies the theory of Maslow's hierarchy of needs model to students' needs in the online classroom and comes to the conclusion, that the idea of collaboration by Palloff and Pratt fulfill Maslow's third, namely the relationship level. Research has shown that collaboration is indeed a factor contributing to community and creation of social presence (Cunningham, 2015). The concept of presence is slightly more complex and will be explained in detail in subsection 3.4.2.

Process is, finally, composed of social/constructivist learning, a key feature of VLEs (section 3.2), and reflective/transformative learning. Palloff and Pratt (2007) explain this type of learning as an unconscious process that is not being disclosed at the start of online courses. It refers to the transformation learners go through during a course which they reflect upon after concluding their study. Students are not prompted that what they are participating in is supposed to foster community sense, but they are asked to reflect on the learning environment and its successes or losses. In the end, personal and intellectual growth is the result of becoming aware of changes that went along with community building. Jonassen and Rohrer-Murphy (1999) see transformational learning also applied in cases where people are part of multiple communities. If conflicts between one's roles in groups arise, reflection followed by transformational activities are required to settle these contradicting experiences.

3.4.1. Constructivist Approach

The second bullet point in the *process* category includes constructivist theory that was already touched on earlier as part of active learner engagement in VLEs (see section 3.2). The theory is based on the belief that students play an active role in constructing their own knowledge and that the learning space itself has to provide manipulative interactions and exploration for learners in order to make learning more meaningful (Dickey, 2003; Jonassen & Rohrer-Murphy, 1999). Jonassen and Rohrer-Murphy (1999) defined a multitude of features that a *constructivist learning environment (CLE)* has to provide for learners which he separates into *problem-project space, related cases, information resources, cognitive tools,* and *conversation and collaboration tools*. CLEs need to include related experiences to the problem for students to build upon which enable learners to adopt multiple perspectives that help understanding the complexity of content. Further, there has to be information in form of text-documents, graphics or similar. These are best embedded in tools that support visualization, organization, interpretation and, accordingly, knowledge building. All learning that uses these resources and tools should at best be shared amongst members of the CLE by communication tools that facilitate dialogue within the community (Jonassen & Rohrer-Murphy, 1999).

Returning to the practical side, Palloff and Pratt (2007) agree with the constructivist approach and can see constructivis teaching emerge in online education. She reminds that it is active learning techniques that have already been utilized in traditional classroom settings which are well usable in online classrooms, too. Practices might include group-discussions, collaborative projects or assignments, role-playing and others (Palloff & Pratt, 2007). The opposite, a passive attitude towards online education, will not succeed. In teleconferencing applications, such as Zoom, one lecture can host many students at the same time following the teacher's talk. Not everyone might switch on their video camera or microphone or contribute at all during a lecture. In these situations it is very hard for the teacher to know, whether students have been there or been active at all (Palloff & Pratt, 2007). As a result, all responsibility for attending and contributing falls into the students hands, say Palloff and Pratt. For a learning process to achieve progress, both instructors and learners will have to actively partake in the online class. A mistake many instructors make is trying to copy their offline held courses and practices to an online course (Bonk & Dennen, 2003). This move completely neglects dynamics that technologically improved teaching would usually offer in online learning environments (Redmond, 2011). Palloff and Pratt (2007) also observed that a large amount of online courses were still content- or facilitator-driven. This model of learners creating content that is supposed to be assessed by a teacher is outdated. Yang and Cornelious (2005) recommend that teachers first need to understand the shifted roles while preparing for courses. This is the move towards constructivist learning in which teachers rather take the role of mediators between learners with the goal of facilitating knowledge acquisition. They should act as "playground monitors or gentle guides" while participants develop rules and norms themselves along the way (Palloff & Pratt, 2007, p. 22). As a last point, Palloff and Pratt account both facilitators and participants as equal in regard of their contribution to the online learning community.

As a final thought on constructivism, it is interesting to know whether virtual worlds can act as CLEs. Looking at the features described by Dillenbourg (2000), students being actors in VLEs already perfectly matches the expectations of constructivism theory. As key difference between regular constructivist environments and VLEs, Dillenbourg underlines that students do not only use, analyze and understand represented information available in the environment, but they are contributors of information to the environment on top. Dickey (2003), in addition, summarizes the great potential that exists for virtual worlds as CLEs. She signifies AW as a tool that suffices all CLE requirements and backs her findings in a later AW case study (Dickey, 2005b).

3.4.2. Sense of Social Presence

The next important topic that has seen a lot of coverage in research after the concept of community has gained influence is *social presence*, or general presence (Palloff & Pratt, 2007). This is the latter element in the *people* section of Palloff and Pratt's community model. Defining social presence, it "is interpreted as the degree to which a person is perceived as "real" in mediated communication" (Richardson & Swan, 2003, p. 70). This includes how anyone can project their social and emotional aspects of personality to the community that they are part of by means of communication (Garrison et al., 1999). In case of online teaching, the definition refers to how any member of the online environment can represent themself through text, voice, video or general virtual world interactions with other participants. Palloff and Pratt (2007) consider how people can express themselves online as critical to the process of community building.

The concept was first established by Short, Williams and Christie who determined social presence as "degree of salience of the other person in a mediated communication and the consequent salience of their interpersonal interactions" (Short et al., 1976, p. 65). They stated that the social communication medium specifies the quality of social presence it can generate. Depending on information that can be transmitted, such as facial expressions, look direction, posture, dress or other non-verbal cues, social presence can fluctuate. Later research by Gunawardena (1995) applied the theory in a *computer mediated communication (CMC)* setting and ascertained that a feeling of social presence can also emerge in media that is low in non-verbal cues and social context. Of high importance was also the learning environment in which the instructor gave space to personalities and allowed social chit-chat in separate areas for learners. Further, Gunawardena presents opportunities of using constructivist principles in CMC environments under the requirement that social presence and a sense of online community can arise.

Garrison et al. (1999) took the concept of social presence and expanded it with two more forms of presence: teaching presence and cognitive presence. They called the resulting framework *Community of Inquiry* which assumes a learning process to occur within a community as long as all three elements are given. The first and most basic element according to the authors is cognitive presence. It depicts the "extent to which the participants in any particular configuration of a community of inquiry are able to construct meaning through sustained communication" (Garrison et al., 1999, p. 4). Differently speaking, it reflects higher-order knowledge acquisition and application that is nurtured by critical thinking through discourse and reflection within a community (Garrison et al., 2001). Secondly, social presence is defined as the ability of members to display their personal identity to other participants. Primarily, Garrison et al. (1999) think of it as a support for cognitive presence which pushes the process of critical thinking. More importantly though, if there exist both affective and cognitive goals in the educational environment, then social presence becomes crucial to the success of learning experience. Finally, Garrison et al. (1999) describe teaching presence as a combination of three main functions. One is the design of the educational experience, the second facilitation of discourse and third, direct instruction (Anderson et al., 2001). Social presence and teaching presence lay the foundation for an environment that is necessary to support communication leading to cognitive presence (Clark et al., 2015).

Based on this theory and the problem of expressing oneself online, Palloff and Pratt (2007) conclude social presence as a critical element for community building. One does not think about social presence in a traditional classroom as physically being there automatically triggers the belief of coexistence of presence. Even if a student's mind wanders, no one around might notice. In a virtual classroom on the opposite, this has severe consequences as other participants will immediately become aware of the absence because there is no physical representation to cling onto. Hence, someone's presence needs to be paid special attention to in course design as a countermeasure (Palloff & Pratt, 2007). The lack of social presence can lead to negative impact on students' satisfaction, motivation and learning (Richardson & Swan, 2003). For development of presence, Palloff and Pratt include the instructors' role of providing guidance and facilitation as pivotal which fits the exact theoretical definitions of teaching presence. The teachers' job is to construct a space that allows students to form community and acquire content knowledge. Rovai (2002) agrees with Palloff and Pratt that especially for online teaching an instructor's job is not finished after having constructed the course. If the support of teaching presence is missing throughout the learning phase, social presence will go down and, as a follow-up, so will the sense of community. This concept has proven effective in various scenarios. In their study, Clark et al. (2015) cite various more recent successful applications. These proved increased sense of social presence and better student performance in synchronous videoconferencing courses or raised engagement and participation through video discussions. Other notable results are improvements of course retention through lowered feelings of isolation by higher social presence (Liu et al., 2009).

3.4.3. Immersion and Experiencing Presence

With the concept of *social presence* in mind, this chapter will return to questions about the user oneself in virtual environments while adding another layer of theory. In contrast to the community focused social presence, but still narrowly tied to it, is the user's side of experiencing presence. The terms presence and social presence are often used interchangeably (Palloff & Pratt, 2007), however, different researchers have developed separate notions for both terms. While social presence describes how others experience oneself as "real" in an online environment, Slater (1999) thinks of presence as how oneself subjectively experiences being in that exact environment, even though being physically situated in another. In addition, the degree to which a user rather feels part of the virtual world than of the physical world matters. Zeltzer (1992) listed presence as one of three key factors for comparing virtual environments in his *autonomy, interaction and presence (AIP)* cube. Therein, presence was defined as "a measure of the fidelity of sensory cues" (Whitelock et al., 1996, p. 5) that displayed the "sense of being in and of the world" (Zeltzer, 1992, p. 128).

Tightly connected to presence is the term *immersion*, which needs to be separated from presence. Slater (2003) suggests to confine immersion to the ability of a technology to deliver an experience that will lead to a sense of presence. Thus, a virtual environment can be very immersive, but every user will build a different level of presence due to how they perceive the technology. This includes how strongly users are willing to suspend disbelief and allow immersion to affect themselves (Dede, 2005; Dieker et al., 2013). In Whitelock et al.'s wording, immersion would match the "fidelity of sensory cues" that belongs to an environment. Summarized this can be expressed as "presence is a human reaction to immersion" (Slater, 2003, p. 2). Put into practice, Slater explains that it is not presence that can be measured, as it is fully subjective. Though what can be quantified is immersion, the incentive for presence to happen. Factors include sensory fidelity (visual, auditory, haptic, olfactory) like field of view, resolution and stereo. Others are behavioral fidelity, which determines if the simulated aspects are accurate, lags or latency or external influences that users still sense in the physical world (Slater, 2003). Dalgarno and Lee (2009) argue similarly by accounting representational fidelity and ways of interaction in the environment as main cues that lead to high immersion and strong presence.

Looking back at subsection 3.1.2, the aforementioned perception of "being there" corresponds to sense of presence. A newer take on presence as "being there together" (Schroeder, 2008, p. 2) relates to *co-presence*, which is about equal to social presence as it contains the notion of multiple users coexisting (Dalgarno & Lee, 2009). Dalgarno and Lee contend that especially 3D MUVEs offer high levels of co-presence because of their close connection to realistic environments that encourage shared experiences and communication. They do not see presence and co-presence as a feature of a virtual environment, but instead as a result of its characteristics. Presence is also part of the theoretical model Whitelock et al. (1996) presented for defining VLE characteristics based on work of Zeltzer (1992). There are three identified properties called *representational fidelity, immediacy of control* and *presence*. Matching the evolution from presence to co-presence, Brna (1999) later construes the jointly developed framework for multiple users and changes the terms to *social fidelity, immediacy of discourse* and *social presence*. Resting on these theories about virtual environments and their features, Dalgarno and Lee (2009) finalize thoughts in a concept for 3D VLEs as seen in Figure 3.2.

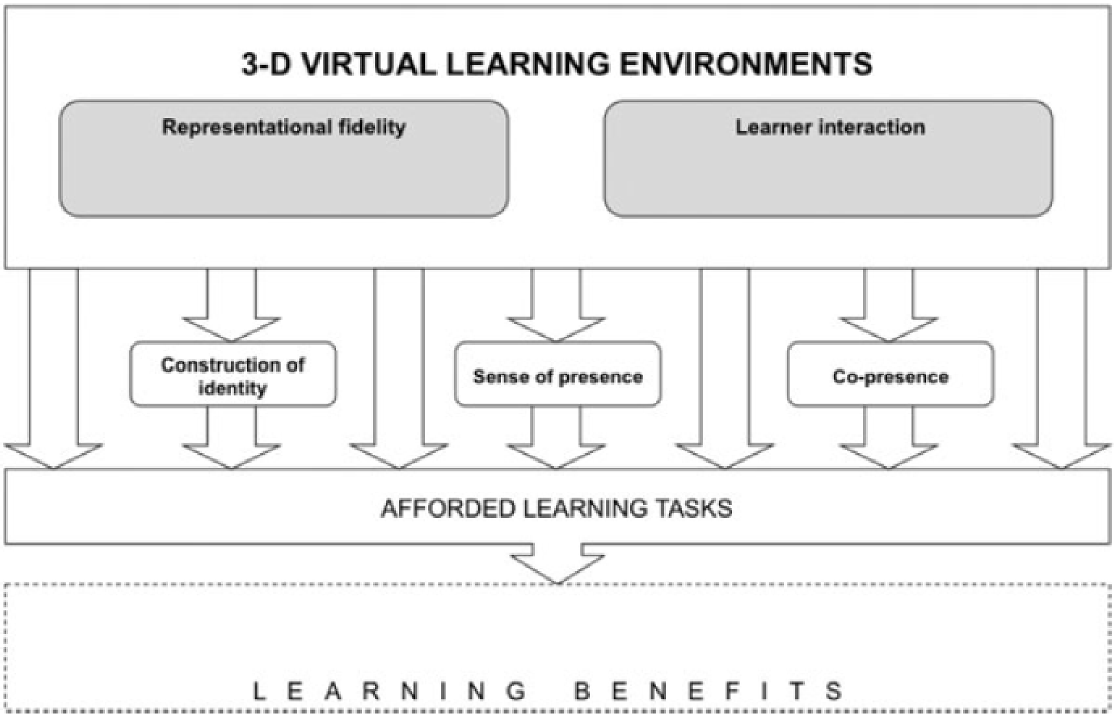


Figure 3.2.: Model of learning in 3D VLEs. Core characteristics are representational fidelity of the environment and the learner interaction made possible by the VLE. Source: Dalgarno and Lee (2009, p. 15)

Dalgarno and Lee adopted representational fidelity and learner interaction as core characteristics of 3D VLEs. The resulting three corner stones, *construction of identity,* *sense of presence* and *co-presence* depict elements of the learner's experience, of which two have already been explained above. The authors further divide the two main characteristic categories into smaller properties of VLEs (Table 3.1). Most important for the representation are the two visual components *realistic environment display* and *smooth view transitions and object motion*. Realistic perspective, occlusion, lighting and texturing of the environment allows for enhanced experience. Even if these do not approach photographic quality, Dalgarno and Lee (2009) mention that a high enough frame rate makes up for it. Moreover, objects should behave consistently also when interacted by users, which resembles behavioral fidelity noted by Slater (2003). The fourth aspect centers around user representation, which has been a relevant concept noted for virtual worlds already (subsection 3.1.2). This includes the visual representation of users through avatars that express both identity and appearance (Dickey, 2002). Dalgarno and Lee (2009) debate that being able to control one's own (possibly imaginary) portrayal encourages immersion and supports communication, collaboration and relationships and, as a result, sense of co-presence. Falloon (2009) for example showed in his case study that avatar-based educational environments leads to great collaboration and interaction especially when applied in group work. For being able to project one's identity onto such a character, there are several features needed. Dickey (2002) and Dalgarno and Lee (2009) name presence, representation in visual ways and online name display, as well as embodiment which means the degree to which players project their real-life behaviors into the virtual world by their avatar. Dalgarno and Lee call this consequence of representational fidelity and learner interaction *construction of identity*, the third piece of user experience.

Category	Characteristics
Representational fidelity	• Realistic display of environment • Smooth display of view changes and object motion • Consistency of object behaviour • User representation • Spatial audio • Kinaesthetic and tactile force feedback
Learner interaction	• Embodied actions including view control, navigation and object manipulation • Embodied verbal and non-verbal communication • Control of environment attributes and behaviour • Construction of objects and scripting of object behaviours

Table 3.1.: Characteristics of 3D VLEs; Source: Dalgarno and Lee (2009, p. 15)

Finally, 3D audio technologies that are able to improve users' sense of spatial awareness act as information and feedback that steers participants of the online world towards points of attention or enables more realistic experience by distance or directional auditory effects. Similarly, feedback provided with haptic technologies can improve perceptions and was also included as a factor for representational fidelity (Dalgarno & Lee, 2009).

Characteristics of learner interaction are heavily based on embodiment, that was part of research by (Dickey, 2002). Dalgarno and Lee see potential in specific embodied actions, like changing the current view by moving the camera of the application, navigating around space with one's avatar or manipulating objects within the environment. In multi-user settings, embodiment can take place through communication that is being presented as if it came from the avatar. Text and voice chat could for example be aligned with movements by the character. Lastly, the authors list possible learning benefits that are caused by the ability to construct places or objects by oneself (Dalgarno & Lee, 2009). Also, defining the spaces behavior such as changing time or gravity contributes to learner interaction. This is only possible with the extensibility of 3D worlds and gaming platforms as featured in SL (Baker et al., 2009; Berge, 2008).

3.5. Avatars as User Representation

Of major concern for both virtual worlds (see subsection 3.1.2) as well as VLEs (see subsection 3.4.3) are avatars, representations of users. As with the term *metaverse*, Neal Stephensons' *Snow Crash* was again one of the first to apply the term *avatar* in a virtual world setting. Nowadays, avatars are being used in all kinds of situations, for video games (Achterbosch et al., 2008; Bessière et al., 2007; Chen, 2008), education (Konstantinidis et al., 2009; Tongpeth et al., 2018) or entertainment (Baker et al., 2009; Berge, 2008). In games, one would rather find the word *character* describing a player's representation (Bessière et al., 2007). Mostly graphical embodiments, avatars indicate a player's identity, presence, location and activities within the virtual environment (L. A. Annetta & Holmes, 2006). The general motivation for embodying users is expounded by Benford, Bowers, et al. (1995) who compare virtual avatars to their real-life equivalents. People's bodies are the information source for all above mentioned attributes of avatars, plus many more like attention, availability, mood or capabilities. They function as a mediator in communication and provide necessary cues for co-communicators. L. Annetta et al. (2008) think that avatars are not really different from emoticons as they are another way for showing expressions online in virtual worlds. Abstractly speaking, an avatar is a natural interface that a user employs to communicate inside of and with contents of applications (Tongpeth et al., 2018). Most often, this includes social interaction through the character e.g. in VLEs or MMORPGs (Bessière et al., 2007). Therefore, they are vital for oneself, as one has to feel connected to and identify with the "aesthetics, appearance, customization and representation" (Kolesnichenko et al., 2019, p. 249) that was chosen. But it is also important for the perception of everyone else who is an interactive member of the virtual world. Other users should be able recognize a player just by their looks, though possibly from their actions and behavior, too. Yalcinalp et al. (2012) had cases in their study in which students of the same course participated in a 3D VLE and recognized others simply by their avatar behaving similarly to the real-world person. Benford, Bowers, et al. (1995) separated this visual recognition task of participants into four possible cases: being able to differentiate a body representing a human player from other virtual objects, distinguishing individuals during interactions, recognising someone again once the identity is known, and lastly, finding out someone's identity solely by their characters appearance. This can be either easy or difficult depending on the implemented looks of avatars. They can have very low level designs, like smileys or portrays, or be developed up to fully modelled 3D characters (Stockrocki, 2007). Some are 2D images and pictures which the community creates itself (Kafai et al., 2009), and some even apply image recognition software for generating accurate avatars from photos (Kolesnichenko et al., 2019). Most notably though, throughout all available resources avatars almost all of the time tend to look human or at least share human features. In research by L. A. Annetta and Holmes (2006) students chose one avatar each from a predefined selection that also included non-human characters. However, all but one person opted for a human representation. It is, therefore, necessary to take a deeper look at how identity forms, what affordances different designs can have and how their usage affects community.

3.5.1. Sharing Identity with One's Avatar

Relating to someone's avatar is a complex combination of factors that come into play. Dickey (2002) mentions that it is not only the visual representation of users, but rather their unique identity that they can be identified by. Notably, this identity also usually contains a moniker or specific ID. This identity can then be utilized for social contact and establishing trust among each other. A unique identity also provides security and determination over identities both online and in reality. Experts of recent virtual world applications coincide, that their users mostly treat their own avatars as a personal brand and identity of themselves (Kolesnichenko et al., 2019). At the core of establishing identity lies user embodiment which requires an appropriate body image. According to Benford, Bowers, et al. (1995), this is a consequence of highly graphically heavy, virtual environments. Still, functions, behaviors and controls need to be considered when designing avatars and are an element of embodiment, too. Benford draws the analogy of embodiment being similar to users controlling a marionette as best as possible. Nevertheless, this power over the avatar is limited to interactions that were granted by designers (Dickey, 2002). Non-verbal communication can be restricted to navigation, available emotions, actions or perhaps gestures. In any case, even though more features of embodiment are preferable, "the ability to see other users and to move around them is in part sufficient to construct at least a limited sense of embodiment for users" (Dickey, 2002, p. 12). Consensually, Benford et al. generally assume the premise that "the inhabitants of collaborative virtual environments (and other kinds of collaborative system) ought to be directly visible to themselves and to others through a process of direct and sufficiently rich embodiment" (Benford, Bowers, et al., 1995, p. 243).

In terms of visuals and appearance of one's avatar, it depends on the application which looks can be decided on. In SL there are many customization options such as gender, shapes, size, skin, hair or clothing. Besides, animations are used to express countenance, posture and gesture (Yalcinalp et al., 2012). Naturally, it is possible to choose a character that completely differs from oneself in gender or looks as roles or races are not assigned (Kafai et al., 2009). The choice of non-human characters is sometimes given as well (Baker et al., 2009). In AW, choice of avatars is limited to the selection that world owners offer from a preexisting library. This can lead to overlaps in looks as many users might use the same avatar (Dickey, 2003). One option Dickey suggests is incorporating colors into few visual attributes of characters to solve this problem. Benford, Bowers, et al. (1995) add that personalization of body images with virtual garments could help improve embodiment, but also raise questions about the social significance of associations that might be made with those garments within the group. Kafai et al. (2009) actually noticed Benford et al.'s predicted social and cultural pressure in the virtual world Whyville. There, one can buy additional designs for avatars, that are made by other users, with a virtual in-game currency. The community developed its own culture over time and deemed looks and their fashion trends in the game as a form of social status (see section 3.4). This included opinions and rules about where to shop on the marketplace and how not to design one's character. Especially game beginners suffered due to their lack of money and owned designs. The intention though of being able to have no restraints at all in avatar design is initially a positive one. A co-founder of *Anyland*, another recent VR universe with avatar creation similar to Whyville's, stated that avatar design is all about inventing one's own identity. His application wants to offer players the freedom of deciding which person they really want to be (Kolesnichenko et al., 2019). As freely as virtual worlds might be allowing identities to form, there is always a danger of real-world social issues transitioning into the virtual world. A good example for better utilization of those two aspects, namely color differentiation and accessories, is the video game *Among Us*. While all character models are equal in shape and size, colors play the role of distinguishing between players. Any further available garments, that can be added enable better expression of one's own identity with the avatar, are free for everyone.

About the social aspect, Berge (2008, p. 28) draws an image that in virtual worlds "a user's skin color, appearance, and beliefs do not matter very much". He is only partly right, as someone's real self is hidden and cannot be assumed (at least not fully) from one's avatar. Thus, there is an opportunity for being confronted less with prejudices. Baker et al. (2009, p. 61) called being invisible behind an avatar a "layer of semianonymity" that feels like a protective shield. In fact, many researchers found more introverted participants to bloom and more actively contribute to courses in online virtual worlds than in real life (Falloon, 2009; Palloff & Pratt, 2007; Yalcinalp et al., 2012). Yalcinalp et al. for example, observed students feeling more relaxed and confident online who would have otherwise struggled due to pressure of speaking in front of the whole class. On the other hand side, students have often been seen designing their characters in ways that resemble themself a lot (Kafai et al., 2009; L. A. Annetta & Holmes, 2006; Yalcinalp et al., 2012). Kafai enumerated physical appearance, personal likes or personality as a couple of reasons for design intentions. Aside from that, participants wanted to relate to characters they liked from video games, hobbies or nationalities. Yalcinalp et al. (2012) likewise reported that selection of avatars rather resembled users actual physical looks in reality as well as their behaviors. This leads to the issue, that if human characters act as an avatar selection roster, one cannot simply neglect someone's skin color or ethical backgrounds, as users will want to represent themselves in the virtual world. L. A. Annetta and Holmes (2006) attempted to only offer two designs, one male and one female, to a group of study participants. The outcome were complaints about lack of individuality, differentiation and identity which resulted in students missing sense of presence. Moreover, the second test group was allowed to choose between a wider selection of avatars that provided gender, ethnicity and personality options. Annetta concluded, through the usage of a server side bot surveying avatar choices, that for many participants of that group it was actually possible to infer information about the real life human from their avatars.

Yet a different setting of virtual world studies goes deeper into how players express their personality within the visuals of their character. In MMORPGs there is a strong bond between player and character, because players usually keep their avatars for months or years (Bessière et al., 2007). As MMORPGs have a determined goal that needs to be achieved mostly with a group, social interaction and communication through their character is vital. A character needs to stand for bravery and wittiness that would make companions believe in the player's strength. The study by Bessière et al. (2007) assumed that players would enact an ideal self with their characters in the video game WoW. There, characters can be adjusted by appearance, profession and personality. It was, indeed, shown that users generally judged their own representation as having a stronger personality, especially for participants with lower self-esteem (Bessière et al., 2007; Ducheneaut et al., 2009). Noted improvements were conscience, extraversion and lower neuroticism. Bessiere et al. summarize that their findings support the idea that provided anonymity and fantasy in game worlds liberates players and grants them the opportunity to be more who they want to be.

Onto the issue of racial and gender representation, activism about the lack of differently colored heads in Whyville has risen, too (Kafai et al., 2009). This made designers include more head colors and realistic skin tones over time. The degree of choice for gender, race, age or able-bodiedness is heavily confined by the designers of the application and can inflict hindered representation of identity (Dickey, 2002). Kolesnichenko et al. (2019), who have interviewed experts working for current social VR applications, collected opinions on avatars appearance and its implications. Often, designers would mention that avatars need to protect especially women from harassment in virtual spaces. They are most likely to be under attack by sexism and often suffer from hostile reactions of male gamers (Ballard & Welch, 2015). As a result, characters were designed avoiding hyper-sexualized appearances. This would allow a more neutral view on the avatar for everyone within the virtual world. Knowing these cases, it is obvious that caring about social issues and proper representation of user community is inevitable for designers of virtual worlds.

The ability to alter the avatar's appearance whenever wished is another highly debated topic. First of all, the initial creation of an avatar, if it is designable by oneself at all, might be already an emotional investment for some users (Dickey, 2002). At least in some virtual worlds a player will need to stick with that avatar for the rest of time (Bessière et al., 2007). While background in design is not needed (Dickey, 2002), so is surely a lot of time in most cases (Berge, 2008). Now, applications like SL or Whyville are strongly centered around the socializing aspect and afford changing the avatar visuals whenever one feels like it. Research suggests that offering this choice of frequent adjustments allows for better self-expression. L. Annetta et al. (2008) found students swapping avatars for better representing themselves according to current assignments in class or just for showing their daily mood. This is similar to how someone would dress and behave differently every day in traditional classroom settings. Falloon (2009) actually reports that in his study with *MARVIN*, avatars could be selected appropriately to the information that the audience was about to be presented with. Moreover, avatars were wearing the students' school uniforms which contributed to sense of ownership and identity. Twining (2009) reviewed the usage of *Schome*, a future learning platform within a virtual environment. Participants of courses responded well about the possibility of changing their character's looks, e.g. clothing or hair, which they did for the same reasons found by Annetta. Often, students reflected upon their identities and many came to the conclusion, that it is themselves, that they are representing. Yet, they stressed that their avatar might be a freer presentation, because the design options allowed for other parts of their identity to be expressed. Twining discovered high success in students being immersed and the implication of having a sense of presence.

Being able to change looks (or possibly nicknames) anytime does yield limitations though for self-representation. Other befriended users might wonder when suddenly a new name was among their friend list or when someone's appearance changed completely. A girl in the study of Kafai et al. (2009) intentionally dressed foreign and then surprised her own friends after sneaking into their conversations. Others would also disguise and startle inhabitants of the world. This behavior can already be seen as an "abuse" of feature, that was initially intended for diversity. This issue is addressed by Benford, Bowers, et al. (1995) who predicted exactly these issues to arise. It is a question of "truthfulness" if users design avatars like themselves or choose visuals freely (Benford, Bowers, et al., 1995, pp. 7-8). The authors divide the application designer's decision into either strictly limiting users in their freedom or opening the possibility for deceit. They propose a gradient of body attributes that are changeable, but the more defining the features get, the more difficult it is changing them. For example changing clothes should be easy for self-expression, changing facial features on the other hand should be more difficult. Identity defining features like names or ID numbers should, therefore, not be changeable or only in exceptional cases. This will reduce the aforementioned issues of abusing the avatar modification options. But what if users would want to impersonate another part of their personality or interests (Berge, 2008)? Kafai et al. (2009) evaluate this case in form of alternative identities by creating a second character. In fact, users surveyed by Ducheneaut et al. (2009) showed an average count of avatars in WoW of twelve and an average of three for SL. Often it is possible to create several accounts that allow players to try out different looks including age or gender changes. Kafai et al. call this *second selves*, which is an inherent concept of identity itself. This entails having a different account name or ID as well, for which a player can establish a new identity, though which is still part of the player themself. Experts of Mozilla Hubs consent that exploring a different identity or "persona" is entirely human and explicitly cared for in their application (Kolesnichenko et al., 2019, p. 249).

3.5.2. Design Issues and Decisions

After having reviewed theoretical social and visual aspects of avatars in VLEs , it is clear that identification with one's character greatly supports losing oneself in immersion of the environment (Dalgarno & Lee, 2009). What is left are inferences from theory that help designing guidelines for development of VLEs as well as technical and practical concerns that one has to be aware of when designing a VLE. An ideal combination is looking at predicted issues as well as reflection on current applications. For this purpose the papers by Benford, Bowers, et al. (1995) and Kolesnichenko et al. (2019) will serve respectively.

Performance A concern that heavily affects the technical side of avatar visuals is performance of the individual platform and its computing resources necessary for running the application. Benford, Bowers, et al. (1995) recommend designing embodiments as efficient as possible to still be able to convey communicational information and enable identity forming. In fact, attempts of completely reproducing a human physical form with high polygonal detail is considered wasteful. Abstract representations that still capture the essence of embodiment are to be preferred. Kolesnichenko et al. (2019) have seen exactly this as the main reason for design decisions on avatar's visual fidelity. Applications like Mozilla Hubs and AltSpaceVR need to run on multiple platforms that have differing performance. Their avatars' designs were, thus, intentionally kept simple so that no user would run into performance issues.

Locating Users in 3D Space On top of users having to be visible in the virtual environment (see subsection 3.5.1), Benford, Bowers, et al. (1995) add that the location plays a key role, too. Players need to be seen positioned and also oriented within the world, which acts as a spatial measuring reference. Depending on the size of the environment, users can guess distances and exact locations of others. Benford et al. attribute high social significance to orientation of characters, because that can be a sign of whom one is talking to or interacting with just like in reality. This extends to interactions with the environment and objects, which can afford spectators with information about what someone is doing at the moment. Benford, Bowers, et al. (1995, p. 245) call this "peripheral awareness" which can support activity coordination between members of the environment. In specific, activity is separated into *viewpoint*, the space where a person is attending, and *actionpoint*, the space that a user is manipulating. Both of these a user can have multiple of at the same time.

Depending on application, avatars also serve as the point-of-view for cameras (Dickey, 2003), which means that the camera is located at the position of the player. For instance, first-person camera views offer a look through the eye of the character. Camera motion can equal to head rotations, e.g. looking up and down or side-to-side, as well as moving the avatar in any direction. Trying to keep the camera in the spot of the avatar seems to be a contributing factor for consistent embodiment. Yet, there also exists the possibility that the user's perspective might not be apparent for other users as camera movement is rarely fully represented as character movements (Dickey, 2002). As a result, viewpoints of that user will not be perceivable for other players. In other cases, users might not be aware that they are visible for others. This meta-information can be critical e.g. in a virtual conference where company partners get into a conversation. That information alone, that two companies talked to each other, might already be worth a lot to someone else. Hence, positioning, orientation and camera view are crucial factors to consider for VLEs.

Availability Tightly connected to the location and orientation of an avatar is it's state of availability. Others may be able to assume view- and actionpoints, but it is also important to guess how busy or available a user is (Benford, Bowers, et al., 1995). Benford et al. suggest implicit display of information about a user's state of activity or explicit indicators on their body. Highly problematic is that even though a character might be acting virtually, that does by no means imply that the person in front of their PC is actually present. This mind-body separation could be the reason for social problems like other players approaching that person, but not receiving any answer. A feasible solution proposed by the authors is keeping track of the user's idle time and employing visual measures, once the system recognizes a player's absence. This could for example be making a player's model translucent or adding special "sleep" animations.

Conveying Emotions Besides explicit text and voice chat, alternative implicit ways of communication are gesture and facial expressions. These are the "most powerful external representation of emotion" (Benford, Bowers, et al., 1995, p. 246), but they are difficult to implement due to the necessity of high technical detail. For facial expressions, Benford et al. suggested tracking the users real face with sensors and mapping its movements onto the avatars skin, just how it is possible today e.g. in the video game *Star Citizen* (Frank, 2017). An alternative way for expressions is using emotes. In many of the applications surveyed by Kolesnichenko et al. (2019), emoting systems are used. Usually emojis can be selected in the *head-up-display (HUD)* and will then either be presented as facial expression of the avatar or shown in a cloud bubble above a player's avatar's head. A practice deemed very helpful by the authors is displaying *speech lines* when a user is speaking through voice chat in a larger group. These are displayed above user's avatars indicating the current speaker. Supporting communication by gestures, avatars could provide manipulable limbs with high flexibility (Benford, Bowers, et al., 1995). Depending on application, limbs can either be controlled directly or by triggering predefined animations. This is again bound by technological aspects of the application and users might only have very limited access (Dickey, 2003). In current VR applications, gestures such as *handshake* or *fist bump* are used to trigger effects like becoming friends with someone (Kolesnichenko et al., 2019). This is a great use of embodiment, but does not appear frequently enough in virtual worlds, say Kolesnichenko et al.

Personal Space While avatars themselves already function as a layer between the player and the virtual world, there are still boundaries that need to be drawn for mannered social contact within virtual environments. Kolesnichenko et al. (2019) have examined a couple of implementations that provide protective means for users' personal space. For example, *Rec Room* allows users to switch on an *ignore bubble* which draws borders around the avatar that others are able to see. Depending on personal preference, the bubble's size can be altered. Whenever a player would enter someone else's bubble, they would turn transparent the closer they got. Mozilla Hubs on the other hand includes a pause function which stops all motion in the world. That allows players to leave the current room or situation. Another approach is Anyland's private home spaces where users can invite others. If the host feels disturbed by someone, they can kick that person out. Anyland intentionally neglected the idea of privacy spaces while arguing that providing means of defense would only incentivize some people to try and break those means (Kolesnichenko et al., 2019). An issue that was not mentioned in that context, is how other guests of that environment deal with disturbing visitors. They do not have the power to make someone leave and would possibly have to communicate their troubles to the host first. Kolesnichenko et al. conclude that the mechanics of personal space often define how social interaction can happen. Depending on someone's privacy bubble, others can come close and interact with gestures or talk. Ultimately, means of protection need to exist all of the time, no matter how they are integrated.

4. Proximity-Based Virtual World

In order to tackle the social issues of online teaching and experiences of educating in pandemic times, this thesis presents a VLE that includes a new approach on how users can connect within a virtual proximity. The application is based on the concept of virtual worlds and expands it with features of an imitated 3D university setting. First and foremost, it serves as a communication tool between teachers and students, presenters and audience, but also and especially between students and students. Its intentions are providing a common ground for every participant that is equally shared while respecting privacy, norms and netiquette. Moreover, it demonstrates possible future features that have the potential to change how users interact within social online environments. By taking inspiration from video game background, the application also offers ideas from a different perspective than common conferencing tools which are mainly used for education at the moment. In this regard, immersive features that originate from games have been included. The following chapter outlines the characteristics of the *Virtual Campus App* from its world and avatar design to communication, privacy and ethical issues that might arise. After a short overview, each section will take reference to the previously summarized information about virtual worlds and learning environments and point out its affordances for a better social experience.

Overview of the Virtual Campus App In the application, each player controls an avatar that has a humanoid body shape. It can be moved around a private room offline, representing the player's home, and an online environment that was inspired by university campuses. The whole world including one's own character is seen from a third-person perspective that moves along with the player. On the virtual campus multiple players can gather and get to know each other. They can take lessons given by another member of the world in a lecture hall, engage in conversations in community areas or study in conversation-free spaces like the library. The communication takes place either through in-game text chat that also allows specialized emojis, or through voice chat between players that are close to each other. The university environment needs to be hosted by the teacher on their computer whereupon students can join with their avatars remotely from their homes via internet. The application was built with the video game development engine *Unity3D* and runs on desktop PC. For the moment it can run besides any software that instructors use for presentation. Individual features of this virtual world will now be presented in detail one by one.

4.1. Virtual Campus as Learning Environment

The world that can be explored in this application is split into two separate scenes. One of which is an offline scene that can only be accessed individually. Every player has their own that no one else can enter. It is designed like a regular but simplified one-room flat that players start off their journey. The online scene is a university campus ground with several facilities, rooms, squares and places to socialize at. The idea of designing a virtual world like a university is nothing new, however. Universities have done the same themselves for their students to experience a sense of being on campus with the same student community as always, even though they are at home (L. Annetta et al., 2008). Simulating a campus setting allows learners real-time interaction with the instructors and other students that are available (McBrien et al., 2009). The looks of a university also enable embodiment in the environment as students can actually feel like they were at school (Dickey, 2005b). Some students especially need to feel like they are in a study environment and won't perform well from home. If immersion of the environment is strong enough, it might be possible to overcome the negative influences of a real-life situation that is not targeted towards being a study space. In addition, as Rapanta et al. (2020) noted, the important conversations before and after class that appear naturally at school are non-existent with video conferencing tools. Once a stream has ended, every participant will automatically leave the room. Palloff and Pratt (2007) imagine the usual flow of students when arriving at the site. Learners already come in groups or they arranged a meeting spot where they will gather. Up until the time when class begins, they practice social exchange or talk about what was going on in their lives. Once again after class ends, students meet and speak about their study topics in the hallways or anywhere else on campus. This is also how friendships and personal connections form. This application aims at recreating these meeting and gathering spots that students, whether intentionally or unintentionally, encounter each other and simply socialize at. In accordance with the *multiple tools* feature of VLEs (see section 3.2) the virtual campus can quite literally implement these facilities as spaces. Rooms and buildings at a campus serve different purposes like studying, registration, assistance, fun, relaxation, etc. (Dillenbourg, 2000). These features can directly be mapped onto a virtual campus environment. As Berge (2008) perfectly explained, developing content for a new medium always starts with the recreation of something that already exists. Only afterwards new creation and exploration will begin for features that other platforms do not provide. Therefore, this virtual environment takes the university campus setting as a foundation for further improvements and inclusion of innovative ideas.

4.1.1. Game Space Design

The environment that a player can traverse in video games is usually called *game space*. It contains all visual elements that a user can see and interact with. In the Virtual Campus App it is comprised of the offline "home" and the online "campus" scenes. The prime task of this environment is shaping a players experience of the game or application (Schell, 2015). It needs to be built for players to enjoy being within that environment (Feil & Scattergood, 2005). In that regard, the design of a space can greatly vary depending on the cultural background and people from different countries might experience the same place completely differently. This has to be accounted for either by a universal style or with many specifically targeted scenes. Another feature of virtual space is supporting navigation of users within it. Depending on the the environment its main design issue is how it communicates information by its spatial representation (Dillenbourg, 2000). Because of the design and building aspect, game space design is often connected to the work of an architect (Feil & Scattergood, 2005; Schell, 2015). It is not the experience itself though, that designers can directly provide. It is rather indirectly defining how people see and feel within the structures created by the architect that influence the experience (Schell, 2015). Looks and sounds work in conjunction to create the stage for joyful time in the game. Still, it is vital to find a balance between the application's several components of aesthetics, performance or narrative (Rouse, 2005). Thus, one cannot simply opt for the most visually stunning graphics. The graphics in this application were chosen to be simplified and stylized, using vibrant colors to create a warm and inviting atmosphere for players altogether. It also does not try to fit any particular architectural style but stays relatively generic. As the proximity-chat world aims at enabling communication amongst participants of all kind, a place to feel comfortable is necessary to create a sense of safety and security (Palloff & Pratt, 2007). In return, this does keep performance requirements low and offers the possibility of releases for different target devices with less power at a later stage. This approach is coherent with the view of Dalgarno and Lee (2009) on representational fidelity. Feil and Scattergood (2005) recommend not experimenting with architecture too much, but rather sticking to architectural clichés. It is best to keep it simple and not confuse new players with overwhelming visuals that might not fit the theme. The authors underline that the proper choice of architecture is especially necessary for immersion as it communicates the mood to the player.

Concerning the structure or layout of the world, it gets slightly more complicated. First of all, it needs to be decided how large the world should actually be. This mainly depends on how many participants the application is planned for. The current campus map is intended for a group of a couple dozen users, which roughly equals a regular school class or small university lecture. For any other amount of players, a differently sized map would be more appropriate. This is due to how many rooms there are and comes down to the distribution of players. Too many players in one space will make it feel crowded and overflown with impressions. On the contrary, too few players might make it feel empty and desolate. It is, therefore, important to keep the amount of users at a balanced level for the world. Afterwards, necessary rooms and facilities available on the virtual campus can be planned. This includes their size and layout, which directs how users spread in the world. It is important to keep in mind that the dimensions of the learning environment also determine walking distances that should not exceed a certain amount of seconds when travelling from one point to another (Feil & Scattergood, 2005).

This leads to the most crucial question of game space design which was formulated in research question two. As feelings of belonging and social presence are to be fostered by the environment, how is it possible to guide people with similar intentions to the same location? Dillenbourg (2000) describes this process as increasing the probability of productive interactions. As users with the same goals will be more likely to engage and create connections, how does the world have to be designed? Spaces of encounter have to be structured by the designers, who create the environment that can direct player's movements (Feil & Scattergood, 2005). Rouse (2005) suggests indicating paths that are traversable and paths, which are not, with different textures so that players will easily recognize where they can go. Schell (2015) adds that dead-end streets make players have to return the same way they came. This grants frequent chances of interaction because players regularly run across each other. Often it helps placing spaces right next to streets where users have to pass by to incentivize a quick peek at who is currently there. Feil and Scattergood (2005) calls this a push-pull principle. While open spaces invite people in, narrow places will push people away. By alternating between these types of spaces, architects can implicitly "force" the positions of players onto them. Feil and Scattergood also mention aesthetics, like textures, angles, colors, sculptures or furniture, that will draw users in.

Where paths and open spaces exist, there also need to be points in space that users can refer to. These are called landmarks and help users orient within the virtual world (Schell, 2015). Especially looks or size are easy to remember and make landmarks often visible from further away. Particularly when the environment becomes complex, landmarks act as frames of reference for wayfinding and support spatial knowledge generation (see section 3.3). Landmarks can, thus, act as gathering points that players will always find the way back to. Creating spaces that people are likely to meet at, whether casually or not, are key for enabling social meetings. The space should provide a structure for overview, order and interactions. How these spaces look like in detail is explained in the next two sections.

Offline Scene - Home

The offline scene imitates a student's home, very much simplified in one single room (Figure 4.1). It is similar to how *Anyland* offers private spaces (Kolesnichenko et al., 2019), but it differs by not letting any other person in. It is a safe haven that protects oneself and that one can always resort to. This is also where the player starts off the game when launching it. It is reminiscent of where students are usually during distance education, namely at home. It caters towards embodiment (see subsection 3.5.1) by recreating the same setting that a student will usually go through. From their home, learners leave to the place of education which is simulated by the door that players have to approach. When they are close enough, they can interact with the door and a menu will pop up in which users can decide to host or join an online campus. Generally, many virtual actions within this world utilize in-world objects that players can interact with. This could also be called trying to make former 2D menu interactions virtually tangible.

Usually, it might just be a map that one can look at in their menu and then decide, where to teleport to. In contrast, Virtual Campus App uses symbolized objects that function as actionpoints. This helps players feel more embodied, raise immersion and presence. In this case the house door acts as a gate replacing a menu that might interrupt the immersion. A main menu as such is not necessary. At the house door a player can also decide to leave the game. Kolesnichenko et al. (2019) have also referred to the issue of travelling between worlds as a problematic one. It is a challenge for virtual world creators to make this process more embodied and socially engaging. An application that stood out was *AltspaceVR* which implements a similar approach. It offers a *party portal* mechanic which is a virtual model of a portal that moves users to another space when they walk through. In the *home* scene there are a couple more embodied navigation and interaction tasks available. One natural interaction, for example, takes place at the closet, which contains clothes in reality. Akin to real-life, in the Virtual Campus App a menu opens for changing a player's looks and outfit.

Figure 4.1.: The offline scene simplifies a regular home condensed in one room. Source: Virtual Campus App

Many video games try to introduce a player to the mechanics of the game by providing a tutorial at the beginning. SL, for example, has a dedicated orientation island. There, fundamental controls like navigation of one's avatar and communication are explained. In the Virtual Campus App, one can regard the home room as the equivalent to the orientation island. In the room there are further objects that can be interacted with, which are placed for players to try out possible interactions that are available in the online scene, too. At their bed and on the couch chair players can sit down with their characters and relax. This comes in handy on the campus site where groups of people are to engage with each other. Then people will probably not want to stand around in groups, but rather sit down on sofas that provide space for a couple of people at the same time. Besides, in their own room players can switch on and off the bed lamp. On campus there are a couple of similar interactions that will affect everyone around like radio, TV or coffee machine. These interactions are examples to test how immersive interaction between players can affect each other. Having tried these interactions in advance, Milheim (2012) notes that it is important to have students be prepared and interactions with interfaces be consistent throughout the application. By allowing players to study the possibilities of control first in a private and safe environment, the students can familiarize themselves ahead of time. By hosting an online campus, they can even explore the campus map prior to class. Still, even if troubles arose when going online, Yalcinalp et al. (2012) have reported that often users were interacting at the first meeting especially due to control questions. This quickly helped as a conversation starter for both sides.

An issue of architecture and design that becomes apparent specifically in a single small room like this is the skew of the player's sense of scale (Feil & Scattergood, 2005). It is a result of the third-person camera perspective that allows seeing the player and their surroundings, but also asks the human brain to project oneself into the character at the same time (Schell, 2015). This leads to crowded spaces in which objects seem smaller than they actually are. A solution to that problem is scaling up the room, scaling up furniture slightly and spreading it out in the room (Schell, 2015). Looking at Figure 4.1, one can notice how furniture is pushed to the outsides and how there is quite some space to move around. In an earlier version of this room that was considerably smaller, it felt like the player could not move around at all. By looking at the size of the bed and comparing it to reality, it would usually occupy more space in a bedroom than it does here. Feil and Scattergood (2005) indicate further, that for all rooms, buildings and paths there must be enough space for the character to easily move around. This becomes even more important, when there are multiple users moving around that have to pass each other while also caring about private sphere and humble distance to others.

Online Scene - Campus

The campus map is where people will spend most of their time at and where all social interactions between participants take place. Once the teacher has hosted it, others can start joining into the world. The campus itself is a divided space (Schell, 2015) that is non-linear (Feil & Scattergood, 2005) where players can choose where to go and where to stay. Partly, separate areas are also nested within rooms and create another, smaller space inside (Schell, 2015). It allows for certain degree of exploration as users can choose different paths to follow. Concerning paths and traversable areas, they are mostly clearly marked by textures and boundaries. Rooms for example have walls around them and doorways indicating passages to other rooms. Squares are limited by hedges and will not allow users to pass through. Further, there is an implicit and an explicit border between rooms and other places. Often, a small staircase will be an indicator for a change in setting by utilizing elevation as a differentiating factor. On top, all entrances to new rooms are marked by a semitransparent "curtain" with the name of the space on it (see Figure 4.4). The names can help identifying the purpose of the rooms as well as remembering them in order to prevent frustration (Feil & Scattergood, 2005). Players will then have to pass through these entrances to enter a new area.

Upon their first time entering the world, players are spawned at one end of the map and can explore it towards any end on the other hand side. This can be quite stimulating for many players (Rouse, 2005) and create immersion that helps fostering presence. In terms of layout, the campus takes strong inspiration from general school architecture design that was mainly influenced by Alexander (1979) who studied how shared spaces can be well designed. Schell (2015) deems Alexander even as the origin for design patterns in computer science. As described in section 3.2, each space within the environment is supposed to serve a different purpose. Summarizing rooms and locations, there are a bus station, arrival plaza, school or university entrance hall, community room, a bathroom, group study rooms, a library, a backyard plaza, a lecture hall, a vegetable garden and some cliff that can be explored. With each space aiming for a different purpose, this can be answer to the question posed at the beginning of subsection 4.1.1. Players who have class will come to the lecture hall, while people who have a break will either relax in the community room or somewhere outside of the building. Students who need to study go to the library or group study rooms. The intention of this virtual environment is representing all these real-life functions and automatically sorting players. That way productive and social interactions may be increased. Each of the spaces found within this world will quickly be elaborated in the upcoming paragraphs.

Bus Station The bus station as seen in Figure 4.2 acts as a spawnpoint for players. This is where everyone including the teacher will enter the campus. It is indicated by a road, waiting benches and a bus schedule sign. The sign holds an embodied menu function which, once players interact with the sign, leads them back to their home or out of the application. The bus station, thus, represents the arrival and leaving area for all players. It can be compared to a portal that connects the different worlds by nothing more than a bus ride. One of the design patterns by Alexander (1977) called *promenade* describes a place that people can go to in order to be seen and to see. Tanner (2000), who conducted a study on the influence of school architecture on academic achievement, included Alexander's pattern for describing the walkway that is right in front. In the US, most schools have bus and car loading and unloading zones which are the first place students will see. These places may allow socializing areas and a space to relax. By including a bus station that is the gate to the world, all players will naturally come to see each other and have the possibility to engage. It also offers a first place where students can wait for each other on the benches in case they set an appointment.

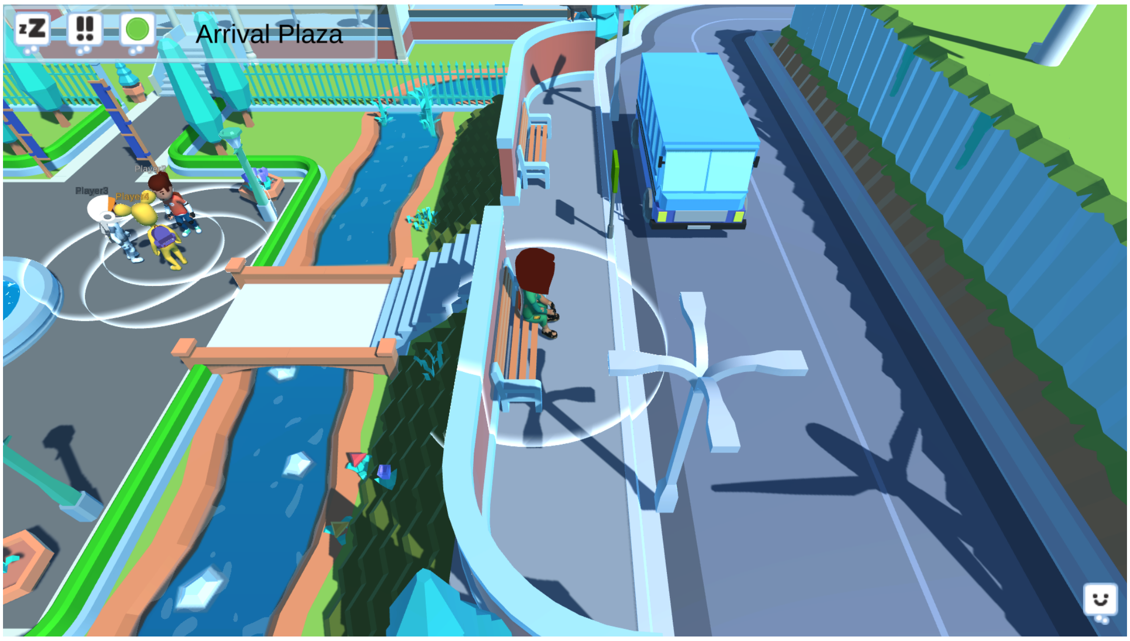


Figure 4.2.: The bus station is the area in which players arrive first. Avatars are spawned in front of the bus and can either begin their stay or leave back home from here. Source: Virtual Campus App

Arrival plaza The arrival plaza is the first larger space encountered right after coming down from the bus station. It has a direct connection to the entrance hall of the study building. According to the principle of Feil and Scattergood (2005), the narrow bus station will presumably push people down the stairs into the plaza. The plaza is designed wide open to accommodate all people who have arrived at campus, creating an effect that draws in people. The plaza contains a large animated fountain in the middle which acts as a landmark for users (see Figure 4.3). They can gather around it and will be able to recognize the fountain from far away. As the ground of the plaza does not have lots of texture, the fountain serves as a reference point instead. Players that are currently at the plaza will always be able to guess their position based on the location of the fountain on screen. Several benches distributed across the plaza allow group forming and serve as meeting spots. Each of the plaza corners is additionally decorated with a flower pot that have different colors depending on the corner. That way, players have another easy to remember decoration object that they can use as reference. If for example a group of friends tried to meet at the plaza, they could coincide on meeting at the yellow flowers instead of trying to convey the lower left hand corner of the plaza. This also supports understanding the layout of the map (Rouse, 2005). Once every player has memorized the location of the flowers, it will be easier for them to refer to spots with their explicit reference objects (Feil & Scattergood, 2005).

Figure 4.3.: The arrival plaza is the first gathering space where users can find friends or engage in spontaneous conversations. Source: Virtual Campus App

Entrance Hall The entrance hall in Figure 4.4 is the space through which everyone passes whenever they want to change location. It is the connecting room for plaza, community room, backyard including the lecture hall, and the study wing of the building. Therefore, it does not have anything besides a few benches and bar tables that players can take a rest at and watch people pass by. Tanner (2000, p. 315) mentions that, in regular school buildings, pathways are like "highways" through the building. They enable traffic funneling towards activity areas, which the community room or the lecture hall are examples of. They are, moreover, necessary for providing links from the outside to the inside of the building and keep the user oriented. The path that leads towards the entrance hall is specifically indicated with flags close to plaza. Tanner underlines that main buildings need to stand out and serve as a place from where one can observe campus activities. The entrance hall itself is elevated in height and separated by stairs from the plaza to address this point. By building a main building like that, sense of community as well as imagination of students can be increased (Tanner, 2000).

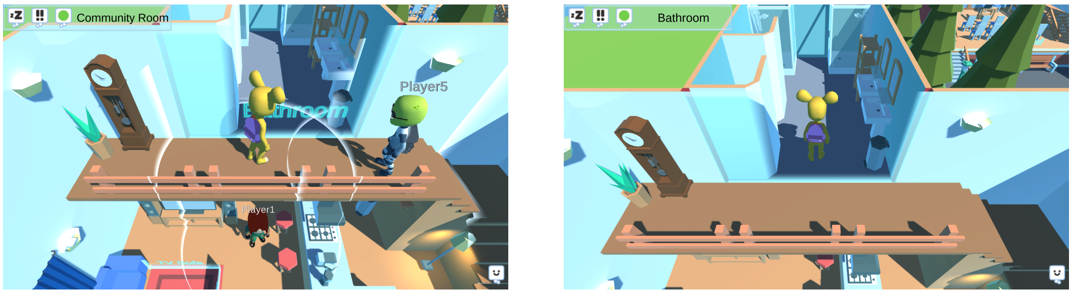
Community Room The room visible in Figure 4.5 directly connects to the entrance hall and quickly be accessed from there. Players can come in and take a look at who may just have finished class. It takes inspiration from Palloff and Pratt (2007), who shifted to creating a community space for members of her course. It is a place to get comfortable with everyone, including the instructor, who is seen as an equal member of the environment (see subsection 3.4.1). Palloff and Pratt (2007, p. 41) also call this room a "virtual cafe" that supports forging social bonds. In the community room people can

Figure 4.4.: The entrance hall of the campus building serves as a traffic hub. From here users can access the community room, backyard plaza, study rooms or go back to the arrival plaza. Source: Virtual Campus App

become aware of each other, connect and create social presence by interaction. There are a couple of couches placed around for students to sit on. Differences in seating capacity give players the choice of how many people they are willing to communicate with. Rouse (2005) stresses that giving choices to the player will keep them engaged and interested in tasks and environments. The room is not designed symmetrically or orderly, but with its own character, just as if students furnished it themselves. Part of the room is occupied by a large corner staircase that leads to a gallery which is one floor above. From there, the camera angle allows a view downwards at students sitting on the couches. Utilizing this height difference offers multiple options to increase the view distance and amount of people that can be observed. This contributes positively to peripheral awareness of others and, in return, to enhanced social presence. Furthermore, there are a couple of interactable objects placed within the room. TV, radio and a mixer can be switched on to emit audio that every player can hear. The lamp can be switched on and off which changes the lighting in the room. These are simple examples that can be used to survey the influence of audio or lighting in a group setting. Any other interaction that can be imagined, such as watching a movie on the virtual TV, is implementable. Lastly, an air hockey table in the middle of the room can be used by two players at the same time and will play air hockey sound effects. Future additions to the community room might include an actually playable game that users can start when interacting with the air hockey table. It could serve as a short distraction in the middle of the break as a way of bonding between students or as a motivation raiser.

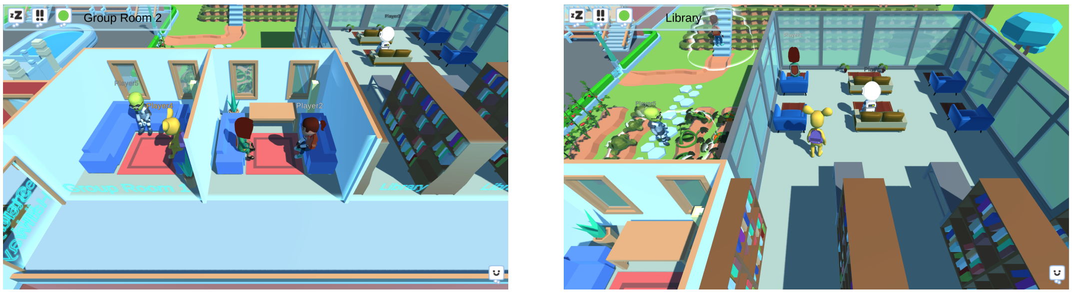
Figure 4.5.: The community room is a place to relax and have casual conversations with other students or teachers. Players can sit down on group couches or switch on TV or radio. Source: Virtual Campus App

Bathroom Having private spaces within schools is a difficult design task according to Tanner (2000). When there are many people around, there usually aren't a lot of places that no one is currently at in the school building. Though the design of each house should provide more clearly separate private and public spaces (Alexander, 1977). Digital solutions to privacy mentioned in section 3.5.2 were bubbles, mechanics that would freeze all other people or only having self-controlled spaces. One of the privacy measures implemented in this virtual world is connected with the bathroom that can be accessed by stairs from the community room (see Figure 4.6). In real-life schools, students might hide inside the bathroom, which is probably the most private place there is. It can usually be found on every floor and is quickly accessible. Yet one can still recognize when others enter the room and might be recognized as well. In the digital bathroom none of that is an issue. When a player enters the room, all other members of the environment will automatically be switched off for the player (see Figure 4.6b). In addition, the player will not be visible nor audible anymore for others until the point of leaving the bathroom. That way students can take time off if they need to, though this does not provide the opportunity to observe others at the same time. This implementation may be better than having players suddenly disappear when they pause the game or even leave to the offline space. It also provides embodiment as it is just another natural routine that has been transferred into the virtual world.



(a) Before entering the bathroom... (b) ... and after

Figure 4.6.: The bathroom is a completely private space where users can go to when they need a break. The bathroom will hide the player from all others' views, but in return also make it impossible for the player to see others. Source: Virtual Campus App



(a) Group study rooms (b) Library

Figure 4.7.: The group rooms serve as collaborative spaces for private discussions or assignments. The library is a place to stay for quietly studying, similar to reality. Source: Virtual Campus App

Group Study Rooms and Library Due to the community room most likely being noisy, the environment also supports a couple of study rooms that are intended for groups and a library for individuals (see Figure 4.7a). The group study rooms support the collaborative practices (see section 3.3) in this virtual study environments. They are designed for four to six people and enable rich group discussions just among the members. These can be used either for breakout rooms, that have become common in video conferencing such as Zoom. Teachers would sometimes want to split learners into smaller groups for group discussions or team projects (Finkelstein, 2006). Overwhelming group size or lack of participation opportunities are further cases (Palloff & Pratt, 2007). These groups can then be allocated in either of these group rooms. For design reasons, it may be simple to copy and paste the same group room multiple times. However, Feil and Scattergood (2005) recommend still differentiating modular rooms by small details like color or a piece of furniture, which has been done for these group rooms. They can also be used for general group meetings that are required during longer self organized projects and are not induced by a teacher. The library on the other hand side offers a silent study space for users to stay at (see Figure 4.7b). The entrance is kept narrow to push players towards the seating area. Its windows are intentionally built large with transparent glass. Users who sit down in order to study are able to see the (virtual) nature outside, which is a key factor for feeling comfortable in regular school environments according to Tanner. He provides evidence that students of schools being "in harmony with nature" (Tanner, 2000, p. 327) scored higher than those of schools without relations to nature. If this does also apply for virtual environments is debatable. Yet, Dillenbourg (2000) emphasizes the positive impact of visuals on motivation to which 3D models of nature surely count. Another impact on motivation could be the presence of students that study along sitting in a different chair. For some students it might be empowering knowing that someone else is also learning hard at the moment. Research has shown, that the presence of others during a well-learned or easy task supports learners' motivation, speed and alertness (Kiesler & Cummings, 2002). Multiple seats generously spaced in the library allow for such a study environment to develop. Finally, important to note is the hallway that connects group rooms, library and entrance hall which is again a space that people are likely to encounter and start communicating.

Figure 4.8.: The backyard plaza directly connects to the lecture hall. From the elevated porch users have a good view at the events on the plaza. Source: Virtual Campus App

Backyard Plaza The backyard plaza serves the same purpose as the main entrance plaza, namely for students to gather and socialize. This time the plaza is within the university grounds and quickly accessible from the lecture hall. As already mentioned, Tanner (2000) deems outdoor learning environments that serve the purpose of relaxation and play as vital for student success. When leaving the entrance hall towards the back, players will be facing the plaza while standing on an elevated porch. This offers another view that makes players able to see more of their environment due to the camera angle (see Figure 4.8). As the plaza is a place where all learners will directly get to after class, looking down from the porch can help orienting and finding friends that might have just had class. Benches spread around the plaza then allow quick group forming around the fountain landmark placed in the middle.

Figure 4.9.: In the lecture hall, students can gather for class and have a seat, while the teacher can give a presentation upfront. Source: Virtual Campus App

Lecture Hall Figure 4.9 shows the virtual classroom that is intended for multiple learners and instructors at the same time. It is located in the back of the university, but on a vertical axis that directly leads from the arrival plaza straight to the lecture hall. It has a central podium inside that teachers can go up to for giving their talk. In total the classroom fits about 20 to 30 people as was the designated amount of users for this world. The chairs for learners are ordered in front, to the sides and to the back of the teacher. Due to the third person perspective, this gives an optimal view at all students for the teacher. In case that someone else might want to present, they can either talk from the audience or step up and easily swap places with the teacher. This is a necessary feature to support constructivist learning concepts in this virtual environment (see subsection 3.4.1).

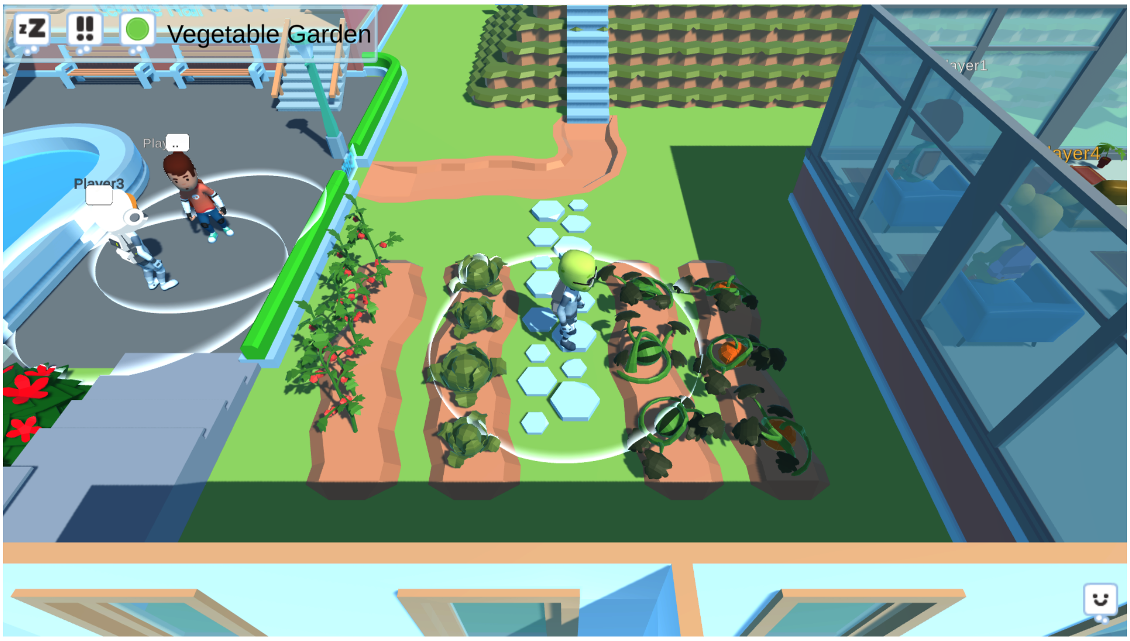


Figure 4.10.: The vegetable garden is an example for how situated learning could look like. Actual interactions and information could be provided about the plants for e.g. biology class. Source: Virtual Campus App

Vegetable Garden and Cliff The vegetable garden and cliff, as seen in Figure 4.10, are examples for further areas that can be included in such a world. While these represent the nature visible from the library, Tanner (2000) notes the positive effect of combining teaching inside with practice related facilities outside. The vegetable garden for example could be a demonstration example for biology classes. Besides, the cliff area invites players to engage in fun exploration of regions they have seen from another perspective before (Rouse, 2005). The window in the library acts like a portal in this case, which lets users from the inside look at the outside and the other way around (Feil & Scattergood, 2005). While the one side might see other players walking by, exploring places, the other side might see deeply concentrated students while studying. Again, this caters towards peripheral awareness and presence in the overall world.

4.1.2. Application Interface

Noteworthy for effects of rooms on players, are few features of the interface provided by the Virtual Campus App. It hosts supporting mechanisms for the notion of social presence. First of all, there is a list of user names that are currently online and the ones that have been online, but went offline (see Figure 4.11a). Finkelstein (2006) calls this list a *presence indicator* whose purpose is showing participation of users. Once a user enters the campus map, their status will be automatically set. Secondly, there are entry and exit announcements when users log on or off (see Figure 4.11c). These announcements, like "Person X joined the campus", bring awareness to the other participants about change in group composition (Finkelstein, 2006). More detail is provided by further announcements that notify about the entering or leaving of users in one's current space. One will not be informed about user actions in other spaces of the map however, as that information does not concern someone who is not in the others' vicinity.

(a) Online Status (b) Settings Menu (c) Notifications Board

Figure 4.11.: The interfaces available support awareness of each other and offer some settings. Source: Virtual Campus App

4.1.3. Camera Perspective

The game space, its structure, models and textures certainly have the largest impact on game visuals. Though a game space will drastically look different depending on the camera angle and setup. Opposed to many VR environments that use a first-person perspective, the Virtual Campus App approaches the setting of VLE differently. It uses a perspective third-person camera that is fixed in rotation and moves along with the players while always facing them. It offers a view from above at the player and their close surroundings. The app can be seen as a compromise between first-person VR worlds with detailed graphics and organized 2D workspace meeting environments like Wonder.me or Teamflow HQ. Dickey (2005a) argues that first-person agents allow stronger embodiment of players within the world. On the contrary, the self-awareness factor missing in first-person view seems to be severe enough for Facebook Spaces to include a selfie-stick just to mitigate this issue (Tauziet, 2017b). Feil and Scattergood (2005) comment on this topic that the positive side of third-person views is that players might care more for the character as they can directly see any actions of the avatar. It is a regular debate amongst designers which of the camera perspectives is more immersive (Palloff & Pratt, 2007). Nevertheless, first person views come with one specific drawback. When looking at the world through the avatar's eyes, the field of view is limited to what lies in front of the avatar. With a perspective closer to a bird's eye, overview of the environment increases. This is especially necessary for awareness of who is close to one's private sphere as well as oneself. In a first-person mode, other users behind one's character cannot be seen and could unwantedly come too close. Still, sticking to a 3D environment keeps the game character of the application and allows deeper immersion than flat 2D applications. Moreover, spatial relationships can be understood more easily as it is not necessary to often rotate the camera. This is improved by a zooming function built into the Virtual Campus App. The camera can zoom towards and away from the player up to a certain point. At its maximum distance it captures even larger areas like the arrival plaza in full and allows players to quickly decide on their next destination. The minimal distance is close enough to comfortably participate looking at a group conversation in detail. Because of the camera setting, a couple of design issues followed for the game space. First of all, due to the angle of the camera, players would be able to hide behind walls. Several solutions that have already been applied in games were considered. One solution could be dismissing walls once it was between player and camera. Though because there are many avatars on the map, all walls would need to be hidden whenever any player was occluded. Otherwise, different users would have the chance to approach people unseen. Another solution included shaders, that would cast a sphere around the player making walls transparent where they touched the sphere. This idea was discarded as well because spaces directly behind walls would have not been usable for environment design anyways. Concluding, the game space was built without walls facing the camera that any walkable path could be hidden behind. This style could be described as a "dollhouse". The second design issue is the camera angle enabling a better view into the distance which becomes especially apparent when height differences are used. A good spot to observe others, that was already mentioned, is the porch towards the backyard plaza. When the players are located higher they can more easily spot friends or other students with similar intentions. Such height differences in locations have been integrated a couple of times e.g. at the bus station or at the library. Generally this improves the awareness of a lively environment and enables a better sense of presence and social presence.

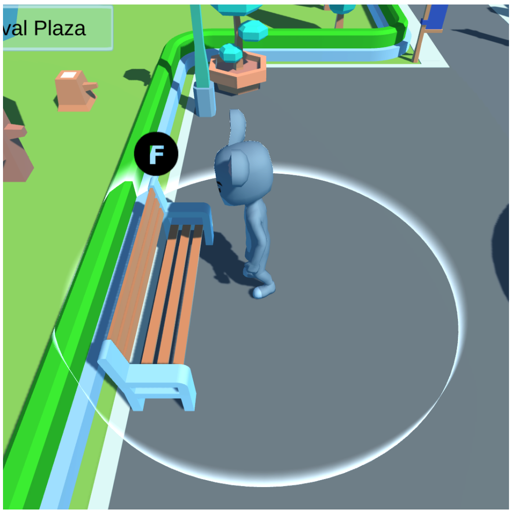
4.1.4. Control Scheme

For successful experiences of games and applications in general that need some sort of input, the controls are crucial. Being comfortable with the technology and its interactions impacts psychological well-being and supports likelihood of participation in online learning classes (Palloff & Pratt, 2007). Right from the start, the control scheme should be easy to figure out. It serves as the interface between the player and the application. Especially using schemes that are similar to those of similar applications can make users feel comfortable (Feil & Scattergood, 2005). As for immersion, Rouse (2005) states that manipulation of virtual objects needs to be as easy to do as manipulation in real-life. Otherwise, there is a high chance of that immersion being destroyed. Buttons need to be understood intuitively, which universally understood icons could be used for. In the Virtual Campus App, there are a couple of interactions implemented. As it may be used by both game-savy and casual users, Rouse (2005) suggests providing multiple ways of achieving the same effect. Players experienced with games might be able to cope with more complex input systems, while casual users will need a control scheme as simple as possible. This includes a small number of keys used which are usually self-explanatory. For character movement the Virtual Campus App allows players to use the 'WASD'-keys or, alternatively, the arrow keys. These are the single most commonly used keys for controlling a character in games due to them already implicitly indicating directions. The 'WASD'-keys are the equivalent to support mouse usage with one's right hand. In comparison, current applications using this movement control scheme are e.g. *Gather.town* and *Teamflow HQ*. Additionally, the Virtual Campus App offers mouse pointer movement for the character. On holding the right button pressed, the player's avatar will walk in the direction of where the mouse pointer is located at. Pointing is a common control usually used in VR environments like *Altspace VR* and *RecRoom* (Kolesnichenko et al., 2019). A potential problem for player movement often seen in games are client side usage of cheats. The Virtual Campus App does validate any movement request first on the host and then sends instructions back to the clients. It is possible though to alter one's position on the client side without trying to move by cheating. This will not change the player's avatar position for other users, but the player might be able to do so locally. This could give insight into positions or even conversations of others, if the system is not robust enough. A critical assessment of potential faults of the app needs to be carried out before field testing.

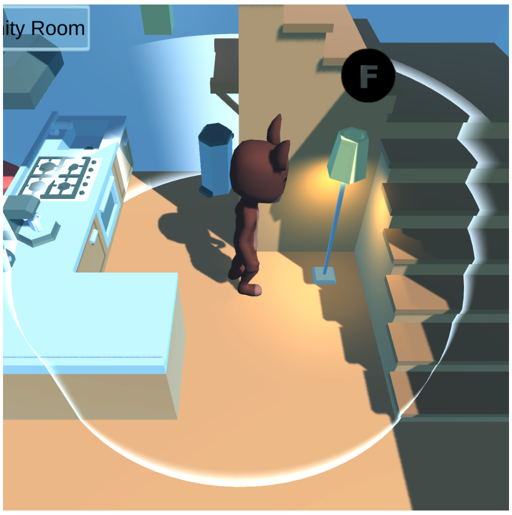
Whenever a character is standing in front of an interactable, an icon clearly indicating the button to press will pop up above the object (see Figure 4.12). The button used for interactions is the 'F' key which is also frequently used in games due to its positioning right next to the 'WASD'-keys. Player positioning in front of an interactable signals all other users around the specific actionpoint. During an interaction, players are also bound to the location and cannot move, which would break the logic of actionpoints. This not only provides peripheral awareness of the user's actions, but can also indicate viewpoints. As a player's avatar moves through the world, it is automatically rotated towards the direction of movement. Users moving towards such an interactable might convey that the person in control is currently also focusing on that object.

A final point noteworthy about controls is the speed at which players move. This has to be in accordance with the size of the environment and should not be too fast or too slow. A player has to be able to properly maneuver around furniture and rooms in the virtual campus (Feil & Scattergood, 2005). Generally, walking would be too slow in the Virtual Campus App, which is why characters rather move in a jogging fashion. The great affordance of virtual worlds is that one could instantly teleport from one space to another, which is impossible in reality. This could save a lot of time, but it comes at the expense of embodiment which is an issue in VR environment (Kolesnichenko et al., 2019). Social interactions, which are at the core of the Virtual Campus App, are not to be neglected as well. If players are simply too quickly passing by, there won't be a chance to socially engage. Most often though, movement in games is regarded as boring and players would like to reach their destinations quickly (Feil & Scattergood, 2005). This indicates a certain impatience that might be developed during phases of simple wayfinding tasks. Sometimes, gamers might tend to release their

(a) Returning home at the bus station



(b) Sitting down on a bench



(c) Switching lights on and off

(d) Playing at the air hockey table

Figure 4.12.: Throughout the campus, there are a variety of interactions available which are indicated by a button icon which pops up when the player is close enough. A button press will engage the player with the interactable and start whichever function it contains. Once the player turns away, the icon will be hidden again. Other interactions that are not shown on the picture include switching on and off radio or TV or sitting down on any other seat. Source: Virtual Campus App

impatience by continuously hitting keys on the keyboard. It has yet to be shown, if the excitement of social engagement around every corner of the campus can oppose impatience or if certain possibilities of player distraction should be included. In any way, the optimal balance of walking speed is an essential factor for user experience in virtual environments.

4.1.5. Audio

A fundamental factor to the overall game experience that should not be neglected is audio. In parallel to the visual channel, it provides users with permanent feedback about their environment or just sets a certain mood. Thus, it enriches the connection and immersion felt in the game (Schell, 2015). According to Rouse (2005) it is an often underused tool that offers so much more information in addition to visuals. It's intentions are allowing intuitive understanding about the game or world one is in. The best audio is one that supports information gain without making the player think about it. There are a couple of ways of auditory feedback included in the Virtual Campus App that attempt to enrich user experience and social presence.

The first noticeable sound effect a user will hear are their own footsteps on the ground. This is an essential effect that any video game normally involves. In a VLE the impact of footsteps on the world gains a whole new dimension of meaning. As players walk around on the campus, they can also hear other players walk around them. The audio is 3D and it can be distinguished from which direction it comes. This helps users locate others within the space and bring peripheral awareness. Even though one might not see another player, one can hear them and notice there existence. This caters towards social presence and might support the building of the sense of "being there together" (Schroeder, 2002, p. 2). Moreover, it is a protective measure that indicates how close someone is to the player. The advantage of 3D audio used in the Virtual Campus App not only includes information about position in space, but also provides a sense of distance. The closer avatars get, the louder the footsteps will become. This could be used as a protective measure against unwanted approaches of players that might be out of sight, but can be heard coming towards the player. Another potential gain is the general notion of people walking by. It makes the space not feel empty and could elicit conversations along the way when players notice their co-presence.

A second type of sound effects being played at the virtual campus is ambient sounds like water noise at the river or at the fountain landmark on the arrival plaza which can be seen in Figure 4.3. These can provide immersion for the player by making the otherwise static environment more lively. Feil and Scattergood (2005) warn that, if overused, sound effects can quickly become disturbing and unwanted. To prevent negative consequences, audio needs to be used subtle and quietly. Notably, players expect similar objects to make sounds alike. The sound effects have to be consistent, yet vary in detail to not become repetitive. It should only provide some background noise that does not interfere with the player's experience unless it is intended to be unexpected or specifically used to address the player. In the Virtual Campus App there are a couple of audio sources that can be switched on by the player themself. These include for example a radio or a TV in the community room. These sounds can be heard by all other users as well and could provide opportunities for consuming e.g. music or talks together in a group. On the contrary, they might also evoke the urge to move somewhere else. If it is noisy in the community room, users might rather want to take a walk outside on either of the plazas. The other way round players might feel calmed by background noises of the fountains and, therefore, move their talks there. Having no sound at all could be a feature of audio as well. In the library there is currently no sound that can be heard besides other users walking in and out. Players might prefer this environment for their studies over a more noisy space. It could still be the case, that some silent background noises like page flipping would improve the attractiveness of this space. Generally speaking, audio affects on campus offer affordances for immersion, group forming or relaxation, but effectiveness has to be evaluated first in the future.

The technical implementation of audio proved to be a minor challenge in the Virtual Campus App. Whereas for first-person virtual worlds like Rec Room or AltspaceVR audio is naturally received at the player position, this does not simply work in a 3D camera perspective view. Usually in game development a point has to be defined at which sounds from the environment are received. When the player is perspectively located within the avatar, receiving audio at the avatars head position works out. In that case anything that the avatar hears e.g. to its left will also be heard from the left by the player. In a third person view the player is not directly located within the avatar's body, however. In the Virtual Campus App, the player's perspective always stays the same, even though the character might turn. If now the avatar were to turn away from an audio source, it would be perceived by the user as if was located behind. However, the user might still see the audio source on the screen in front due to the camera perspective which creates a mismatch between aural and visual perception. Solving this issue, the audio receiver was fixed at the camera position with a matching rotation corresponding to the player's view. Thus, every sound perceived will always be somewhat in front of the user and character rotation will not matter anymore. A resulting problem was that zooming out with the camera distanced the player further from the events in the world. Because of sounds being played in 3D, they would get more silent the further away the player zoomed. This could be used as an immersive feature as the experience of audio does indeed match what the player sees. It was decided against it in the end to keep the audio volume steady at all times and only dependent on positioning. This was achieved by fixing the audio receiver at the closest spot the camera can zoom in on the player. As for the voice chat, 3D audio was disabled and only features a volume change based on distance to the player. This does take away parts of embodiment as audio cannot convey the position other players are talking from in relation to the user. E.g. players being situated on the right side of the avatar will not sound as if it came from the right, but simply be internalized. This leaves the player with less spatial cues about the environment. The probably more important upside though is that there won't be issues of voices coming from the "back" even though one would naturally face conversation partners in real life. If a 3D approach for voice chat was implemented, players located north of another talking member would hear that voice coming from behind, which is unnatural. Facing someone is not possible as the audio receiver is steady, which led to the conclusion to keep 3D audio for voice chat excluded. This would be better suitable for any first-person view application.

4.2. Avatars in the Virtual Campus App

User representation is consistently mentioned throughout the history of virtual worlds (see subsection 3.1.1) and as a defining feature for VLE (see subsection 3.4.3). It is the single-most defining feature for construction of identity through its visuals, the embodiment a player experiences and how present a user is in the world. In the Virtual Campus App every player controls their own avatar which represents them both in the offline and online scene. The avatar is based on a stylized human model that is gender neutral. Its shape cannot be changed by the user, neither can height, nor width. Thus, the base is equal for every player. The players also assign a name to themselves which will be displayed above their head on the virtual campus. All details of the character are expressed by its "skin", a texture that overlays the model. If a player wants to change their looks, they will have to swap the whole skin instead. The avatar configuration screen is located at the user's home map when interacting with the cabinet. There, users can alter their visuals before they enter the online world, which L. A. Annetta and Holmes (2006) suggested. Once they are online, there is no option to change it, as the changes of a full skin might be too drastic at once. In addition, players cannot be seen in the bathroom, which would be the preferred place to try other outfits. Upon becoming visible again, it might not be obvious anymore, who the player is. Besides skins, players are also able to add head accessories and backpacks that allow for representation of personal preferences and identity. All accessories and skins are equally available for everyone and easily swappable by cycling through a list of each. Therefore, users do not need any prior knowledge of 3D design or creation. They can simply select whichever design they enjoy most. This allows users, including casual ones, to quickly "gain a sense of ownership within the world[...]" (Dickey, 2002, p. 10).

4.2.1. Available Design Options

The avatars selection menu offers several design options for the character. First of all, there are skins related to humans, skins related to animals and other skins, like aliens or robots, available. All of those use the same humanoid model and do not differ in functionality. Animals and humans differ slightly in terms of head accessories. Animals can be further equipped with different kind of ears that might define the animal more in detail. The animal skins as such are quite generic, too. They are very differentiable by their bright colors which are the strongest indicator for which kind of animal they are. Some of them could be thought of as mouse, fox or rabbit, but in the end it is up to

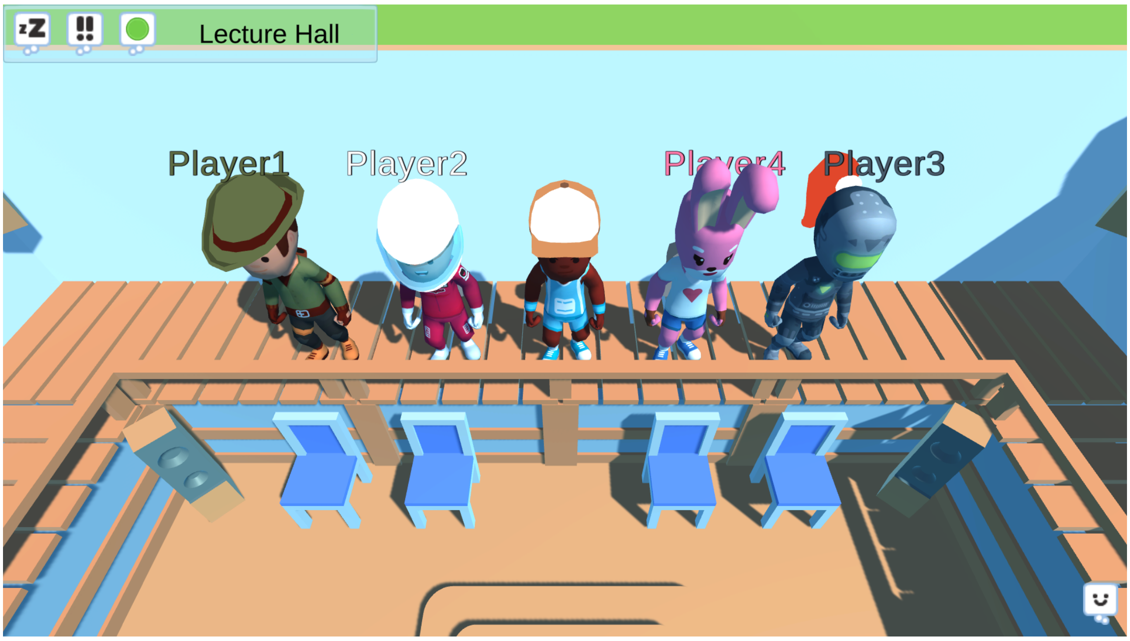


Figure 4.13.: The image shows a variety of avatars that are selectable. Options include the choice between animals or humans, different head accessories and backpacks. Source: Virtual Campus App

the imagination of the user. The animal skins do have facial expressions that sometimes show emotions which underline their anthropomorphic design. Some might also be distinguishable more or less as male or female. Besides basic fur colors, there are also few humanly dressed animals that look like wearing e.g. casual, athlete or race driver clothes. During the development of Facebook Spaces, their team tried similar characters they called *Rabbitars* (Tauziet, 2017a). Tauziet, former lead designer, regarded the rabbit-like avatars as very successful and expressive. Their downside was distinguishability when it came to meeting more than a couple of friends as they only differed in colors. With customization options available for animal skins and accessories in the Virtual Campus App, this issue might be less severe, but it still needs to be looked into. Humans on the contrary come in different faces, skin tones, hair colors and professions. Professions are indicated by the dress of the skin. Some of them are astronaut, athlete, farmer or racer. The faces do have a tendency towards either sex, but each profession is represented by both male and female looking skins most of the time. As with animals, humans have several facial expressions depending on the skin. About head accessory configuration, users can choose from a baseball cap, helmet, beard, glasses, bob-cut hair, ponytail and alike. Any head accessory fits any skin obviously. Finally, all characters can be dressed with a backpack of different types which also includes e.g. sword and shield for a middle-aged skin. All in all, there is no fully distributed and equal spread of skin types, but it could be achieved by creating more assets. In terms of possible combinations, there seem to be fairly enough for everyone to express themselves without overlapping with someone else. The mix of three different options, skin, head accessory and backpack, allows for enough possibilities of dressing (see Figure 4.13).

4.2.2. Potential Design Issues

About issues that need to be addressed, Benford, Bowers, et al. (1995) named performance as critical. With the stylized character models, they are abstracted enough to not be a burden on computing load. Adding few low-polygonal accessories will not make a difference either. Still, there is enough room for self-expression with a wide selection of items available to the user. Skins are distinct and designs clearly recognizable as certain professions or dresses. Due to their looks and animated character, avatars cannot be overlooked in the virtual campus. Locating users in 3D space will always be a rather easy task, as the architectural design made sure that no avatar will ever be occluded. The bright colors and discernable skins contribute to ease of recognition. As for degree of presence, there are several indicators. While players walk an appropriate animation is played, indicating the obvious availability of the user. During interactions, such as switching on the lights, a "touching" animation will represent availability, too. Whenever users are standing still, an idle animation is being played. It is not discernable in that case, whether the user is active or not. The same situation counts when a player is seated and a sitting idle animation is shown. The animations might contribute to presence of player, but hide the actual status of the player. Ways of indicating one's absence have to be self-initiated. There are two major options, one of which is walking to the bathroom which will hide the player automatically. That way, the avatar will not get into the way of others, cannot be addressed or possibly harassed while the user is offline. A second option users have is using a sleep emoji that they can post which will indicate their absence (see subsection 4.4.3). In video games it is common practice to send a text message indicating that the player will shortly be "away from keyboard". The sleep emoji can be regarded as an equal method to do so. Though a more embodied way of showing availability would be full character animations. This is, in fact, easily achievable and only needs more assets to be created. Facial animations could not be included because of the technical nature of avatars. The same skin texture would have to be reproduced with different faces for each expression. This is possible, but more generic approaches are preferable like separating face and body textures. Conclusive it can be said that the avatar design options allow for various expressions of self in any situation. Falloon (2009) proposed fitting the avatar's outfit and looks to the topic of study. Available designs make this idea already possible and further visual changes are only up to asset creation. If the freedoms of avatar customization suffices for virtual campus members has yet to be evaluated.

4.3. Proximity and Private Space of Users

Due to the special focus on privacy and the intention to offer a better spatial distribution of players, the Virtual Campus App employs means to protect one's proximity and private sphere. As in the introduction preliminarily explained, proximity defines a distance between users on which basis they are able to communicate. Proximity is actually a term stemming from physical circumstances as opposed to virtual ones. Kiesler and Cummings (2002, p. 58) define it as "the physical distance between people measure in units such as inches, meters, or miles". It is used as a term that helps describing the closeness and cohesiveness of work groups and can mean anything from hallways separating the group members, amount of different working sites or a distance of coworkers from the headquarter of a company. The virtual proximity on the other hand side might be more about how users perceive their closeness in a spatially distributed work environment, say Kiesler and Cummings. Generally, close proximity has been found to have positive impact on relationships and group interaction (Kiesler & Cummings, 2002). These parallels do remind of the sense of social presence within VLE. The new approach that can be found in current technologies is transposing a representation of proximity into the virtual world. In comparison to a simply perceived closeness, it visualizes or renders audible the distance to others. Its affordances are manifold. In one example using a proximity based voice chat in first-person shooters enabled multiple improvements (Gibbs et al., 2006). Instead of employing a team wide voice chat, only players in close vicinity were able to hear their teammates in a voice-over-IP system by Gibbs et al. This alleviated cross-talk of team members who were not involved in current actions by the user anyways. Proximity served as a filter to unnecessary information. Moreover, it enhanced the realism of the game as close enemies were similarly able to hear and spy on a teams conversation. On top, players would stick together more closely during a match as they could not communicate from further away. The result was improved collaborational engagement and deeper player experience. Another early example by Viegas and Donath (1999) utilized proximity for visualizing text chat groups on a 2D plane which looks like a spiritual predecessor of Wonder.me. It tried providing structure to long and confusing message exchanges of multiple users that were displayed vertically in order. Viegas and Donath found their concept to intuitively divide groups into smaller subsets of conversations. It allowed users to filter important contributions regarding their current conversational topic while still maintaining overview of activities in the rest of the chat environment.

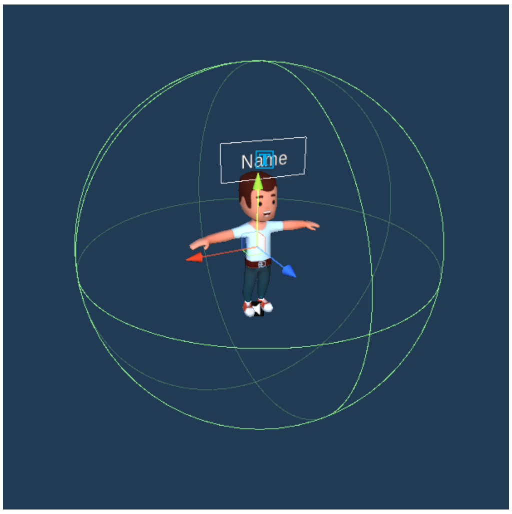
4.3.1. Proximity Circle as Foundation for Communication

After having seen possible advantages of proximity in applications, the question arises, how proximity can be implemented in a VLE that also includes a visual indicator for distance. First, the calculation of distance needs to be determined. In a virtual environment these are measurements in virtual space that refer to units on the world coordinate system (Benford & Fahlén, 1993). Dickey (2002) thinks of proximity as everything that can be seen by the user in a first-person environment. Due to the camera perspective of the Virtual Campus App sometimes providing views of users very far away, this is not a viable approach however. If proximity is about communication, it would not make sense to talk to people who are in a different room. One also has to keep in mind, that some spaces like the arrival plaza are large enough to allow bigger group conversations. Whereas indoors, spaces like the community room might not have enough space to fit those. The character size plays a role as well as large characters would also need larger circles. Wadley et al. (2014) further detected specific issues in SL. With the camera being freely rotatable, it was impossible to estimate distances and audibility of others. All in all the proximity heavily depends on the individual VLE that is being used.

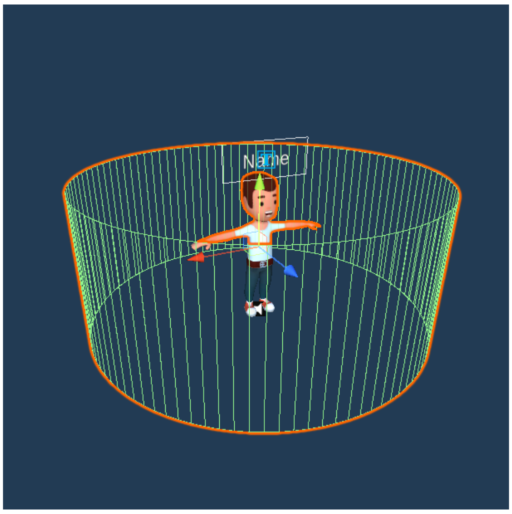
Figure 4.14.: This bird's eye view demonstrates the proximity relations. Each player is surrounded by their proximity circle in white. Players yellow and brown are in each other's proximity, while players pink and grey do not share any proximity. Source: Virtual Campus App in Unity Editor

The virtual campus map employs two different implementations of proximity. First is a discrete approach that separates all rooms and plazas into their own spaces. Thus, a player can always only be member of exactly one space at a time like the lecture hall or the library. Each discrete space then defines a rule set of communications that can be used within that space. The second instance of proximity is a circle around the player that visually defines the close vicinity. Benford and Fahlén (1993) called this the *aura* of an object which determines a subspace that enables interaction. In fact, Benford states that the visual aura and the aural aura can differ as players might see others before they can hear them. The proximity circle can therefore be assumed to be the communication aura for text and voice chat. Within the circle, players can communicate with each other while players who are outside can not. The circle border is indicated on the floor around every player and moves along when the player moves. It also intersects objects and its extents will always be visible. By being circular this privacy circle covers each direction around the player equally. It will be explicitly visible when a player enters one's private circle as they have to cross the circle line (see Figure 4.14). This provides feedback and immediate visual awareness about who can be talked to and who can not. A setup alike is used for example by *Teamflow HQ* in a 2D environment. The proximity circle in the Virtual Campus App is also subject to influence by the discrete spaces. There are few exceptional rooms that do not provide a continuous proximity feature. Logically, group study rooms that are made to only fit four or five people will be closed environments in itself. Once a player enters, all other users within the small space will be audible equally. Similarly, couches that are intended for groups in the community room are individual spaces themselves and do not need a continuous proximity feature. The circle mainly gets into play in the larger environments like the plazas outside of the learner building. In order to start a private conversation, users need to come closer and enter each other's circle. A characters's proximity can be seen by others who will have to keep in mind these boundaries. In the Virtual Campus App, movement is continuous and distances are not fixed values. Therefore, the initial setup of a good circle radius is rather difficult. On the virtual campus, the avatars' minimum radius setup is about one character arm-span. This allows one more user to comfortably fit into the radius on either side of the player. For larger group settings or situations in which more space is available, each player can increase their radius manually by a slider (see Figure 4.11b). This change is reflected for all other players instantaneously as well. Depending on the user, they might want to adjust their proximity circle themself for different reasons. It is a matter of privacy who one wants to talk to and how open one would like to set their boundaries. For more extroverted users a larger radius could be appropriate while introverted users are able to keep their circle small.

Regarding the technical solution of the privacy circle, the first strategy was using a sphere collider centered on the players (see Figure 4.15a). The development engine would then recognize collisions between a player's model and other privacy spheres. A problem due to the geometrical shape of spheres became imminent when the ability to change one's radius was introduced. When modifying the sphere's radius it extends further into all three world coordinate directions. Now if a player was located on a higher floor, e.g. on the veranda of the community room, the privacy sphere would sometimes reach players on the floor below. This allowed communication between different floors, which is not intended. Replacing the sphere with a cylinder mesh that allows scaling in two dimensions solved the problem (see Figure 4.15b). The radius of the cylinder can be modified separately from its height and elicits the desired effect in 3D equal to changing a circle's radius in 2D. The height of the cylinder was set to match the avatar's height so that collisions would reliably be recognized by the system.



(a) Using a sphere vs...



(b) ... using a cylinder

Figure 4.15.: Looking at both volumes from the same perspective it becomes apparent, that the sphere is not a viable solution. While cylinder and sphere share the same radius, the sphere extends far above and below the player. The cylinder is set to match the avatar's height. Source: Virtual Campus App in Unity Editor

4.3.2. Protecting Personal Space

As Kolesnichenko et al. (2019) outlined, many current applications use means of protection for users. In fact, close proximity can also have negative influence in reality. People are only comfortable with others to the degree that they know each other. When someone gets too close either physically or personally people will feel very uncomfortable most of the time (Kiesler & Cummings, 2002). Avatars are already one layer of protection, but when the sense of presence is high enough, people might still feel infringed about their personal space. Especially in first-person environments this could be the case. When players feel embodied in their characters, looking at the world through the avatar's eyes, other users coming too close will block large parts of the view. A designer interviewed by Kolesnichenko et al. (2019) argued that hugging, which requires two avatars to come really close, could be very discomforting to the player even in virtual space. Even though the Virtual Campus App offers a slightly more distanced view on the world, similar issues regarding the personal space might arise. Characters in the Virtual Campus App can walk anywhere as long as they stay on paths. This includes standing in the exact same position as others which might be a cause of overcrowding or possibly intentional. The result might be blocking other user's view of their character. With slightly different positioning avatars can also clip into each other and lead to an unpleasant knot of models. This is both unrealistic and disturbing and could even cause a disruption to immersion experienced by users. If these actions are done deliberately in order to bother another member of the world, then this can be called cyber-bullying (Ballard & Welch, 2015). Often, this issue is elevated by the anonymity online according to Ballard and Welch. This type of bullying is not exclusive to such visual manners, but mostly more prevalent in communication through text or voice. A barrier against direct attacks through voice and text is the implemented proximity circle. It might not stop users from approaching, but it is a first indicator for someone's privacy.

Figure 4.16.: If another avatar gets too close to the user, the avatar will be hidden partly to prevent model overlap, visual clutter and protect private space. In this case, Player3 will still see their character, while the yellow character is transparent instead. Source: Virtual Campus App

Regarding the close personal space, two implementations were considered. A first possible solution are colliders that are also used for the proximity circle. The circle itself can be penetrated, usually though colliders prevent two objects from entering one another (Feil & Scattergood, 2005). Hence, characters could receive a collider that would enclose the avatar model and circumvent models from clipping. Subsequently avatars would not be able to come closer than their colliders allowed them to. This would also eliminate full occlusion of characters due to the camera angle. The downside to this approach is that space shrinks due to more objects that cannot be walked through. Paths would need to be designed wider to accommodate more users at the same time. Albeit its potential increase of awareness, that one should not walk into others, it opens possibilities for a different kind of bullying. Players would then be able to block paths altogether and not let other users pass. This is a general issue present in some MMORPGs. Players have been complaining for example in forums that mountable creatures with colliders were so large that they would block access to important *non-*

playable characters (NPCs). Another solution proposed by Schell (2015) is allowing players to push each other away. First of all this is counterproductive as pushing does not seem to be a socially friendly way of engaging. And secondly, Schell admitted that it can be taken advantage of by shoving players to completely different locations. Whether intentional bullying or not, remedies would need to be implemented as well in the Virtual Campus App. The second variant that was also deployed for Facebook Spaces (Tauziet, 2017b) and Rec Room (Kolesnichenko et al., 2019) changes a character's opacity and makes it translucent. It still uses colliders in the Virtual Campus App, but, similarly to the proximity circle, it only detects collisions. Once an avatar gets too close and is about to touch the user's character, the other body will become half invisible (see Figure 4.16). Equally, the user's character will become transparent for the other player. One's own character will always stay fully visible to oneself, maintaining immersion and presence. That way, visual clutter is prevented and players can freely move around and feel comfortable in their personal space.

4.4. Channels of Interaction

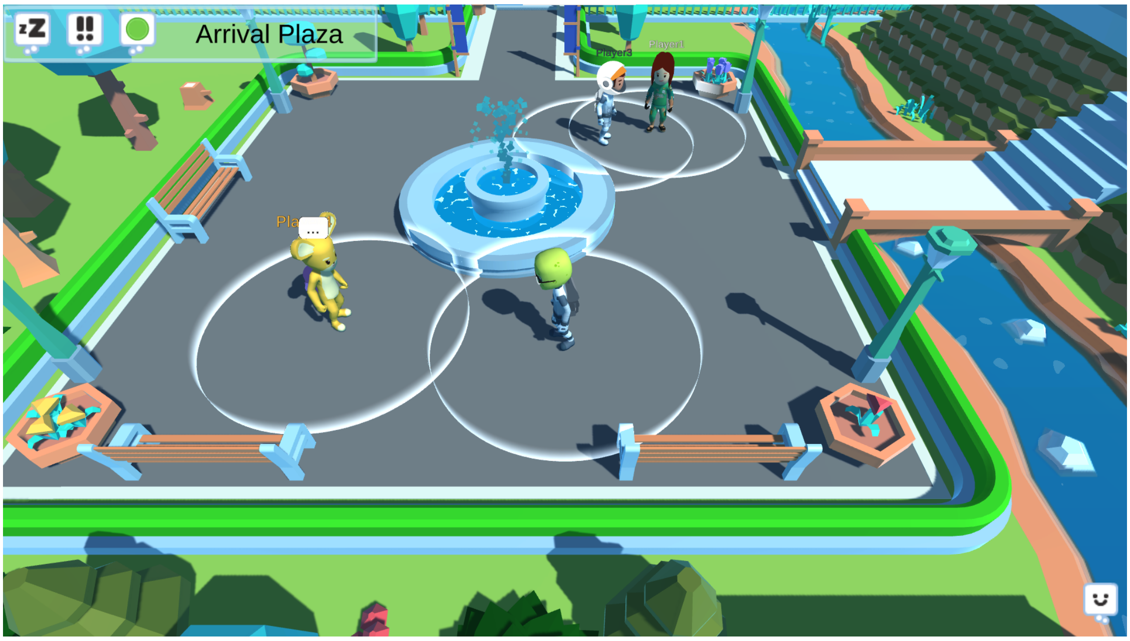
One key factor for facilitating a community in the online VLE is the *people* that the community is comprised of. The foundation for communicating with people in the Virtual Campus App, namely the proximity system, has already been discussed above. The interaction and communication between the users are the driving reasons for collaborational success (Palloff & Pratt, 2007). Before interaction can take place, instructors should utilize the channels provided to set up guidelines about netiquette in advance. In addition, it is necessary to teach users about the importance of not sharing their personal data. While interactions in a VLE are mostly not private, groups can establish their own rules together which helps promoting a safe and secure community (Palloff & Pratt, 2007). Only then a safe chat environment can be guaranteed. The Virtual Campus App offers multiple forms of communication for players, which include textual, verbal and emoji-based messaging besides character animation. These channels of communication, which are based on every player's proximity, are explained in detail in the following sections.

4.4.1. Text Chat

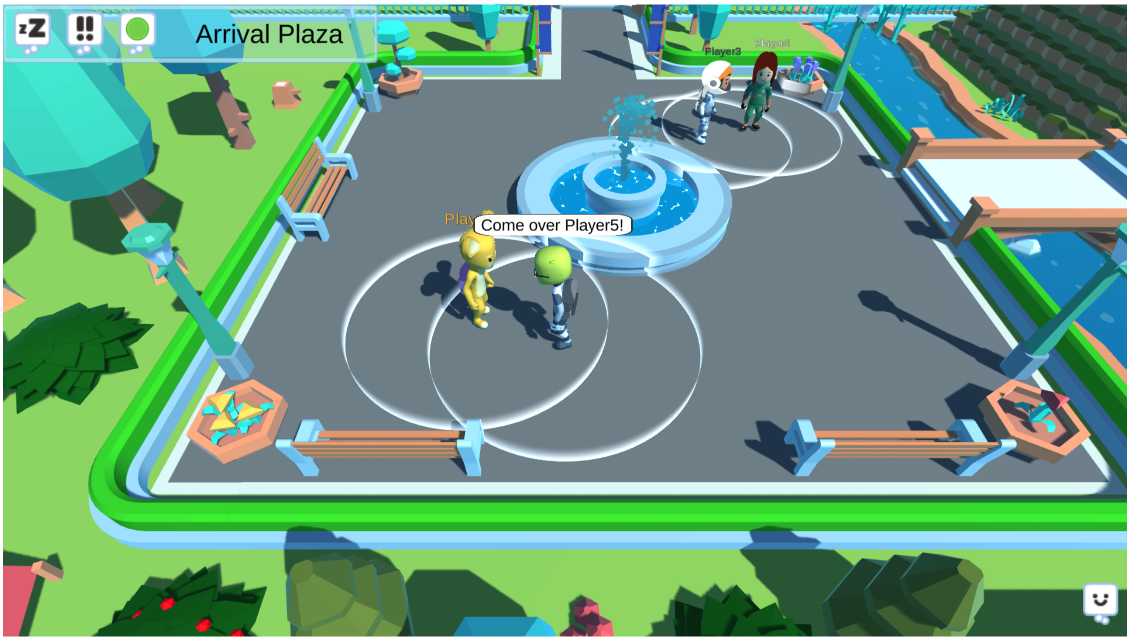
Based on the proximity feature in the Virtual Campus App, text chat enables users to communicate by exchanging text messages while meeting online. In his definition of virtual worlds, Bell (2008) describes avatars as the representatives of actions by the user. He emphasized, that even forms of communication can be presented as if it was the avatar talking. Taking this aspect quite literally, the Virtual Campus App neglects the usage of chat boards and uses speech bubbles as visual indicators instead. Whenever the user sends a message, it will pop up above their head in a frame that other users around can see. This embodies the player within their character which acts and communicates in place of the player. The speech bubble represents anything the player might have said in reality. Any message will stay active until a new message is posted or until the player moves their character. This gives users enough time to read and reply with an answer. Once a new message is posted, it will replace and delete the old one to keep visual clutter low. It is necessary to watch out for overlaps of messages, if avatars stand too close to each other. Then, a text message might be regarded as belonging to someone else. There is still a need for better visual indicators of message ownership in the future. Besides, having messages replaced entails the issue that it is difficult to prove any conversation that occurred between members. In case of inappropriate comments, the only option is reporting to the instructor. This makes it even more important to set up guidelines for social intercourse ahead of time. Dieker et al. (2013) argue in favor of an ongoing data collection about attendance or chat saving for course improvement, which is way easier than in a real-life setting. One has to mind boundaries of privacy though that need to be kept, which is why the Virtual Campus App does not offer any data saving yet.

The text message type is split into three different channels, which is a concept well established in MMORPGs (Chen, 2008; Dickey, 2011b). Depending on a chosen range, the message can either only be seen locally within the proximity of the author, which will be called *proximity chat* from here on. When a player is outside of the proximity circle of another player who has just sent a message, a *speech line* bubble will be shown instead (see section 3.5.2). Only players who are inside the proximity circle at the point where the message is sent can receive and read it (see Figure 4.17b). Upon leaving, the message will become unreadable and change into a dotted line (Figure 4.17a). By displaying "unreadable" messages, a player is confronted with an indicator for the activity of others. Viegas and Donath (1999) elaborate that the proximity metaphor is equal to someone entering a party. The person can not listen to every ongoing conversation, but senses the activity around. Even if it might just be within the peripheral awareness of the user, it can still support the notion of social presence within the virtual environment. On the other hand side, proximity chat keeps private messages to players themself and limits people who are not member of that conversation from listening. Compared to a confusing global chat that has many users typing messages in, it is a filter for the conversations that the user is actively participating in. A downside to proximity chat is that one can only talk to people who are around. This might, however, make setting up appointments with friends at locations on the virtual campus necessary, which could lead to better spatial knowledge and immersion.

Players also have the option to post their message visible for everyone within the room/space, which will be called *space chat* (see Figure 4.18). The space chat messages are indicated by differently colored speech bubbles. They cover two intentions, one of which is supporting group and friend finding when a user is not yet member of a conversation. For example, when players all arrive at the arrival plaza and gather, they can post their interests or questions while waiting for class. Other players will notice the message and approach that user if they want to talk about the topic or can help out.



(a) Before entering a player's proximity...



(b) ... and after

Figure 4.17.: When a user posts a proximity chat message, it is unreadable for players outside the circle. Once the user enters that circle, the message becomes readable and conversations can start. Source: Virtual Campus App

Thus, it is like starting a forum entry with a headline that people who are interested in can reply to and enter the conversation. This is a potential method for causing group formation based on the players' interests. As textual communication entails more anonymity, it might also be easier to post a space message than approaching everyone around one by one (Palloff & Pratt, 2007). The second idea of space chats is exclusively the case for the lecture hall, group study rooms or couch corners. Upon entering either of those, the proximity circle and chat will be fully switched off. The latter two cases have already been explained before, they do not need a proximity chat. The lecture hall on the other hand side tries to limit conversations with neighbours, but allows textual participation in class. While the teacher gives a talk through the voice channel, students can synchronously ask questions through the text channel. The messages will be displayed above the students heads and remain until the teacher addresses them. In addition, learners could send textual reactions that do not interrupt the vocal channel. Another advantage of limiting users in certain situations in their ways of communication can be imagined with the following example. Once a lecture is over, students will leave the lecture hall and enter the backyard plaza. It could happen, that accrued urge for conversation leads to instant group forming at the plaza where proximity chat is allowed. As students are able to have private talks again, they might do so right after class.

Figure 4.18.: In order to attract attention and get into conversation, in some areas there is the option to post a message visible for everyone within that space. In this case, Players one, three and four can read the message in the blue bubble. Source: Virtual Campus App

Finally, there is an option to send a message to everyone currently online, which equals a *broadcast*. Participants are not allowed to use every type of chat anytime. It depends on restrictions inhibited by the spaces, as touched on earlier (see subsection 4.1.1), and permissions set for each player. Broadcasts for example are generally only allowed for the host of the online world which should be the teacher in most of the cases. "Broadcasting [...] is a one-way channel of communication" (Finkelstein, 2006, p. 37) that supports e.g. announcements of the teacher for a lesson starting soon. Due to the teacher's avatar not always being visible for everyone, that message is delivered to users in a global notification board.

A downside to text chat in general, but mostly depending on the platform, is the limited character length for messages (Dickey, 2003). Discussions can become complicated when users have to send multiple messages to convey their opinion. The listeners might not be able to follow, as previous messages are deleted in the Virtual Campus App. Baker et al. (2009) mention general delay in typing comments and responses, too. Multiple conversations at the same time are not possible either, as there are no threads that act more asynchronously (Dickey, 2003). More in-depth synchronous communication should thus be better carried out with the built in voice chat.

4.4.2. Voice Chat

Besides being able to see each other in shape of their avatar, L. A. Annetta and Holmes (2006) posit that students need to hear others too for engagement in the learning process. Compared to textual conversation it can project more information on a player's identity, leading to a more sociable play experience (Wadley et al., 2014). Wadley et al. do acknowledge though the issues of voice not scaling well with larger group sizes and voice being received by the wrong recipients. Therefore, the Virtual Campus App provides a voice chat coupled with the proximity feature to circumvent these problems. The app implements a version of the open source voice chat application *Mumble* which requires the host to install a voice server onto their computer. Alternatively it can also be hosted on an external server. The way how proximity is designed in the Virtual Campus App allows one voice sub-channel for each discrete space in the world. That means there is one sub-channel for the library, community room, lecture hall etc. Whenever a player changes rooms or space, they actually also automatically change the voice channel. The entering and exiting of rooms is accompanied by a "swoosh" sound effect giving auditory feedback that the player just changed rooms, and as a result, audio channels. Usually users of voice chat applications like *Discord* need to manually switch channels by clicking on the respective one in a list. The Virtual Campus App however visualizes this process to a point where it becomes natural and might not even be recognized as such anymore. These channels serve as an organizational mechanism and allow players in spaces, which do not have proximity chat enabled, to freely talk. For example in any group study room users will be located on the specific room's channel and clearly hear each other. By using the space chat feature, the lecture hall provides an advantage over real-life situations. Each and every user will be able to clearly hear one another, event though they might be spaced at the opposite sides of the room. Once proximity chat is enabled, e.g. at the plazas, the voice output volume is regulated by the app and only players within a user's proximity will be audible to that particular user. Herein the volume is once more regulated to fade from zero to maximum depending on the distance within the proximity circle to the particular user. At the border, a player will be almost not audible, whereas at a distance of half the radius the player will be fully audible. This is reminiscent of how sound waves travel in air and lose strength along the way. It provides not only visual feedback for the distance to the player, but also audible feedback for how close a player is and might contribute to immersion. When an avatar leaves one's proximity, the volume of that player is again set to zero. Space chat is not available for voice outside of the dedicated rooms though. As e.g. the arrival plaza is one single voice channel on its own, the combination of proximity voice chat and space voice chat would not work. If someone used the space voice chat, everyone could hear it, even though they might not want to. By the design of the voice channel system one would have to search for a different solution. Lastly, an important feature included are muting options for oneself. A player might have situations in which they don not want to actively participate in voice chatting or can not. The microphone can be switched off in the HUD and will be indicated by a red icon above one's avatar's head for all other world members (see Figure 4.19). A blocking or muting option for others has not yet been included, but considering the safety of users, been determined valuable for future enhancements.

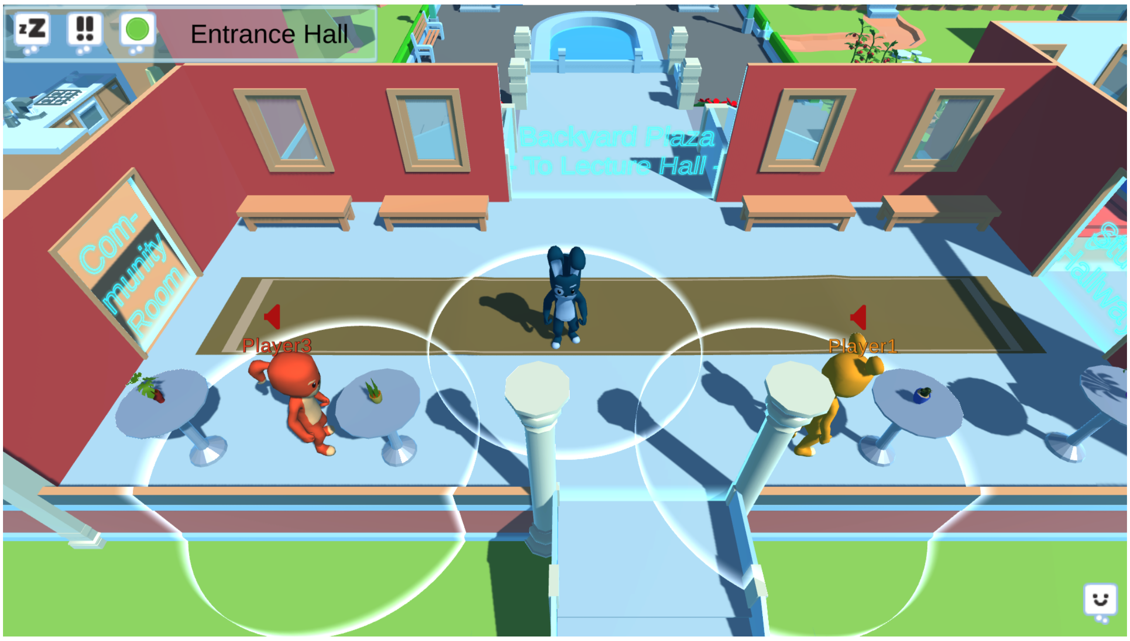
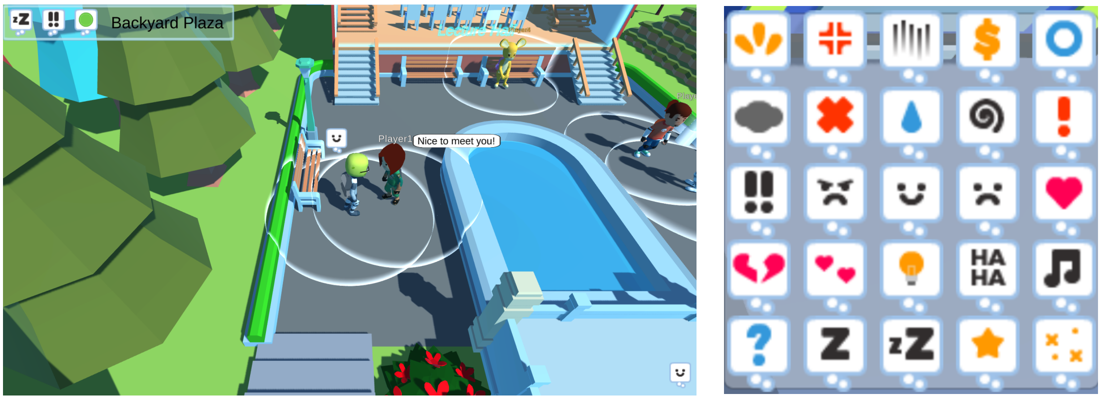


Figure 4.19.: Player1 and Player3 are currently muted which means their microphone is switched off. Even though someone might enter their proximity, they cannot be heard. Source: Virtual Campus App

4.4.3. Emojis

Section 3.5.2 talked about how in VLEs it is of great profit using non-verbal communication embodied by the avatar. A tool in real life useful to get people feel closer to each other is *immediacy* (Finkelstein, 2006). This contains interactions like facial expression, eye contact, tone of voice or gestures, so Finkelstein says. One way of employing these types of body language virtually are emojis. They can support communication of a user's mood, tone or give more depth of meaning to a statement. They have been incorporated into the virtual campus map mainly due to the technical difficulty of facial animations in relation to available assets, but also for their variety of expressions that do not necessarily relate to countenance.



(a) Emoji usage during a conversation (b) Emoji selection

Figure 4.20.: The emoji selection can be opened by clicking on the small emoji face at the bottom right corner of the screen and contains 25 different emojis for expressing emotions. Source: Virtual Campus App

Emojis in the virtual campus map work very similar to regular text chat bubbles. The selection of emojis can be accessed in the main HUD quickly and at any time (see Figure 4.20). When posting an emoji, it will be displayed above an avatar's head as well. It also features a thought bubble shaped frame that seems to be coming directly from the character, embodying the player in it. Equal to text-chat bubbles, an emoji bubble will be replaced once a new emoji is posted. As for expressions, there is a variety available that tries to cover many usage applications. These icons compare to ones used in previous applications and can give an intuitive understanding of their meaning (Rouse, 2005). It is important to mention that the selection however might not be universally understandable, as emojis can differ greatly from country to country (Moore, 2003). These icons can support various situations throughout the course of an online session (see Figure 4.21). In order to start a conversation or attract other members of the world, emojis could be posted by using the space chat feature similar to how can be done with text chat. During a regular text-based or voice-based conversation with someone else emojis might be used to express one's feeling more clearly. For such cases there are "sad face", "happy face", "angry face", "heart", "laughter" etc. included. For indicating inactivity, icons like a visualization of snoring sounds or "starry sky" can be used. Most interesting is a setting during class where all students sit next to each other. In reality a teacher draws on facial expressions and gestures of students, e.g. when a student raises their hand. As virtual interactions with the teacher are most likely carried out through the voice channel, the textual channel and non-verbal channel remain unused. Without disturbing the teacher, learners can post a "question mark" emoji that will appear above their head. This could indicate that the learner has a question they want the teacher to react to. Consequently the teacher can let the student ask their question publicly by voice. An "exclamation mark" emoji could indicate that a learner would like to comment on the current topic. Similarly, the "light bulb" could indicate that a student knows the answer to a question. With the setup of the lecture hall, an instructor standing on the podium is able to see all learners around. It will be easy to spot any emoji that was posted while not being majorly disturbed. Instead, students could also post their questions instantaneously, but it might be more distracting for the teacher to read a post while talking. Understanding a simple meaning of an icon could however be done concurrently. Further possible applications are quick polls that require "yes" or "no" answers. Every student can respond simultaneously with an emoji which offers an overview about the poll result for the teacher. In the end the designer gives tools to the users, but the opportunities for their use are manifold. The culture that develops within the virtual environment will determine over time how to apply these possibilities (Dillenbourg, 2000).

(a) Teachers asking...

(b) ... and students indicating an answer

Figure 4.21.: Emojis can be used flexibly during class to indicate questions, the wish to talk, to participate in polls, to express emotions about the topic and more. Source: Virtual Campus App

5. Discussion

The Virtual Campus App is a 3D VLE that explores concepts of better social communication incorporating a proximity system. The initial idea stems from the lack of social interaction before and after class in other VLEs (Rapanta et al., 2020). By focusing on spatial mechanics of the virtual world, the Virtual Campus App tries to leverage its space to the advantage of social discourse. It does not try to be a wholesome learning platform, but it shows potential for more embodied engagements with each other and the environment. It also offers more game-like graphics for the environment and avatars to foster motivation of players. The initial premise was the development of a 3D application that offered all features of virtual worlds. As such, the Virtual Campus App is a desktop application that can be played on the internet with multiple players at the same time and suffices the definition of Dickey (2003) (see subsection 3.1.2). Bell (2008) defined further aspects of virtual worlds against which the Virtual Campus App will be compared with in the following paragraphs (Bell, 2008). Affordances and limitations of the prototype will be highlighted.

5.1. Matching the Features of Virtual Worlds

The Virtual Campus App offers *synchronous* communication between users via multiple channels, such as text, voice and non-verbal interaction. Text messages or emojis can be posted and will instantly be visible for other members of the world. Voice chat is also executed on a voice chat server that allows live talks wherever the user is on the virtual campus. In contrast to many other current proximity applications, like Gather.town or Teamflow HQ, the app omits video chat. This might, however, come in favor of privacy and well-being of the user. Recently, multiple studies have detected the negative impact of video-conferencing tools, such as Zoom, especially on women (Campbell et al., 2019; Fauville et al., 2021). Some participants of a study conducted by Yoshimura and Borst (2020) preferred the interaction with avatars and not having to be seen on camera. Even though these studies focused mainly on VR applications, their positive outcomes of increased user engagement and sense of presence through the use of avatars is backing the choice of neglecting video chat (Campbell et al., 2019; Yoshimura & Borst, 2020).

The Virtual Campus App is, first and foremost, also a multiplayer experience that can be played on the internet with anyone. Therefore, it fulfills the requirement of being *facilitated by networked computers*. This feature qualifies the app for two other key features of virtual worlds. Virtual worlds are *persistent* and actions within them affect the environment which is reflected for every user. Actions in the Virtual Campus App have direct influences on what others see, too. Players can change their clothing, and will appear differently afterwards, or are able to switch on music in the community room, which everyone else can hear. Nevertheless, the Virtual Campus App is usually only hosted temporarily by the teacher and will, thus, not persist without interruptions. This bears the advantage that only users knowing the teachers' address and class time frame will be able to join. Moreover, less technical resources are needed for maintaining the world. The role of the teacher in this scenario is a very crucial one. In constructivism, the teacher takes on a moderating purpose and facilitates the communication among learners. Palloff and Pratt (2007, p. 22) describes teachers in such a setting as mediators or, more fittingly, "playground monitors" who support the learning process in the VLE, but always stay on an equal level to students. In the Virtual Campus App the teacher also acts as a guide who regulates the environment. A possible alternative to hosting oneself is running the world permanently on a dedicated server. This is the approach chosen by many VR applications like Rec Room or AltspaceVR. That makes them fully persistent as they are always online, but it comes with the downside that they need to deploy dedicated moderators that regulate in-world interactions (Kolesnichenko et al., 2019). For a smaller university internal world, providing a server by the learning institution itself could offer more flexibility and security than hosting the server at a third-party company. This is especially important as crucial information like names of students and conversations are transmitted to the server (Palloff & Pratt, 2007). The Virtual Campus App is not yet designed for such an operational mode, but it can be adapted easily to support constant operation on servers.

Through the provided methods of interaction, the Virtual Campus App is also a platform for a *network of people* that, together, constitute the *social space*. The interactions can occur between anyone online, between students and students or teacher and students. But the app is not restricted to an educational context only. Other application areas include friend group or club meetings, work environments or large conferences. Even though the setting changes, the basic discourse and collaboration stay the same. This is what drives the community and contributes to the success of the group (Palloff & Pratt, 2007). The second important factor influencing the social space is how strongly users can feel *socially present*. This sense is, in addition to verbal communication, dependent on the ability to express oneself with non-verbal cues (Short et al., 1976). Virtually, these cues are often indicated by facial expressions, gestures or emojis (Kolesnichenko et al., 2019). The Virtual Campus App utilizes all of these features to certain extent. First of all, during avatar creation, players have the option to choose skins with explicit facial expressions. Some of the available avatars look happy, angry or relaxed and can indicate someone's current mood to other players. For more spontaneous self-expression, the app offers various emojis that function as a strong non-verbal cue for "emotions, expressions, feelings, greeting, blessings, and appreciation" (Zhou et al., 2017, p. 751). As indicated in subsection 4.4.3, the app already supports emojis for a wide selection of usage scenarios. Especially during the Covid-19 pandemic, emojis have gained more popularity in the educational context. Special applications like *Bitmoji* or *EmojiMe* offer ways of creating emojis that are generated from a selfie. The result is very much similar to a picture of an avatar expressing emotions, which can then be sent to teacher or students. The usage of these emojis is deemed to enhance personal feedback and conveying of expressions (Kuklinski-Rhee, 2021; Nölte, 2021).

When emojis are used in the Virtual Campus App, they are visible to the other members of the conversation within the proximity. Thus, the impact radius of an emoji is limited by the proximity circle, unless the user makes their post available in the current space chat. This is rather unlikely, as a player in a private conversation will probably use the proximity chat instead. In order to further improve the sense of social presence, two possible methods come to mind. By increasing the players' proximity circle, more emojis and reactions could be picked up by the player. This might lead to the unintended downside however, that more private chats will be readable. On the other hand, Viegas and Donath (1999) mentioned a situation that can give clues for a solution to this problem. They described a party where a person will naturally recognize activity all throughout the room, but not necessarily understand conversations that are further away. It can be inferred, that emotions expressed by emojis might not have to be limited to the proximity circle, but rather noticeable in the whole room or space. Similarly, walk or interaction animations of other avatars are already visible anytime. This seems more natural and could support general awareness of people. In that case, e.g. players who gathered on the main plaza could see emotions of members of other groups, but not their actual conversations.

In regard to conversations, it is also of interest, how the players will position themselves within the space while talking. Dillenbourg (2000) considered movements and orientation in space, which are also non-verbal cues, as even more important than direct messages. In subsection 4.1.5 the issue of locating voice chat audio was already addressed by removing any 3D functionalities. This comes with the consequence, that avatar orientation is less important, at least in terms of aural sense during voice chat. Group couches in the community and group study rooms are already oriented in a way so that avatars will face each other. This looks natural and conveys the sense of conversations. But when sitting on benches, players' characters face a predefined direction. If another user joins the group, who cannot sit down anymore, it is questionable in which direction the user will turn their avatar. Most likely, as the avatar approached the group head-on, the character will be facing them. Nevertheless, the proximity chat does not utilize audio direction for voice chat and it is possible to turn away from the group, but still be part of it. In reality, this behavior would most likely be considered very rude. In the virtual world, this scenario might hinder embodiment of users as it is unnatural. It yet has to be evaluated in a larger group setting which can draw conclusions on the impact of orientation on social presence.

Besides audio present in voice chat, the Virtual Campus App incorporates 3D audio effects emitted by the environment. Audio itself offers high impact on immersion if used correctly as it makes the environment feel more real (Feil & Scattergood, 2005). As seen in subsection 3.4.3, immersion is the defining factor for creation of presence within the VLE. The Virtual Campus App utilizes audio for indicating the locations of other users through their footsteps as well as for background sounds that enrich the environment and provide an information supplement for visual cues (Poeschl et al., 2013; Rouse, 2005). Rumiński (2015) found that spatial audio can greatly enhance search tasks and navigation which are also essential to the Virtual Campus App. When the players arrive at the bus station, sounds emitted by the river clearly indicate its location. By getting closer, the sound volume increases. Participants of the study by Rumiński (2015) had to locate sounds in an *augmented reality (AR)* environment and were able to do so precisely by figuring out correct angles to the audio source. This promotes that localizing other players or sound emitters in the Virtual Campus App might be effective and support wayfinding in the world. Another study by Poeschl et al. (2013) examined the general influence of spatial sound within an immersive environment on presence. The participants were embodied in an avatar walking through a forest scene that incorporated spatially distributed nature sounds and foot step effects. The results indicate that spatial sound contributes to feeling of presence with a medium to large effect. In return, it might also afford that hearing footsteps of other users within the Virtual Campus App contributes to a stronger feeling of social presence. Similar to Feil and Scattergood (2005), Poeschl et al. (2013) found that sounds that did not belong into the environment, such as a sneezing sound which did not have a clear origin, disturbed the sense of presence. Feil and Scattergood, thus, recommend integrating audio wisely for every possible source to keep the environment consistent. The environment of the Virtual Campus App includes sounds emitted from TV, radio, river or fountains, but might lack further details such as wind rustling or birds chirping. On the contrary, in the library space there is no sound yet available by intention in order to keep a non-disturbing studying atmosphere. A study on background white noise, however, indicates that memory performance can be improved for inattentive children by exposing students to white noise (Söderlund et al., 2010). Attentive students' performance did not profit, but worsened in return. An additional option in the library to turn on background noise like page flipping seems, therefore, viable.

Continuing with features according to Bell (2008), users of the Virtual Campus App are also *represented as avatars*. They are digital representations that support the feeling of presence for the player as well as the creation of social presence for others. The Virtual Campus App utilizes a generic humanoid 3D model and a variety of accessories for expression of one's personality and current mood. The flexibility of customization is higher than in current applications that have a less game oriented approach like Wonder.me and Teamflow HQ. These mostly only allow photographs as user representations. The amount of customization available in the Virtual Campus App tends more in direction of applications like Gather.town with possibilities to change skin color, hair or accessories. This allows for stronger identification with one's character and potentially impersonating a completely differently looking avatar (see subsection 3.5.1). Nevertheless, the range of looks in the Virtual Campus App is exceeded by applications like SL that also provide body shape transformation and specific facial features (Ducheneaut et al., 2009). With such a wide spread of avatar design systems existing, it is debatable which aspects of avatars are most important for players of the Virtual Campus App. Ducheneaut et al. (2009) have conducted a study on this topic and ascertained the most important customization features offered in three different virtual worlds, namely *Maple Story*, WoW and SL. The applications' avatar editors differ in such that complexity and scope increase from Maple Story to SL. The most highly rated design features were hair style and color and were found to be important across all three instances. This is especially vital as many highly-customizable options in SL weren't even used to the full extent. Ducheneaut et al. (2009) suggested focusing more on parts like hair that have stronger user influence. In the Virtual Campus App, players have the option of both different hair colors and also styles that are additionally available as hair accessories. Thus, it covers the most crucial design aspect found by the authors. Another study by Rice et al. (2013) confirmed that hairstyle is most important, but adds clothing as a second necessary factor. Clothing was not listed by Ducheneaut et al. (2009), possibly because it only plays a minor role during initial avatar creation in SL and can be swapped later. Similarly, several clothing options are available in the Virtual Campus App and can also be exchanged later on. Ducheneaut et al. (2009) found that the more high-fidelity an avatar system was, the more likely players tried to recreate themselves. This applied especially to the capable editor in SL. Players who, however, built avatars that looked differently, were mainly doing so in order to idealize themself, stand out or follow a trend. Younger users in the study responded most to the latter reason. The authors concluded, that a system offering slightly limited, but popular selection of design options would be best fit for a young audience. This description matches the audience of the Virtual Campus App which will most likely attract pupils and students. With themed clothes, hats or backpacks, the app seems to be prepared for testing. Whereas detailed features might allow for truly unique representations of oneself, this is not the intention of the Virtual Campus App. It is intended as a space to socialize before and after class, but not as a place to solely enjoy one's leisure time and have fun like in SL. Therefore, easy avatar creation that allows quick entry to the world with a decently accurate representation is preferable (Dickey, 2002; Ducheneaut et al., 2009). In addition, the whole world setting is more stylized and colorful in which highly detailed models do neither fit visually nor performance wise (Benford, Bowers, et al., 1995; Kolesnichenko et al., 2019). The utilized cartoon characters, on the other hand side, seem to keep a good balance for young learners and the teacher (Rice et al., 2013).

The limitations of the current avatar system are little and mainly due to the third-party assets used. First of all, ethically important design features like skin colors or facial looks are included in the app. Though these are not separately selectable and bound to the skin texture that is used which also determines further visuals like clothing. This results in lack of combinations which users might need to represent themselves. On the positive side, an adjustment of avatars with separated skins or more hair accessories can easily solve this issue. Secondly, incorporating more animations for different applications in the Virtual Campus App is recommendable. While sitting, walking or interacting animations already offer a high degree of interaction awareness, animations that indicate players talking and gesturing would improve the overall atmosphere and liveliness of the world. Gregory and Wood (2018) reminded that customized animations which differ from default movements are more natural and likely to facilitate the suspension of disbelief within the world. Generally, a wider selection of idle animations would already make the world appear more lively and attractive when avatars e.g. suddenly corrected their hair or glasses. Animations that indicate meaning in class also come to mind, like raising one's hand, giving thumbs-up or simple greeting animations like waving. Looking at the implementations of Facebook Spaces and achievements in facial animation, a combination of avatar facial expression and gesture animation is a possibility for replacing many of the emojis (Tauziet, 2017a). Interactions like the handshake or high five from *VRChat* could also contribute to the expressivity of avatars (Kolesnichenko et al., 2019). Another example is sleeping animations for users, which are a more embodied way of indicating availability than the currently self-initiated sleep emojis (Benford, Bowers, et al., 1995). These animations could also lessen visual clutter that is slightly caused by speech bubbles for emojis at the moment. The first step of introducing character movement has already been made in the Virtual Campus App. Adding further content is no issue and only depending on resources. Replacing emojis with more embodied emotions through animations seems to be a good way of adding to player embodiment, immersion and, thus, social presence.

5.2. Bringing People Together

The main goal of the Virtual Campus App is enabling users with possibilities for frequent encounters that support group forming and community building. Being able to engage in rich interactions between participants of the world is the key foundation necessary to allow learning processes to happen (Palloff & Pratt, 2007). Within the Virtual Campus App, there are two major factors influencing how users distribute and gather. One of which is the game space, or rather the design of the game space. The first obvious difference to current applications that often tend towards VR is the view of the game space. There are mostly either browser-based 2D worlds that have great overview but stay very neutral and do not touch on any game mechanics, like Wonder.me, Remo or Teamflow HQ. Then there are some 2D game-inspired applications that offer a game feeling like Gather.town (Kuklinski-Rhee, 2021). Or there are highly-immersive 3D VR social worlds, for example Rec Room and Anyland. Out of these some can also be played on desktop, but nearly all of them use a first-person perspective (Kolesnichenko et al., 2019). The unique affordance of the Virtual Campus App is that it offers the overview of 2D paired with the immersion of a 3D game. The camera perspective in the Virtual Campus App is crucial as it allows all-around vision and notion of one's own proximity. The user becomes aware of other players passing by even if it might just be within the peripheral view (Benford, Bowers, et al., 1995). This might be detrimental for embodiment, but advantageous for social presence and privacy (see subsection 4.1.3).

As MUVEs and 3D VLEs are considered powerful environments for situated learning, the camera perspective could yield a possible limitation (Dede, 2009) though. With a fixed camera perspective, the whole world will always have to be centered in one direction. Imagining a conference for example, exhibits would always need to face the camera. They cannot be viewed from another angle and need to be displayed mostly on a horizontal axis next to each other in order to limit occlusion. By making the exhibits, e.g. statues of an art museum or a skeleton dummy in biology class, rotatable, at least one of these downsides can be circumvented. In return, giving students the ability to interact with these objects would reverse the disadvantage into an advantage. Then, users become actors themselves in the environment which is an inherent concept of VLEs and the constructivist approach (Dillenbourg, 2000). The exhibits would, thus, create meaningful interactions that also serve as spatial reference points where users gather and connect. Currently, the Virtual Campus App offers these interactions e.g. at the bus station or the air hockey table. There, players meet when they are on their way home or when they want to relax together in the community room. Possible future interaction points are for example virtual post boxes, whiteboards or notification boards. They would elevate the usage of different rooms in the world and generally the possibilities for education. Moreover, they could all have 3D models in the world embodying the actual function that they are used for in reality, such as handing in homework, collaborating or making announcements. Some applications that already provide such feature are e.g. SL, Gather.town or Remo (Kuklinski-Rhee, 2021; Livingstone et al., 2008). Whenever users with the same intention, such as dropping off the mathematics homework, gather at the same spot, they might get into conversation with each other about the topic of their intention.

This leads to the general structure of the game space which has been designed to look like a campus familiar to students. Virtual campuses have already prior been used a lot in research as an environment for studying that did also result in positive impact on presence and communication (Baker et al., 2009; Lucia et al., 2009). As with the above mentioned interaction points, each space in the campus serves a specific purpose. The spaces are *integrated tools* themselves and allow for different usage scenarios (Dillenbourg, 2000). The rooms of the university resemble rooms in reality and try to shape the crowd of users to draw on the spaces' individual features. These are closely connected to the communication options available for each room. Students who would like to talk with their friends in between a break are most likely not going to meet in the library, where they cannot talk. The Virtual Campus App offers a room for many functions that might initially be necessary in a campus environment. These include e.g. relaxation, studying, conversation, collaboration, fun or class attending. While the app also provides spaces to disperse during regular times, there are no (or not enough) group rooms for splitting users during lectures yet. Palloff and Pratt (2007) mention the advantage of breaking larger courses into smaller groups for completing assignments, discussion or similar. This feature is often used in videoconferencing lectures and seemingly very important for better collaboration (Oliveira Dias et al., 2020; Serhan, 2020). An improvement to the lecture hall room would be adjacent smaller group rooms that are exclusive to the lecture. As a model of the group room already exists, further group rooms could also be generated on demand, depending on how many group rooms the teacher needs. Then students could then leave the lecture hall at the back and gather again in the new rooms. This feature does not only offer an embodiment of walking into a virtual room, which is non-existent e.g. in Zoom calls. But it is also a feature that exceeds limitations of reality. In a physical classroom, there just is not enough space to have that many private group spaces that one can quickly retreat to.

The second factor that influences user spreading in the world is the proximity system that works as a foundation for all communicational channels. The theory of proximity has been there for quite a long time but seems to only recently have caught on due to the urge of privacy and security online (Benford & Fahlén, 1993). Proximity is generally used as a term that describes any kind of interaction within the vicinity of a player. This could be movement enabled through pointing at the destination or as a bubble preventing other players from coming too close (Kolesnichenko et al., 2019; Tauziet, 2017b). It can also be used as an area that defines interaction methods (Benford & Fahlén, 1993), which is the case for the Virtual Campus App. The proximity circle encompasses the space in which other players can talk to the user. In order to actually communicate, one has to enter that circle. This enforces group formation within the spaces of the campus. Benford and Fahlén (1993) couples the idea of proximity strongly to how aware one is of another. The closer users are, the higher the awareness and the more likely are new interactions. Thus, the proximity is a huge collaboration of visuals and what the player can see on screen, the audio emitted from other users and the notion of explicit proximity radii that define the distances. It is the spatial relations of objects that account for possible interactions (Benford & Fahlén, 1993).

It is apparent that proximity is a defining concept for the use in VLEs as it is frequently employed in current applications especially as protective means against harassment or cyber-bullying (Ballard & Welch, 2015; Tauziet, 2017b). Benford and Fahlén (1993) posed the question, whether the player even has to be aware of their proximity. Often, the proximity is not even visibly indicated as they are implied by the environment. A case in the Virtual Campus App can be exemplified by entering another room through a door which naturally reminds the player that there are new people inside to talk to. There are other implementations to proximity e.g. by Gather.town that uses voice and video proximity without any visual indicator. When players move next to each other, these communication channels are simply opened. The application does have the advantage though that movement in the game is tile based and distances can always be estimated easily. On the contrary, distances are difficult to guess within a continuous 3D environment. Teamflow HQ for example enables the visual representation for proximity whenever users move. As the proximity radius stays the same, resting avatars can still assume the moment when another user's proximity will touch them. In Facebook Spaces the safety bubble only engages once a user is actually breaching it (Tauziet, 2017b). This equals the use of the safety bubble mechanic in Rec Room and the personal space mechanics of the Virtual Campus App. In favor of visual fidelity and practicality when there are more users online than just a few, these other approaches of indicating the proximity circle should be tested with personal user opinions about the Virtual Campus App.

For differently sized environments and group sizes as well as personal preferences, the Virtual Campus App offers a setting to change the radius of the personal proximity circle. On the one hand this allows multiple users to share the same group conversation and more extroverted people to open up their communication borders. On the other hand this could create a mismatched setting in which a player with a smaller proximity circle is fully enclosed by someone else's circle, but not the other way around. Benford and Fahlén (1993) call this situation a *semi-aware* state in which one users wants to speak, but the other user can not hear it. This results in an asymmetrical level of awareness of each. A potential solution for both solving group conversations and discrepancy in awareness might be merging player's proximities once they engaged in a conversation. That way, whenever a new member joins the talk, the circle becomes slightly larger up to a certain point. A limit has to be drawn as it still requires the group to naturally be able to have a proper conversation. This function would render the radius setting obsolete. Whenever a player leaves the circle, they will then regain their original proximity indicator.

6. Conclusion

The following chapter concludes this thesis by giving a summary of the Virtual Campus App and its approach to the research questions. It especially recalls affordances which the application offers in relation to social interaction within the environment. Afterwards, an outlook is given on potential test scenarios of the Virtual Campus App as well as future research areas.

6.1. Summary

This thesis presented a standalone 3D VLE developed with Unity3D which offers a space to interact and communicate with players online. It addresses the central issue of users experiencing a lack of social contact in other communication applications throughout the Covid-19 pandemic. First and foremost, it can be used as a tool for virtual courses in schools or universities and enable a better course experience for participants by leveraging spatial concepts. The application combines advantages of both 2D organizational views and 3D immersive game visuals.

As foundation, the Virtual Campus App makes use of the features of virtual worlds and considers the main ideas of VLEs. It became aware, that the most crucial affordance of VLEs is the facilitation of a collaborative environment and, thus, the formation of community. Key to online education is the interactions between students that are possible within the environment. Furthermore, it is the environment's representational fidelity that enables immersion for all users. This is enhanced through embodiment in a user's virtual world's depiction, namely avatars. That way, users can create a sense of presence or *being there*. Through rich interactions with other players, this presence extends towards a sense of social presence, the notion of being in a world populated with real people. These factors enable experiences within the environment that lay the basis for further learning benefits.

The virtual world takes a lot of inspiration from actual game design and implements them in space structure, visuals and aural experience. The environment imitates a campus with its arrival areas, gathering plazas and buildings. Several facilities that can also be found in reality are depicted and serve as focal points for users. Depending on their intentions, students will visit different rooms or places and meet other players who share the same goal. This crowd control feature is enhanced by the restriction of communication channels available, which differs throughout the rooms. Additionally, the campus map makes use of push-pull principles by alternating open and closed spaces. Thus, players are naturally drawn towards open spaces in which they can gather for conversations. Dead-ends increase intersecting paths of players which allow them to get in contact especially in hallways and narrow places. These interaction enhancing features are completed by 3D spatial audio effects that provide position and orientation cues about the environment and other players. Finally, the environment uses an appropriate art style, that is not heavy on performance, yet still allows polished visuals that affect representational fidelity of the VLE.

The core feature of the Virtual Campus App involves proximity as a measure of distance and sorting mechanism in space. It subdivides the environment for each player in smaller subspaces that become inherent communication bubbles. They make the interaction of users possible and support text chat, voice chat and the exchange of emotions via emojis. Therefore, they govern how people position and orient themself within the environment and how groups are formed. The proximity is visually indicated by a circle that evokes awareness in users about the personal space of other members. Aurally, the proximity also contributes to the sense of distance to a player as voice chat volume increases the closer players get. However, the proximity system also enforces a measure against stepping too close by fading users' avatars and delivers, on top of avatars, means for protection of privacy.

Lastly, the Virtual Campus App employs avatars as visual representations for users. The avatar editor entails a human model that can be outfitted to look like various animals or persons. Customization options for dress, skin color, profession, hair and accessories offer a broad selection for self-expression. Users have the freedom to design their characters depending on their current mood, their own looks or an idealized image they have. It is important to note, that the range of design options addresses every possible player, no matter their looks or personality. The aim of avatars is achieving the construction of identity of users by enabling embodiment within their character. Taking over control of their own avatars, in which they feel well represented, encourages immersion of the world. This is supported by suitable animations for the avatar and interactions that take place with other players in form of their avatars.

All in all the Virtual Campus App is a platform promoting the construction of community through social engagement in an online educational setting. This thesis connects the ideas of recent virtual world applications with more conventional VLEs in a game-like manner. It also describes how virtual world design can impact the distribution of users. This should not be neglected, when developing a 3D VLE, and is utterly essential for social discourse to emerge. As a prototype of its kind it indicates the high potential of spatial proximity concepts for user immersion, sense of community and online safety.

6.2. Outlook

The Virtual Campus App is seen as a foundation for future research in the area of proximity based interaction and virtual worlds. It provides a fully functioning communication environment in which users can perform work and study related tasks or hang out together. For further insight into how proximity affects the user, it is recommendable to use the Virtual Campus App alongside an online distance education course conducted e.g. in university. It could function as a communication channel accompanying video lectures or task sheets. As no learning management tool is currently integrated into the prototype, one would need to be used in addition. In relation to such a course, there are several topics that could be investigated.

Most importantly, it is of interest how users reply to the usage of proximity in general, the proximity circles and the personal space. A study could reveal how users mostly engage within the world and which spatial criterion is most crucial for successful interaction. For example, there are various points on the virtual campus that indicate areas to sit and gather in a group. As there is almost no difference but the visuals at the moment, would it make a difference in perception of the users if they stood together in some corner instead? Also, the proximity circle has a very strict line indicating its borders. The awareness of users about crossing this line and entering the private area is to be explored. Along with it, a more implicit and relaxed indicator for proximity, e.g. letters of text speech bubbles appearing the shorter the distance, might be appropriate. Depending on the outcome of the study, it may be considered to make the personal safety space adjustable instead of the proximity circle or add explicit muting and banning options for the teacher.

In order to arouse interest in and act as a conversation starter with someone else, the Virtual Campus App already advertises specific dresses and avatar designs. Even more, these could shine in situated learning situations when the clothes are matched to the course topics. It is imaginable to offer two different designs that users have to decide between in order to cause a discussion about the topic. This concept resembles icebreaker questions which can be found in few other current applications. Avatar designs could be the embodied version of icebreaker questions as their function is initiating a conversation as well. Thus, it is recommendable to use the app to its full potential also in situated learning. The creation of further, more specific worlds that incorporate themes is easily realizable.

Another potential future topic concerning the group dynamics within the social environment is the influence of emojis on others. In the Virtual Campus App it is possible to react to one another with emojis that express someone's emotions. Given a situation where more students are gathered, e.g. the lecture hall, the possibility of joining a certain reaction by others is conceivable. Players could react with the same emoji automatically in case of applause at the end of class. With multiple identical reactions, this could also cause feedback on another channel, like an applause audio effect. These context sensitive interactions with emotions are an interesting topic to explore within this virtual world.

Finally, with a video game design approach being employed and the controls also partly being designed for gamers, it is questionable how users will look at the Virtual Campus App and what they will expect from it. Players might conceive it as a game, due to its visuals and audio integration. The walking speed has already been adjusted to fit various kinds of users, but it is still likely to mismatch with someone's expectations. It is, therefore, necessary to listen to user feedback in studies about how immersive they think of the world. Possibly introducing additional features that are not necessary for a proper experience, but enrich the time being in that world, would be appropriate. This could include mini games and embodied interactions in the world like rope jumping, but in a gamified way.

Altogether, the Virtual Campus App indicates a lot of future features and research that is possible on the basis of this prototype. The use of proximity features and embodiment of actions within the environment allow imagination of truly social interactions equal to reality.

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Abbreviations

2D	two-dimensional
3D	three-dimensional
AIP	autonomy, interaction and presence
AR	augmented reality
AW	Active Worlds
CLE	constructivist learning environment
CMC	computer mediated communication
F2F	face-to-face
HUD	head-up-display
MUD	Multi-User Dungeon
MOO	MUD, Object Oriented
MUVE	Multi-User Virtual Environment
MMO	Massively Multiplayer Online Game
MMORPG	Massively Multiplayer Online Role-Playing Game
NPC	non-playable character
PUBG	PlayerUnknown's Battlegrounds
SL	Second Life
VLE	virtual learning environment
VR	virtual reality
WoW	World of Warcraft

A. Overview of Proximity Platforms

Application	Description	Goals	Features	Platform	Price Tag	Status	Importance
http://vircadia.com/	3D interface, server foundation, metaverse engine	Creation of social & educational platforms, metaverse	Chat, play, custom avatars, 3D spatial audio, realtime object building	Desktop, VR	free	Alpha	++
https://altvr.com/	3D world meetup tool with own world creation	Attending live shows, meetups, classes	Chat, play, youtube integration, avatars	Desktop, VR	free	Online	+
https://getmibo.com/	Browserbased 3D island meetup	Informal gathering, office drinks, events, workshops	Avatar, 3D spatial audio, minigames, one-to-many voice chat	Browser	free, pricing options available	Online	o
https://calla.chat	Jitsi meeting addon in shape of an RPG map	Spatial solution to organizing group chats	Avatar, 3D spatial audio, grouping, customization	Browser	free	Alpha	o
https://cozyroom.xyz	Peer-to-peer spatial audio envir	Spatial audio voice chat	Minimalistic 2D room, spatial audio, moving objects	Browser	free	Online	-
https://cubechat.io/	Web app for work & play in 3D	Place for meetings, office hours, parties	3D spatial audio, screensharing, games	Browser	free	Online	o
https://gather.town/	Remote-social and work commu	Spending time with others, virtual universe for improving online interaction	Whiteboard, podium, games, videos, livestream, chat, customizable worlds, 3D spatial audio, etc.	Browser, Desktop	free, pricing options available	Online	++
https://happyhour.ianwdavis.com/	Browser based video chat with group tables	Recreating small group situation	Tables for small groups	Browser	free	Online	--
https://here.fm	Digital home for teams, communities, friends	Enabling parties or productive sessions	Notes, drawings, stickers, screenshare, video chat	Browser	free	Online	+
https://hopin.to	Online platform for professional virtual events	Event hosting with video chats	ticket sales, analysis data, private chat, scheduler, screenshare, sponsoring	Browser, Mobile	charged	Online	+
https://gatheround.com/	Online events with focus on specific group settings	Replacing video calls with better ways of interaction	conversation games, group chat, videos	Browser	free, pricing options available	Online	+
https://mixaba.com/	Video chatting with rooms for parties or conferences	Making social video calls human	Periodic room shuffle	Browser	free, pricing options available	Online	-
https://party.vipshek.com	Jitsi extension with rooms based on a house	Virtual house party	Video calls separated by rooms	Browser	free	Online	-
https://rally.video/	Browser based video chat with venue, room, tables	Make group meetings interactive and engaging	Breakout rooms, separation into venue, room, tables	Browser	free	Online	o
https://rambly.app/	90's style video game chat space	support natural group forming and splitting	spatial audio, overworld map, avatar, public chat	Browser	free	Online	+
https://recroom.com/	Place to build and play games together	Partying with friends all around the world	Avatar, games, chat, custom game creation and playing	Desktop, Mobile, Console, VR	free, pricing options available	Online	+
https://remo.co/	Professional audience centered 1:n video chats	Creating webinars, summits, live Q&A's or conferences	Polls, Q&A Voting, sponsorships, rooms, games, stage, whiteboard, presentation, video playing	Browser	charged	Online	+
https://sine.space/vr/	Virtual world platform/playground with monetization for developers	Tearing down creative barriers for relaxing games and party	Avatars, custom worlds, mini games	VR	free, pricing options available	Beta	++
https://spatial.chat/	Voice chatting platform with visualized rooms	Video chat conversations that recreate real-life social interactions	Text chat, screensharing, videos, rooms, spacial audio, custom backgrounds	Browser	free, pricing options available	Online	o
https://tivolicloud.com/	Creative and inclusive metaverse for everyone	Hosting events, hanging out, expressing imagination	User created worlds, avatars, non-verbal communication	Desktop, VR	free	Early Access	++
https://speakeasy.co/	Rotational chat with time limit	Offering a place to hang out with communities and friends	Chat rotation, icebreaker questions, timer	Browser	free	Online	--
https://wavexr.com/	Interactive live virtual concert by artists	Bringing people together through virtual entertainment	Real time motion tracking, virtual stage, animated singer, money gifting, live streaming, live interaction	Browser	free, pricing options available	Online	+
https://welcome.topia.io/	More human video chat in a customized virtual world	Bringing people together in meetups, holidays, office, festivals, conferences	Spatial audio & video, movies, games, private messaging, whiteboard, websites, live performance, gated entry, etc.	Browser	free, pricing options available	Online	++
https://www.airmeet.com/	All-in-one platform for hosting virtual and hybrid events	Delivering real engagement and interactions for conferences/fairs/webinars	Virtual venue locations, youtube livestream, ticket sales, real time polls, analytics, Q&As	Browser, Mobile	free, pricing options available	Online	+
https://www.banger.digital	Always-on virtual space for remote teams to connect and have fun	Delivering more engaging experiences online	Overworld, avatars, spatial video chat, games, music, customizable maps	Browser	free, pricing options available	Online	+
https://www.brella.io	Virtual event platform for conferences & exhibitions	Fostering engagement and interactions between participants	1:1 video chats with AI matchmaking, advertisement, booths, analytics, personal agenda, breakout rooms, livestream	Desktop, Mobile	charged	Online	+
https://www.highfidelity.com/	Online spatial audio space & library	Making gatherings sound like real-life ones	2D environment, spatial audio, music integration	Browser	free, pricing options available	Alpha	++
https://www.teamflowhq.com/	Virtual office for teams to hang c	Bringing back presence of being in the office, working in the same room, the spontaneity of hallway conversations	Video bubble, spatial audio, screensharing, whiteboard, scratchpad, timer	Browser	free, pricing options available	Online	+

https://www.ivent-uk.com/	Professional virtual event and digital hub platform	Fostering highly engaging communication experiences	Video chat, social media integration, event monetization, analytics, live event hybrid approach, polls, etc.	Browser, Mobile	charged	Online	o	
https://www.joinglimpse.com	Social platform for community building with 1-on-1 video chats	People staying active, building bonds and feeling connected	Speed-matching system, time limit, custom branding, icebreakers, games, photo booths, rooms, mini games	Browser, Mobile	free, pricing options available	Online	o	
https://www.kitely.com	OpenSim-based virtual worlds	Role playing, meeting people and learning	Virtual goods market place, avatars, world creation	Browser	charged	Online	o	
https://www.muze.nyc/	Social nertwork with conversation as freeform canvas	Elevating boring binary ways of messaging to something more collaborative and natural	GIFs, drawings, stickers, art editing, group chat, quizzes, scrolls	Mobile	free	Online	-	
https://www.sansar.com/	Virtual future of concerts, world creation engine	Seeing favorite artists without travelling to shows, meeting friends, buying merchandise	Avatar, emotes, avatar animations, calendar, world creation, chatting	Desktop, Browser, VR	free, store	Early Access	-	
https://www.somniumspace.com/	Blockchain VR Metaspace with own economy and currency	Creating open, social virtual reailty world	Virtual land ownership, monetization, marketplace, games, avatar	Desktop, Mobile, VR	free	Early Access	-	
https://voice.tenxeng.com/	Free voice chat with co-workers or friends	Allowing for different conversations while maintaining a 'group feel'	1D Line as Space, 2D map as space, spatial audio/video	Browser	free, pricing options available	Online	o	
https://www.veertly.com/	Engaging virtual online events	Making workshops and events as engaging and interactive as ever	Live stream, video conference, backstage area, breakout rooms, moderator, interest matching, social media integration, Q&A, polls, analytics, etc.	Browser	free, pricing options available	Online	++	
https://www.wonder.me/	Virtual space where people can meet and talk	Making online gatherings fun	Video chat, spatial group forming, rooms, topics	Browser	free	Online	+	
https://www.shindig.com/	Turnkey solution for online video conferences	Communicate. Collaborate. Connect.	Live audience interaction, private rooms, monetization, question management tools, ticketing, analytics, recording, screen Share, etc.	Browser, Mobile	charged	Online	+	
https://www.runtheworld.today/	One-stop solution for virtual social gatherings, webinars and conferences	Organizing interactive events for groups to learn and socialize	ticketing, custom invitation page, cocktail party (auto speed mathcing), rooms, attendee demographics, polls, sponsor logos, booths, Q&A, 1-on-1 chats, profiles	Browser	free, pricing options available	Online	+	