Preprint

Preservice Teachers' encounter with Social VR – Exploring Virtual Teaching and Learning Processes in Initial Teacher Education

Gabriela Ripka
Chair of School Pedagogy
University of Wuerzburg
Germany
Gabriela.Ripka@uni-wuerzburg.de

Silke Grafe
Chair of School Pedagogy
University of Wuerzburg
Germany
Silke.Grafe@ uni-wuerzburg.de

Marc Erich Latoschik
Chair of HCI
University of Wuerzburg
Germany
Marc.Latoschik@uni-wuerzburg.de

Abstract: With 21st century challenges ahead, higher education teaching and learning need new pedagogical concepts. Technologies like social VR enable student-centered, action-oriented, and situated learning. This paper presents findings of the pedagogical implementation of a distributed social VR prototype, a fully immersive VR learning environment, into an Initial Teacher Education program in Germany. The exploratory study addressed the following research questions: 1) How do preservice teachers perceive teaching and learning activities in fully immersive VR and 2) how should teaching and learning processes using social VR in Teacher Education be designed? It followed a design-based research approach. The pedagogical concept for teaching and learning in social VR was based on principles of action-orientation. A convenience sample of three groups of five students each took part in a 90-minute teaching and learning scenario using a fully immersive VR learning environment. During these seminar units, students engaged in qualitative group interviews and shared their perception of the action-oriented teaching and learning activities in VR. The results showed that preservice teachers had the feeling of being less distracted in social VR. Additionally, during group activities, missing social and behavioral cues made communication procedures more challenging for participants. However, some participants noticed a stronger sense of community while collaborating with others.

Introduction/ Study context

During the pandemic, the transition from classroom teaching to virtual instruction has emphasized the necessity to promote teachers' pedagogical media competencies from early stages on in Teacher Education (Ferdig et al., 2020). Already existing demands for Information and Communication Technology infrastructures, innovative concepts embracing technology infusion, and action orientation in seminars are still pressing (Foulger et al., 2019). However, to meet expectations that envision teachers to be "fully capable of taking advantage of technology to transform learning" (US Department of Education, 2017) and for additional pedagogical value and improved learning outcomes, the sole implementation of technology in classes is not sufficient (Blömeke, 2017; Eickelmann et al., 2019, Foulger et al., 2017, Krumsvik, 2014). The effective use of emerging technologies for pedagogical purposes also includes promoting preservice teachers' media-pedagogical and ICT-related competencies (Blömeke, 2017; Eichelberger & Leong, 2019; Tondeur et al., 2019; Tulodziecki et al., 2017, Tiede & Grafe 2019). Consequently, learning scenarios in higher education need to offer opportunities for teacher candidates to gain in-practice experiences using and reflecting on digital media in initial teacher education (Borthwick & Hansen, 2017). Social VR is already being used actively in education and training programs and could promote constructivist learning environments that embrace situated and action-oriented learning in teacher education (Dawley & Dede, 2014; Hellriegel & Cubela, 2018). However, there is still a lack of studies dealing with the design and development of pedagogical concepts and best practices for social VR in teacher education.

Against this background, this exploratory research study focuses on the pedagogical integration of a fully immersive social virtual environment into a teacher education course in Germany. We aim to answer the following questions:

1) How do preservice teachers perceive teaching and learning activities in fully immersive VR?
2) How should teaching and learning processes using social VR in Teacher Education be designed?

We hope the results may be valuable for elaborating pedagogical concepts using social VR in initial teacher education.

Literature Review

Social VR

Years of enhancing immersive virtual reality technology lead to the use of VR on a mass-market scale (Perry, 2016b; Scavarelli et al., 2020). Developers and companies are still facing, however, ongoing challenges such as developing VR headsets with increased mobility, designing VR applications according to current standards, and considering ethical concerns (Slater & Sanchez-Vives, 2016). With user-friendly hardware and software becoming affordable, immersive VR attracts a wide range of consumers from different backgrounds approaching the technology with varying demands such as gaming, socializing, or collaborating in formal or informal contexts.

When emphasizing the use of VR's potentials to promote virtual and synchronous social collaboration and interaction in diverse contexts, the terms "social VR", "collaborative virtual environments", "immersive multi-user virtual environments or "collaborative VR" are sometimes used interchangeably. The virtual environments which are described by these terms share the characteristics of being " a web-based social interaction paradigm, mediated by immersive technologies and taking place in predesigned three-dimensional virtual worlds where individuals, represented by an avatar, may engage in real-time interpersonal conversation and shared activities" (Dzardanova et al., 2018).

Sharing the same definition, the term social VR, when used by commercial companies, underlines the immediate virtual environment's attachment to social media and its primary purpose of social networking. Dzardanova et al. (2018) describe the change towards social media's use in VR as "the second generation of social networking." Social VR applications like AltSpace, VRChat, or RecRoom attract increasing numbers of users that enjoy interacting with the VR experience (Gunkel, 2019). According to the authors the four key uses for social VR, in the understanding of a social networking platform, are "video conferencing, education, gaming, and watching movies." The question, which one of the key uses, does profit the most from social VR is open to discussion (*ibid*.).

Regarding VR's usefulness for education, there is disagreement about whether the additional effort and expenses required when implementing VR in class do justice to the added value on learning outcomes (Radianti et al., 2020). Regardless of their purpose, technically, social VR platforms seek to improve as best as possible the feeling of "being there together" in VR. Whereas 2D digital media and single-user VR systems lack in mediating the whole sensory impression of social encounters, immersive embodied multi-user virtual environments (MVEs) provide the possibility of communicating and interacting with each other via avatars, thus coming close to "real/offline" social communication and interaction. People can deal with and successfully interpret a wide variety of artificial and/or augmented signals to carry social meaning (Roth et al., 2018). However, implementing head and body tracking, a faithful avatar representation, spatialized audio, and natural nonverbal communication cues lead to reinforcing a "close-to-reality "experience (Latoschik et al., 2019). Thus, the sensory impression of diving into a simulated "real" world including artificial bodies intensifies prominent VR factors like the degree of immersion, presence, and virtual body ownership (Roth et al., 2017; Roth & Latoschik, 2020). If the sensory perception of the virtual environment is designed as closely as possible to reality, the brain does not differentiate between "real" or "virtual" sensory perception and, as a consequence, interpret them as real stimuli in VR (Slater & Sanchez-Vives, 2016; Slater & Steed, 2000).

Teaching and learning processes in social VR

Social VR's potential for teaching and learning processes lies within offering authentic learning environments that enable to interact remotely and synchronously as well as to permit learning experiences that affect learners in a multi-sensory way. Schwan and Buder (2006), stressing the advantages of the authenticity and interactivity of virtual environments, categorize virtual environments according to the user's level of interactivity with the virtual world into three types (Schwan & Buder, 2006): (1) In the focus of the *Exploration Worlds* is the sensory experience and self-paced exploration of objects, places or rooms that otherwise would be too difficult, not feasible or too dangerous to access. Learners can walk through virtual museums or travel to places they have never been before (*ibid*.), gathering information on their own or in groups. The National Geographic "Explore VR" App, for example, enables the user to walk through the historical site of Machu Picchu, and while fulfilling short tasks on the way, the user learns about Incas' history. The virtual environment provides information in multimodal ways and can thus promote declarative knowledge acquisition. Whereas interactivity is restricted in Exploration Worlds, (2) *Training Worlds* offer more potential to train procedural knowledge and psychomotor skills through action-based

sequences in scenarios like evacuation drills (Feng et al., 2018). The advantage of using VR to train psychomotor skills is that situations can repeatedly be simulated under the same circumstances over and over again. Otherwise, in real life, this procedure would not be possible due to high costs, efforts, or the risk to harm people. (3) *Construction Worlds* have the highest possibility of interactivity for learners and virtual environments. In these worlds, users themselves can create and design objects inside the virtual environment. Increasingly, software is released that enables VR's users to create their own 3D objects or express their ideas with drawing and modeling tools. The results are available in different formats and exportable to other media. Such a categorization might be helpful to distinguish between different virtual worlds. However, the chosen terminology refers only to exploration, training, and construction, therefore concealing its potential for important other learning activities, such as problem-solving, decision making, and critical thinking. Designing pedagogical concepts for teaching and learning processes in social VR on the grounds of constructivist learning theories offer great potential for promoting various competencies of learners (Burdea & Coiffet, 2003; Dawley & Dede, 2014; Scavarelli et al., 2020; Wang, 2020).

The integration and implementation of social VR for teaching and learning purposes are connected to some challenges. For one, the development of social VR platforms takes time and is extensive regarding resources. VR software and content suitable for teaching and learning settings are rare and need further development. Concepts and best practices that introduce teachers to how to use social VR in classes with materials explaining step-by-step procedures are missing (Stavroulia et al., 2019). Also, there are technical challenges concerning the choice of hard- and software. With the development of social VR platforms and thus making social VR commercially accessible for a bigger audience, also ethical questions arise in the context of users' data protection, harassments in open social VR places, fraud or avatars' influence on one's identity (Shiram & Schwarz, 2017). This makes designing teaching and learning processes in social VR quite challenging, as not only the pedagogical view has to be considered but also the technical characteristics of social VR have to be taken into account.

By exploring teaching and learning processes in social VR and how they are perceived by preservice teachers, the present study seeks to give valuable insights for further developments of pedagogical concepts for teaching and learning in social VR. Based on the needs analysis of Ripka et al. (2020) the following conclusions have served for the development of the pedagogical concept and the social VR prototype used this study:

1) Design of action-oriented and constructivist teaching and learning scenarios with changing social formats
2) Preservice teachers are supported in their exploration and the use of the virtual environment.
3) Room design of social VR must be clean and simple, allowing interactivity and social collaboration
4) Communication and interaction in social VR should work easily without interruptions
5) Avatar representations can either be abstract or real

Research Methodology

1. *Study Context*

The overall goals of the research project are the design of a theory and practice-based pedagogical concept for promoting media-pedagogical competencies using social VR in Initial Teacher Education (ITE) and the interdisciplinary development of an according social VR platform. As a result of this iterative design process, the social VR platform will be integrated into seminars in ITE at university and used as a distance teaching and learning tool that promotes media-pedagogical competencies of preservice teachers. In this developing process, following up on the needs analysis of teacher educators and preservice teachers' requirements for teaching and learning in social VR (Ripka et al., 2020), this study focuses on the following research questions:

1) How do preservice teachers perceive teaching and learning activities in fully immersive VR?
2) How should teaching and learning processes using social VR in Teacher Education be designed?

2. *Study design*

Social VR prototype

Regarding room design, the social VR prototype, based on the game engine Unreal Engine 4.24 and optimized for Microsoft Windows 10, offered a fully immersive seminar room. The *Oculus Rift S*, a Head Mounted Display, and a Laptop served as VR hardware. To avoid unnecessary distractions for the students, the virtual seminar room is kept clean and simple, offering room for collaboration and interaction.

The implemented virtual whiteboard enables the teacher to use webpages, presentation slides, and collaborative web tools throughout the seminar session. The board can be operated with a control board integrated into one's avatar's virtual wristband. For avatar representation, a comic-alike abstract avatar is used. Outer appearances like the color of

the upper body, gender, and name are customizable for the users. After entering the preferred avatar choice, representations' names appear over the avatar's head, visible for all participants. Students are able to move around via teleporting.

Pedagogical Concept

For the preparation of students using the VR hard-and software, a face-to-face introduction had been performed before the seminar started. In addition to a hands-on approach throughout the process, with the aim in mind that students need to get used to the VR user interface, a collaborative and interactive group activity in the virtual environment was designed. A planetary system was simulated inside the virtual seminar room, and participants would have to communicate with each other to put the planets into the right spot. To be able to closely observe teaching and learning processes and to support students with getting used to VR's hard-and software, two main choices were made. First, the group of participants for one seminar session was restricted to five. Second, the intervention took place in one big lab instead of locally distributed to support students in case of having difficulties with the technology and to ease the detection of technical malfunctions and troubleshooting.

The pedagogical concept for the 90-minute seminar session was designed based on action- and development-oriented didactics (Tulodziecki et al., 2017; Tulodziecki et al., 2019) combined with flipped classroom principles. This involved a task-based approach and collaborative learning processes in the virtual learning environment. Students prepared the learning content for the seminar session in advance according to flipped classroom principles. The seminar session was divided into two units:

(1) a teacher-centered introduction of the topic and the presentation of a situated task asking the students to design a concept for using VR in schools which was followed by a joint brainstorming (10 minutes),

(2) a learner-centered group activity in which preservice teachers designed a concept for using VR in the classroom with pupils and presented their results at the end of the session (30 minutes).

3. *Methodology and data collection*

The convenience sample consisted of 15 preservice teachers (3 groups of 5 students each). Due to sickness one of the students did not appear. The students had the opportunity to sign up voluntarily for the intervention which was promoted in school pedagogy courses focusing on the use of digital media in educational contexts. The participants represented a mixed group of 12 female and 3 male teacher candidates. Group 1 and group 2 consisted each of five female students. Three male and two female preservice teachers participated in group 3. Data was collected qualitatively in group interviews.

The development of the interview guide was based on the central components of teaching and learning with technology, according to Tulodziecki et al. (2019), and the requirements of teacher educators and preservice teachers (Ripka et al., 2020).

I. Teacher-centered teaching and learning processes
   a. What is your experience with the social VR application?

i. When you think of your seminars in "real" classrooms, how did you perceive the interaction with the lecturer in comparison?
ii. What advantages and disadvantages do you see in learning in social VR?

II. Learner-centered teaching and learning processes
a. You have worked together in the group activity in VR. The sketch of the design task is the result of this group work. What was your experience during the group work in VR?
i. What experiences have you had during the process of finding mutual consent in VR?
ii. What was your experience in giving mutual feedback?
iii. What was your experience with consultations within the group?
iv. Which other functions in VR would have been helpful in the group activity?

The group interviews took place in-between seminar units and outside of VR. The interviews were recorded, transcribed, and analyzed through qualitative content analysis (Mayring, 2015). They were coded using MAXQDA (Rädiker & Kuckartz, 2019). The following categories were determined deductively following the approach of Mayring (2015):

1) Teacher-centered teaching and learning processes
a. Interaction between lecturers and students/ students and students
b. Interaction with social VR environment
c. Communication and language in social VR
d. Media pedagogical content

2) Learner-centered teaching and learning processes
a. Interaction between lecturers and students/ students and students
b. Interaction with social VR environment
c. Communication and language in social VR
d. Media pedagogical content

Also, an exploratory participatory observation was carried out to help interpret the results of the group interviews.

Results

1) Teacher-centered teaching and learning processes

a. Interaction between lecturers and students/students and students

When asked about how they perceived the interaction with the lecturer in social VR in comparison to "real" classrooms, one student said that it would not differ so much, "Well, I think it was not much different [...] I think you need a few minutes to get used to it. But you see and hear quite good who is talking and what it is all about" (Group 1_C). Some participants experienced a shift of focus in VR, and one explained, "I had the feeling that somehow the attention of us lay much more crassly on what was said, […] I think the focus was just completely different because I cannot be distracted" (Group 2_C). Further, describing the perceived relationship between the students and the lecturer in social VR students commented for example: "I don't know if this is due to the format, but I thought that it wasn't a real teacher-student relationship because we were standing in a circle and also much closer together. The classroom is usually bigger, and you have more distance to the teacher and he usually stands in the front. I thought that was the group feeling that was addressed, not only including the students but also the teacher" (Group 3_D).

b. Interaction with social VR environment

Regarding their experiences with the social VR environment, some students reported unease while getting used to the VR environment: "I thought it took a lot of time to get used to it. In the beginning, I didn't know at all if this is a blackboard" (Group 1_E). Concerning the change from the "real classroom" to the VR environment one student stated: "So it was just a strange feeling to be in another room from one second to the next" (Group 2_A). Others valued that there were no distractions in the virtual seminar room: "There is no window, where I can distract myself from any people who might be walking around, […] I don't have anything that tempts me" (Group 3_C). Emphasizing the positive effects of a mobile-phone-free learning surrounding a student said: "If I sit in a face-to-face seminar for example, then 80% of the students have their mobile phones at the table […] but this doesn't work here, and because of that, I don't have the possibility at all, I think the focus was completely different because I can't be distracted" (Group 1_C). Referring to the effects of wearing VR headsets over a specific time-period, most participants agreed on the following impression: "At the beginning, I thought: Super interesting. And at some point, you realize: It's getting super tiring to look at the virtual board and to concentrate" (Group 2_C).

c. Communication and language in social VR

As abstract avatars represented participants, facial expressions, and full body gestures were missing. The consequences influenced the way of communicating and interacting in social VR. Several participants observed positive effects of missing communication cues, as these examples show: ”I also agree with what you said about concentrating on the language because somehow, I don't have to concentrate on facial expressions and gestures and my appearance, and everybody is looking at me” *(*Group 3_B) and some felt more comfortable to talk, pointing out: “But I think you also have a little less inhibition to say something because you feel so anonymous […]” (Group 2_B).

d. Media pedagogical content

There were no comments regarding the media pedagogical content.

2) Learner-centered teaching and learning processes

a. Interaction between lecturers and students/ students and students

Regarding the interaction between students in the second collaborative unit of the session, most of the participants thought that the group work in social VR was not too challenging, as this statement shows: “Well, I thought it went very well, I didn't think that we would come to a result so quickly. I know it from other group work, where you discuss forever and then I heard a quarter of an hour, I was like "Oh god oh god", four of us, four opinions in a quarter of an hour, but it went well, so we agreed relatively quickly, and were all happy with it*” (*Group 3_C). Referring to the learners‘ proximity of the learning setting in VR compared to a real classroom one, a student thought, “it's better because somehow you have the feeling that you can't retreat. Because we all see each other. We are all standing in this circle and it would also be noticeable if one of us just wouldn't do anything” (Group 1_C). Also, during this process, the missing social cues influenced the communication between students. As one participant expressed: “I can also imagine that when you do this in larger groups, I mean we are a really small group now, it can sometimes be a bit confusing when you have to assign the voices, because you don't see that someone is speaking, and then you are a bit confused” (Group 3_D).

b. Interaction with social VR environment

Several participants described positive consequences using the social VR environment, stating for example, "Well, I would say that I think: I'll just profit more of it. Because somehow - I don't know - I feel more like I'm present" (Group 1_C). Additionally, one participant pointed out social VR's potential being a "safe place" in that one could act without fearing consequences: “I think it is really good if you don't have any direct consequences, so you can really test a lot. And if it goes wrong, then you just do it again or something like that. Things that you could not do at all, or if you have to do them once, you do them once. I think that's a very, very big opportunity” (Group 1_A). However, other students expressed their concerns: “I think it's a difference if you put on your glasses and you have everything already in place than having to create it yourself, especially if you are technically a bit insecure […] I think I would - personally I'm afraid of it - so I'd be really afraid, if I really could manage that - especially with students” (Group 2_A). Also, some wished to be able to take some notes: “…what I missed, was that you can't take notes. Because it takes a bit longer and everyone gives input, and so on - you can't take notes” (Group 2_D).

c. Communication and language in social VR

Similar to the teacher-centered phase, the missing social cues lead to more challenging communication: “So, what you really have to get used to: You really have to approach people directly. By name, really. You really have to get into the habit of addressing people directly by name. Because otherwise you really don't feel addressed” (Group 2_D).

d. Media pedagogical content

Regarding the lessons’ content and its extent, several participants commented like this: “It would have been hard to memorize all this or not to write it down on the side. Especially when it is something bigger and longer that you can take notes on the side” (Group 2_A). Another student added:“ I got more out of it than if I would have just sat there and written it down“ (Group 2_C). Concerning the potential of using VR in their future classroom, students described examples of how they can imagine getting their pupils involved in learning content: “[…] for example, when I imagine that I somehow deal with the topic of factory farming in class, and then just say that the chickens are totally cramped in cages, but I only have a picture, which perhaps doesn't concern anyone that much. But if I can really stand there in this farm with the help of social VR and look around and see how cramped these cages are, then

it might be more enduring and impressive for me, and it keeps me more engaged, and then it might have more impact on my future actions and consumer behavior" (Group 3_B). Additionally, one student commented on the use of social VR from a more differentiated perspective: "I can perhaps imagine it quite well in the didactics, less in other disciplines, [...]but I think it's a good opportunity to try it out if you're designing a lesson with a group […]" (Group 3_C).

Discussion and Implications

Concerning the further development of the social VR platform and the pedagogical concept for teacher education, the results and the participatory observation of the study are leading to the following conclusions and implications for the research questions:

RQ 1) How do preservice teachers perceive teaching and learning activities in fully immersive VR?

Results show that several participants pointed out that based on the virtual surroundings they focused more on the content shared. However, most of them agreed on the efforts that had to be made to read the presentation on the virtual whiteboard. As an improvement, few students would like to have the possibility of taking notes. Throughout the design task in the group activity, communication cues like facial expressions and gestures were missing leading to more time spent with managing communication flow. Observation showed that the speaker turns posed difficulty for two groups to anticipate. However, both groups started to compensate for the missing social cues. One group started to use hand signs. The other group concentrated on the avatar's upper body as a signal when the speaker's turn took place. Students commented on this and agreed that they felt losing valuable time to work together productively. Some recognized, however, that they had the urge to be more attentive and actively participating in keeping the workflow going. Shy students even felt they could participate in social VR more freely because, in their avatar representation appearance, they felt more anonymous and safer to speak.
Close to the end of the session, the majority agreed that wearing the VR headset would be exhausting, in particular when focusing on the digital whiteboard panel.

The exploratory observation of participants throughout the teaching and learning activities shows that preservice teachers were curious and open to the VR experience. Most of the preservice teachers got used to VR's hard-and software and did not need any technical support. Furthermore, the observation showed that the group task and the results' presentation were carried out from all groups without problems. However, taken from the results, some remarked that group size might be a limiting factor regarding fulfillment as communication was challenging.

RQ 2) How should teaching and learning processes using social VR in Teacher Education be designed?

Concerning the pedagogical concept, the observation showed that combining the seminar concept with the flipped classroom approach has proven beneficial for the action-oriented and situational teaching and learning processes in VR. As integrating social VR in teaching and learning processes takes more time, it was possible to use the seminar units in VR intensively to work on the subject matter without mentally overloading the participants. As results show, the lesson's extent of content was described as manageable; otherwise few participants stated they would have had to take notes. Overall, observations showed that all groups could perform the tasks. Technical limitations, such as the resolution of virtual media presentation, headset quality, and mobility as well as missing communication cues, made the seminar session in VR more challenging, however, did they not prevent the teaching and learning processes overall. Combining seminar sessions concerning 1) location (online/face-to-face) and 2) teacher-or learner-centered, on a selective basis, teacher educators and preservice teachers could profit from the positive effects on motivation to use VR in class themselves, group dynamics, and participation in VR, without being dependent on technical limitations. Results showed that most preservice teachers thought the VR experience to be exciting. However, this is possibly due to novelty effects. Also, some stated that they felt a sense of community and group feeling including the lecturer. Concerning the social VR environment, distraction-free surroundings seemed to help that students' kept focus. Keeping the balance between functionality and usability, the room design itself needs no change. However, it might be interesting to observe in future studies what effect different sceneries would have on preservice teachers. As missing social cues lead to challenges in communication and interaction during a group activity, supporting social cues should be implemented into social VR's functionalities.

On the one hand, restricted communication cues in social VR lead to positive effects. Interview results showed that several participants focused more on the spoken word and thus felt more involved in activities. Also,

observation and results show that some of them tend to pay more attention to addressing their peers, and attentively followed the communication.

On the other hand, social cues are vital for communicating with each other and interpreting non-spoken context. Without the extra information included in communication clues, it takes more time to keep up the communication flow during group activities and might influence the learning process. According to Roth et al. (2016; 2018) the absence of social or behavioral cues can have impacts on social interaction in VR, such as decreased communication efficiency or decreased affective understanding. Leading to the assumption that learning processes might profit from the implementation of social and behavioral cues, further studies in this regard are needed.

The results summarized above are subject to certain limitations. Regarding the samples of this exploratory study, it is essential to note that a convenience sample was used. Hence, against the background of the qualitative research approach and sampling method, the interviewees are not representative of their respective groups. Thus, the results may not apply to other preservice teachers in the same way.

To substantiate the findings, more investigation is needed to observe how teaching and learning processes in social VR can be designed effectively. At this moment, the close interdisciplinary work between pedagogical and technical disciplines plays a vital role, as necessary pedagogical processes need to be enabled by the technical environment of social VR. It will be insightful to extend the observation to more seminar sessions with changing learning environments as well as changing teaching and learning scenarios. Moreover, a further step will be that interventions take place locally distributed. Regarding the shift to distance teaching and learning formats in higher education during COVID 19 pandemic, in connection to the most commonly used video-mediated platforms, social VR represents a possible extension tool to integrate action-oriented and situated learning in new pedagogical concepts for distance learning.

The findings from this exploratory study are currently incorporated into the further development of pedagogical concepts using social VR in teacher education. The provision of the pedagogical approaches and the developed materials as well as the social virtual environment as open source will contribute to the dissemination of social VR scenarios in different educational contexts. Thus, the presented social VR teaching and learning activities offer a wide range of transfer and possible uses for students and lecturers of different disciplines in higher education in the future, also promoting international mobility and inclusion.

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