Suitability of Immersive 2D Environments for Tertiary Education using the Gather Environment as an Example

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***Abstract*— In the last two years, university teaching has been strongly influenced by online formats, mainly by video conference systems. Beyond that, there are also some practical examples for the use of immersive environments in higher education, mainly focused on the usage of virtual reality (VR) or augmented reality (AR) environments. However, this study aims to see if immersive 2D environments are also holistically suitable for teaching in terms of presence, participation, collaboration, and active learning for higher education, as they can offer advantages over video conferencing systems, but are not as costly as VR and AR solutions. A Master's program at the University of Applied Sciences Würzburg-Schweinfurt was chosen for the study. The selected course was held completely in an immersive 2D environment over one semester. Accompanying the course, subjects were asked to complete the Online Learning Environment Survey (OLLES) questionnaire weekly for analysis. Thereby a descriptive evaluation of the questionnaire takes place. All dimensions of the OLLES questionnaire achieve high to very high values. From a purely descriptive point of view, it can therefore be assumed that the used immersive 2D environment is holistically suitable as a learning environment in the tertiary sector. Nevertheless, this should be further explored in future studies by also comparing different courses (immersive 2D environments, video conferencing systems, VR/AR environments, and real-world teaching lectures) to make even stronger statements.**

Keywords-Virtual Learning Environments; Online Teaching; Tertiary Education; 2D Environments; Desktop virtual reality

I. INTRODUCTION

University teaching has been heavily influenced by online teaching over the past two years as a result of the COVID 19 pandemic measures. Besides the isolated usage of VR or AR environments [1], primarily the classic video conferencing tools such as “zoom”, “GoToWebinar” or “Cisco Webex” were used, according to their market shares [2]. All of the classic video conferencing tools use video and audio transmission in a simple representation of the participants on the screen of the end device. Due to the continuous and time-consuming use of these systems, signs of fatigue and weariness could be observed, often referred to as "zoom fatigue" [3] [4] also and especially for university students within online courses [5]. However, it can be assumed that online communication and events will continue in the future after COVID 19 pandemic [6]. Therefore, alternatives or additions to classic video conferencing systems such as VR should also be analyzed in order to check their suitability, especially for online university lectures. A first pilot study showed higher spatial and social presence for VR group meetings in comparison with video conference systems [7]. In contrast to video conferencing systems, the representation of the participant in VR is integrated into a virtual world and allows to explore and interact within a dynamic virtual environment [8].

Further, within this introduction there are given some definitions and explanations about the basic terms like VR and immersion and the status quo of VR in education and virtual learning environments (VLE). Section 2 shows the related works for VR and VLE in higher education and especially in tertiary education. Section 3 presents the virtual learning environment gather.town and their specific software features which are used in the study and also the measuring instrument OLLES [9] for analyzing the different dimensions. Section 4 resumes the results, which are then discussed in detail in Section 5. The paper is finished with Section 6 to describe limitations and give an outlook to further work.

A. VR/immersion

VR can be distinguished between immersive VR (I-VR) including additional devices like a head mounted display (HMD) and non-immersive VR on the screen of some end devices, also declared as desktop VR (D-VR) [10]-[13]. Di Natale even suggest a three-way division between non-immersive systems like desktop VR (D-VR), semi-immersive systems like AR or wide field displays and immersive systems like HMD or special designed rooms with projected walls (CAVE) [14]. While the definition for VR seems to be clear in literature, the term of immersion is a multifaceted concept without clarification [1]. On the one side, immersion is viewed as a kind of objective characteristics in terms of technical systems and affordances [15] or a psychological subjective characterized by one’s perception of presence and interaction [16]. While Bergstrom defines immersion as an objective property of the platform environment and presence as a subjective feeling [17], it seems that the term of immersion started to become synonymous with “presence” [18]. Despite the strict separation between non-immersive and immersive VR, recent studies tend to consider immersion as a kind of continuum from highly immersive or high-end for I-VR and low immersive or low-end for desktop VR systems (D-VR) [18]-[20]. This is probably because there can be some kind of immersion and spatial presence on desktop VR systems as well.

B. VR in education

The high-end immersive VR seems to fascinate and inspire people in their first reaction, probably because of the high level of immersion and appearance [21]. Especially in terms of education, there were several announcements about ground breaking improvements by the usage of immersive VR, like increasing memory capacity or making better decisions [23]. Wu et.al. reported that I-VR-lectures are more effective than non-immersive environments [24] and Gao assumes better learning outcomes because I-VR is more engaging than traditional methods [25]. A meta-study found that the majority of studies on immersive learning environments from 2014-2019 used AR or VR applications, although all forms of immersion in learning and education were explicitly included. Among other things, the study shows the need for more research on less immersive learning environments with higher narrative and greater challenge [1]. Although the level of immersion in desktop VR systems is not as intense as fully immersive VR technologies, it is not the case that higher immersion and presence directly lead to better learning performance [19]. Johnson-Glenberg discovered, that the main effect for better learning is not the level of immersion between 2D or 3D virtual environment but the level of embodiment. The study compared the learning outcomes between groups learning with a low immersion platform on a desktop and a high immersive platform with an HMD (I-VR). The low embodied I-VR group performed significantly worse than the desktop group with high level embodying [18]. Radianti, states that immersive VR technologies are particularly used in education, even if their level of maturity still seems questionable and there are several research gaps [26]. Hamilton found in his literature review that in most I-VR studies between 2013 and 2019, there was a significant benefit of using I-VR in education. But he also restrict that most studies used short interventions and were mainly focused on scientific topics such as biology or physics [13]. Additionally, there are still limitations remaining, while using immersive VR. Besides higher costs for immersive VR, above all cyber sickness in terms of e.g. headache, blurred vision or dizziness are effects of using HMD technologies [27]. This is one reason why such systems should be used only for a limited span of time [28]. Due to this and considering the specific requirements and accommodations for university lectures, desktop VR applications appear to be more suitable for online education [9] [29] [20].

C. Virtual learning environment (VLE)

Another keyword often used in connection with virtual learning is virtual learning environment (VLE). This term includes a wide range of systems like simple web pages, learning management systems like MOODLE but also three-dimensional learning environments like Second Life or OpenSim [30]. Reisoğlu, following Zuiker, defines the term "3D Virtual Learning Environment (3DVLE)" and describes it as platforms for virtual worlds with avatars as representatives and the ability to communicate via audio or text, such as Second Life or OpenSim [31] [32]. Other authors use the term of “immersive 3D virtual world” or “immersive 3D virtual environment” for similar systems to describe computer based simulated environments in which users are able to immerse themselves through avatars [33] [34]. We will follow the wording of “immersive 3D/2D virtual environment” to describe desktop VR with different levels of immersion. Within this paper we do not include learning management platforms (LMS) for distribution of contents, messages, notices and communication via forums and chats, like e.g. Moodle although they are included in the term of virtual learning environment (VLE) [35] [36]. We want to focus on low immersion desktop solutions that provide the ability to move, interact, collaborate, and communicate in a kind of virtual environment using an avatar. The aim is to use them for online master lectures at universities.

II. Related Work

There are already a number of studies and experiences for the use of virtual learning environments in higher education which are presented below.

A. Immersive VR (I-VR) in higher education

There are several studies on the impact of mainly immersive VR (I-VR) in higher education. Chien et.al. stated that a VR environment increases the motivation and critical thinking skills [37]. Tepe concluded that a VR environment increases performance and professional skill development [38]. Other studies also showed several positive effects on the academic success and motivation [39] [40]. Wen-Yu Lee discovered higher scores in science concepts for sixth-grade students learning with I-VR systems in comparison to students without the help of immersive systems [41]. In the field of higher education, a meta-study analyzed studies on desktop-based virtual environments, games and simulations in particular. They concluded that these virtual tools could be effective in improving learning outcomes [12]. Mystakidis et. al. conducted a literature review analyzing the outcomes of distant learning and their effect on various criteria of "deep and meaningful learning" such as cognitive, social or affective aspects for K-12 high school students. As a result, positive outcomes were found, especially in terms of performance, satisfaction, cooperation and motivation. Although it is also emphasized that insufficient didactic quality cannot be compensated by online formats [42]. In a metastudy on the effects of immersive VR on students' academic performance, Akgün concluded that there are many positive effects on students' abilities, such as an increase in motivation and other positive contributions to learning. Despite to these positive results, the study also determined that there are still technical and health problems to be solved [43].

B. Virtual learning environment (VLE) in higher education

In addition, studies with desktop VR in higher education detected better performance achieved in groups using desktop

VR. However dependent from the individual spatial ability [44]. Reisoğlu analyzed studies between 2000 and 2015 on 3D virtual learning environments (3DVLEs) and various aspects such as platforms used, research topics, and achievements. He found that the Second Life platform is the most used platform and that studies on 3DVLEs peaked around 2012 for simulation and learning support. He concluded some overall positive emotional and cognitive achievements on presence, satisfaction, communication skills and engagement [31]. Coffey also analyzed the second life platform against a normal computer surface for comparing the impact on intercultural sensitivity and reveals significant gains with the usage of a virtual environment [34]. Another study analyzed the effects of collaborative learning in virtual environments with the use of 3D avatars in a virtual learning environment (VLE). The results showed that regardless of a collaborative group or an individual group, learning improved, but participation in a collaborative group had a significant positive effect on academic achievement and satisfaction in higher education [45]. In a systematic literature review on "simulation games", it was discovered that better results in terms of declarative knowledge, procedural knowledge and knowledge retention could be achieved through the use of desktop-based immersive environments for the education of trainees [46].

C. *VR/VLE in tertiary education:*

One of the early publications on "desktop 3D learning environments" without the use of head-up displays in tertiary education comes from Charles Sturt University. Here it is already pointed out that a desktop application is easier for the users and reduces physical and psychological stress compared to immersive virtual worlds with head-mounted displays [47]. A combination of learning management system with Moodle and 3D desktop environment with OpenSim was used in a study to design and evaluate a VLE for teaching with undergraduate students. There were effects on learning skills and understanding of sociocultural aspects that have a strong impact on social interaction when students participate and collaborate in common tasks and activities [30]. Collaboration and interaction seemed to be a high demanded factor influencing VLE systems, either by students and also academic staff [48]. A special form of 3D virtual learning environment is used for analyzing dental students' performance. When comparing stereoscopic 3D vision with passive circular polarized glasses to 2D vision on screen, significantly better results and higher appreciation for the 3D vision were found [49]. Another specific anatomy medical study about the role of stereopsis in virtual and mixed reality conducted that virtual and mixed reality is inferior to physical models [50].

Overall, there are several studies of desktop VR (D-VR) respectively VLE for specific topics, often computer science or medicine [28] [49]-[51]. These studies include various intensities of immersion, but still lack an evaluation of the overall and holistic suitability of 2D desktop learning environments for higher education, including the new immersive 2D environments that have appeared in the last three years.

III. Method

In the following we present the immersive learning environment gather town, in which the course took place and the measuring instrument OLLES, which was used for the assessment.

A. *Immersive 2D environment gather.town*

The software gather.town [52] was used as an immersive 2D environment. This is a web conferencing software that allows to create a complete virtual replica of the teaching building. Within this virtual space, users can move around using avatars and interact with each other and their environment. Similar to real life. If the avatars now walk around in the virtual environment and then meet each other at a certain distance, the camera and the microphone of the computers are automatically switched on and the users have the opportunity to communicate. The graphical user interface is quite simple and it does not demand any special requirements to run on a variety of computers. In preparation, the entire real seminar building was recreated in the gather.town environment and the following virtual environment settings and software features were used:

1) *Podium:*

The podium is the classic teaching situation (see Fig. 1). Within the gather.town environment, all students and the tutor are in one large room. The tutor stands in front at the lectern, while the students take their places at the tables. All students can see, hear and of course communicate with each other via camera and microphone. It is possible to share the screen to provide lecture slides or other content to all participants in the plenum area. In this way, the tutor can use lecture slides in addition to a verbal execution of the learning topic, as they would be used in a real teaching situation.

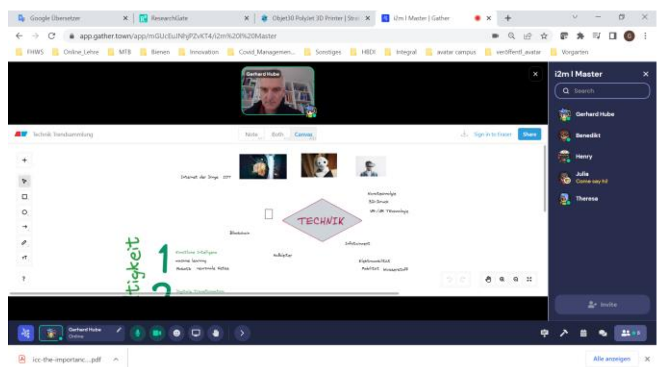

Figure 1. This is the podium. You can see a classic teaching situation in a shared space.

2) *Whiteboard:*

The whiteboard (see Fig. 2) provides an opportunity for collaborative work. To do this, the whiteboard must first be activated. After that, all users who access the whiteboard at the same time can work together on it. This means that all users get write permissions and can interact with the whiteboard. In addition, a video and audio function for communication is available for the workgroup to discuss and exchange while working on the board.

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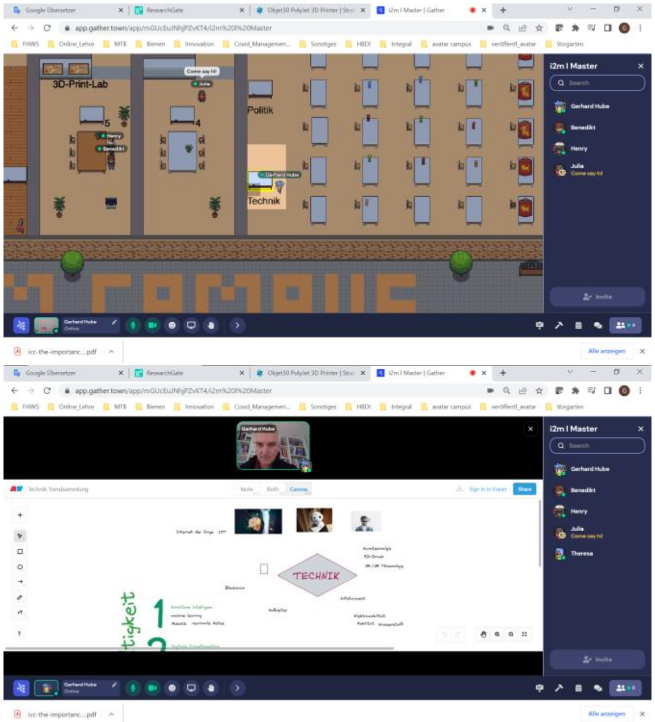

Figure 2. In the upper part of the picture, you can see the whiteboard placed in the room. Below you can see the view when using the interactive whiteboard.

3) *Workshops:*

Workshops are smaller rooms that provide fewer seats than the large seminar rooms. Here, there are tables with seats and a whiteboard (see Fig. 3). Thus, the users have the possibility to do smaller group work. They can use the table for meetings via the camera, or the whiteboard for joint work or screen sharing for presentation.

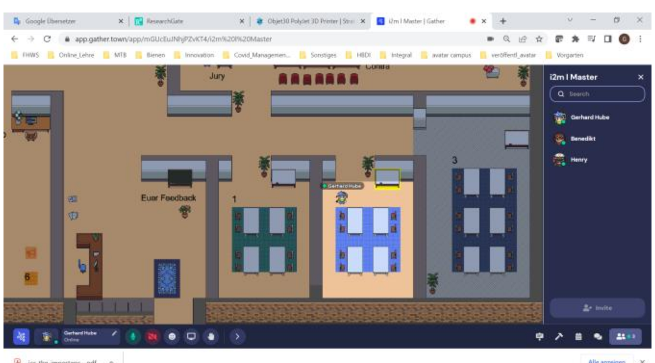

Figure 3. Here you can see a small workshop room with several seats and a whiteboard in the room.

4) *Group discussion:*

This is a room that is designed in such a way that a pro and a con side can sit opposite each other and participate in a group discussion by means of the camera (see Fig. 4). The whole setting is accompanied by possible viewers, but would also be monitored by a jury that rules the discussion and evaluates the individual arguments.

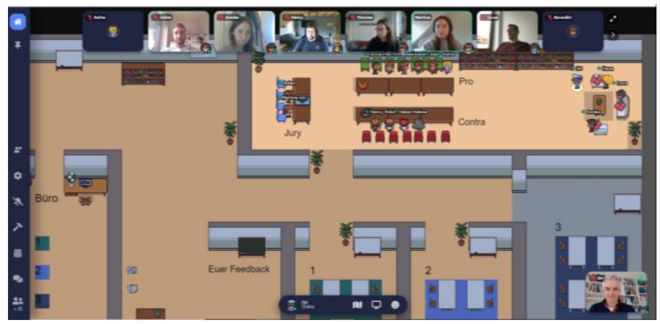

Figure 4. This is a group discussion room, where users sit across from each other in teams and a jury sits in the middle.

5) *Break rooms:*

In the break rooms, users can stay between the individual seminars and have the opportunity to play various card games at a game table, making music or watching videos (see Fig. 5). In another break room, users have the opportunity to get on a yoga mat. A 10-minute instructional video is then played so users can join in on the yoga session from home.

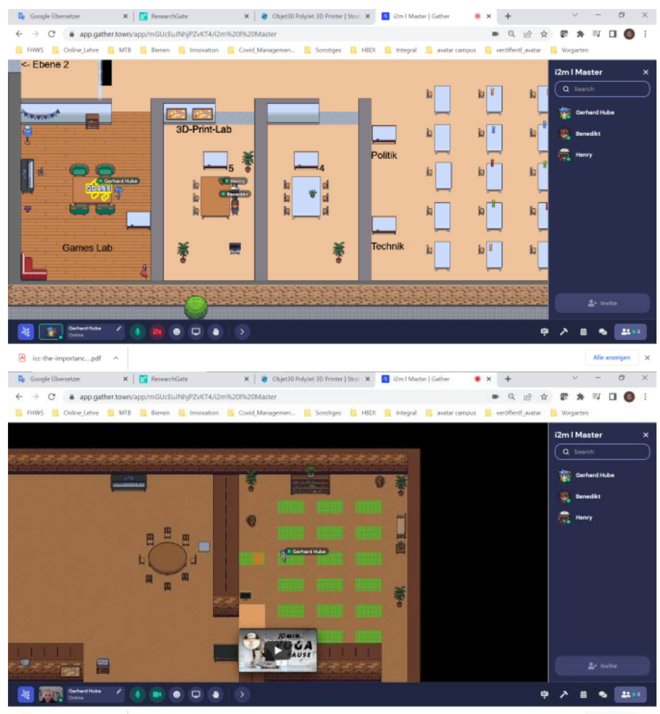

Figure 5. Here you can see the break rooms, where multiple users can gather and share interactive applications like a gaming table or a yoga room where a yoga tutorial is played as a video as soon as you step onto one of the green mats.

6) *Other Interactive Objects:*

Within the environment, other interactive objects are stationed in the individual rooms or corridors. In the entrance area, for example, there is a blackboard on which the timetable can be viewed, and next door, there is a tutorial that once again describes the functionality of the gather.town environment in a video. There is also a bookcase. If you use it, you get a web window within the gather.town environment, which leads you to the online catalog of the university (see Fig. 6). There the literature search can be accomplished.

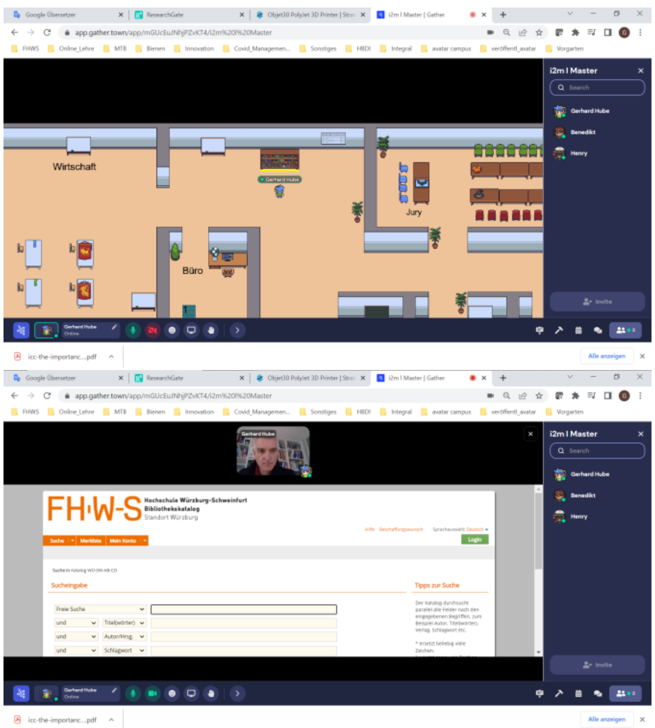

Figure 6. In the upper part of the picture, you can see a bookshelf, which stands freely in the room. Below is the view when you use the bookshelf. This is the online catalog of the university.

B. Measuring instrument

The OLLES questionnaire in its modified 35-item form was used as the measurement instrument [9]. The OLLES questionnaire is a web-based survey instrument for use in online learning environments in tertiary education. In this context, the OLLES questionnaire provides inferences about students' perceptions of interaction opportunities within an online environment in terms of economy and efficiency. The dimensions of the OLLES are Student Collaboration (SC), Computer Competence (CC), Active Learning (AL), Tutor Support (TS), Information Design and Appeal (IDA), Material Environment (ME), and Reflective Thinking (RT). In addition, questions about general computer use and Internet use were also recorded. All items were measured using a 5-point Likert scale.

C. Experimental procedure

Even before the first seminar, all test persons were familiarized with the gather.town environment. Especially the basic functions were tested, so that everybody knows them and can use them independently. In addition, the OLLES questionnaire was introduced, since this was used in its original language English, but the test persons were not native English speakers.

There were a total of four measurement time points. The seminar duration was always from 8:15 am to 13:15 pm. From the start of the test, the seminar was always first held in the gather.town environment and at all four measurement times the entire questionnaire was completed online directly afterwards.

D. Sample

All data were collected at the University of Applied Sciences Würzburg-Schweinfurt within the seminar "trend analysis and innovation assessment" of the master study program "Innovation for small and medium Enterprises". A total of 17 subjects participated in the study. However, there were not measured values from all subjects at all four measurement time points. From two subjects there were only three measured values and from four subjects there were only two measured values. This is still sufficient to form an arithmetic mean. Nevertheless, one subject was excluded from the final analysis because he produced outlier values on three dimensions. This leaves n = 16 valid subjects for the final analysis. The average age of the subjects is 24.44 years, with a minimum of 22 years and a maximum of 30 years. Of the n = 16 subjects, 7 are female and 9 are male.

IV. RESULTS

The first part of the evaluation is purely descriptive and refers exclusively to the mean values of the dimensions of the OLLES questionnaire, as well as the further questions on computer use and Internet use.

In the case of computer use, it was found that all subjects use their computers daily or at least several times a week. In the case of Internet use, it was found that all subjects used the Internet on a daily basis.

When tested for normal distribution with respect to the dimensions of the OLLES, Student Collaboration (SC), Computer Competence (CC), Active Learning (AL), Tutor Support (TS), Information Design and Appeal (IDA), Material Environment (ME), and Reflective Thinking (RT), all were found to be normally distributed. Those descriptive values can be seen in Table 1.

In the second part of the evaluation, the Wilcoxon signed-ranked test was used to examine whether there were differences between the individual measurement points and thus whether there was a change in the evaluation with regard to the repetition of the use of the gather.town environment.

Since a normal distribution could not be determined for all variables, even after the exclusion of six subjects with partly missing values, the Wilcoxon test was used. Here, all requirements were met.

There were only significant differences between measurement time point 3 and measurement time point 4 for the dimensions Student Collaboration (Exact Wilcoxon Test: $z = -2.09$, $p = .037$, $n = 12$) and Material Environment (Exact Wilcoxon Test: $z = -2.41$, $p = .016$, $n = 12$). Otherwise, there were no other significant differences between measurement time points.

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TABLE I. DESCRITIVE ANALYSIS

Descriptive Analysis					
Dimension	***Mean Value***	***Standard Error of the Mean***	***Standard Deviation***	***Minimum Value***	***Maximum Value***
Student Collaboartion (SC)	3,76	0,11	0,42	3,10	4,60
Computer Competence (CC)	4,57	0,11	0,44	3,55	5,00
Active Learning (AL)	3,64	0,13	0,46	2,70	4,60
Tutor Support (TS)	4,10	0,12	0,55	3,20	4,80
Information Design and Appeal (IDA)	3,73	0,12	0,47	2,93	4,80
Material Environment (ME)	3,84	0,07	0,28	3,50	4,45
Reflective Thinking (RT)	3,19	0,16	0,62	2,25	4,10

V. DISCUSSION

In the dimensions of computer use and Internet use, the subjects indicated that they use this on a daily basis. In addition, the gather.town environment and all basic functions were sufficiently explained before the start of the study. Thus, we assume that there were no poor ratings for the environment due to possible lack of technical skills.

All dimensions of the OLLES questionnaire reach high to very high scores. From a purely descriptive point of view, it can therefore be assumed that the gather.town environment is holistically suitable as a learning environment in the tertiary sector. Nevertheless, the individual dimensions will be examined below.

The Student Collaboration (SC) dimension asks in particular about the frequency of communication between students. This includes the question of help and feedback as well as the mutual exchange of information and resources. As already mentioned, studies have shown that collaboration [42] [45] [48] and communication [31] [48] have positive effects on users within a VLE. Therefore, this is an important factor for learning. It can be assumed that high values were achieved here in the evaluation, since gather.town provides enough possibilities, especially through the functions whiteboard, workshops, group discussion and informal encountering, that this can also be used profitably.

The dimension Computer Competence (CC) asks in particular about the assessed competence of one's own computer and Internet use and also the ability to solve minor problems oneself. Since the highest values were achieved here, this further supports the assumption that all subjects had more than sufficient technical skills to use the gather.town environment to its full extent.

The Active Learning (AL) dimension specifically asks about the motivation created, as well as the feedback received through the activities or the teaching unit within the environment itself. Again, various studies already showed that motivation [37] [39] [40] [42] [43] is a crucial factor in the use of VLE's. We assume that especially the varied design of the gather.town environment, but also the use of break rooms led to good scores on this dimension.

The dimension Tutor Support (TS) asks in particular about the participation and accessibility of the tutor. In this respect, the response time to questions and feedback play an important role. Good communication [31] and interaction [48] lead to positively perceived VLEs. The second highest score was obtained for this dimension. This may be due to constant availability and timely communication, as the tutor himself was also always present and responsive within the environment. Therefore, from this perspective, the gather.town environment is well suited for interactive teaching.

The dimension Information Design and Appeal (IDA) asks in particular how creative and original presented teaching materials are and whether graphics used are helpful and visually appealing. This mainly refers to the teaching slides presented as if they were in a presentation. Nevertheless, the colors and walking around within the environment can also have an impact on visual perception and lead to improved learning. In addition, there are the varied break rooms, so that there is also a fairly high rating here.

The dimension Material Environment (ME) asks in particular about the installation process and clarity in using the software. Since very high values were also achieved here, this further supports the point that all test subjects had more than sufficient technical skills to use the gather.town environment to its full extent. In addition, it can also be assumed that the environment is easy to learn and therefore has a high practical value. In general, it can be assumed that VLEs must be accessible and not have too many hurdles to ensure a successful learning environment.

The dimension Reflective Thinking (RT) asks in particular how well subjects were able to learn within the online environment, but also for a comparison to a real classroom. Since the scores here are also good, but lowest, it can be deduced that an online environment can be a sufficient substitute despite having sufficient features that are rated very positively in other dimensions, but real-world classrooms are still the most suitable form of teaching.

Repeated measurement of user ratings of the gather.town environment showed that there was virtually no difference. Although a meta-study by Merchant et al. [12] found small effects in simulation studies in terms of number of sessions, these were measures of learning outcome and not an assessment of the immersive environment as in this study. Therefore, it can be assumed that a one-time survey after the first unit or even after the last unit is quite sufficient.

VI. Conclusion

This study was exploratory in nature with the primary goal of seeing if an immersive 2D environment is holistically suitable for teaching in terms of presence, participation, collaboration, and active learning, and thus an enhancement over classic video transmission tools such as “zoom”, “GoToWebinar” or “Cisco Webex”, and the like. Thus, for now, only an overview of the use of an immersive 2D environment as a learning tool could be provided through this study. Group comparisons with other teaching formats could not yet be made. However, this is the next step in the research. For the next winter semester it is planned to complete the same lecture with a classical video conference tool and to run the same questionnaire. Afterwards a comparison of the two forms of teaching can be made. In addition, it seems to make sense to run another questionnaire in the form of the igroup presence questionnaire (IPQ) to see if there are differences in the sense of presence and how they affect the use. Furthermore, it was found that subsequent interviews may well provide additional important insights. In conversations with students, for example, we found that the gather.town environment was also used by students outside of the seminar to complete other group tasks. In further subsequent studies, I-VR environments can then also be tested in order to be able to make a comparison for this as well. At the moment, there are many indications that hybrid forms of teaching and learning will be used in the future.

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