Using 2D and 3D Desktop based virtual Avatar Environments to weaken Zoom Fatigue in Tertiary Education

Gerhard Hube, Nicholas H. Müller, Christian Möllmann, Hakan Arda
Faculty of Economics and Business Administration and
Faculty of Computer Science and Business Information Systems
University of Applied Sciences Würzburg-Schweinfurt
Würzburg, Germany
e-mail: gerhard.hube@fhws.de, nicholas.mueller@fhws.de, christian.moellmann@study.thws.de, hakan.arda@thws.de

Abstract — **This paper builds directly on the last study, which showed that Zoom Fatigue in online higher education can be reduced by using Zoom avatars instead of the usual camera images. This case study examines whether Zoom Fatigue can be reduced by using desktop-based avatar-based virtual environments. For this purpose, we used gather.town (hereafter Gather) as a 2D desktop-based environment and framevr.io (hereafter Frame) as a 3D desktop-based environment. In addition, the representation of the avatars in Frame varied between a humanoid and a non-humanoid representation. The two virtual environments were used alternately in the course "scenario-based strategy development," a regular lecture of the master's study program "Integrated Innovation Management" at the Technical University of Applied Sciences Würzburg-Schweinfurt, Germany. The same questionnaire was used for the evaluation as in the previous study, which used the Zoom video conferencing system. The result confirms, as in the previous study, an overall relatively low level of perceived Fatigue in both Gather and Frame. However, significant differences in emotional exhaustion were observed, specifically when using the non-humanoid avatar in Frame. Overall, the 2D desktop environment Gather performed better than the virtual environment Frame in all types of Fatigue. To better interpret the results, the findings from the qualitative interviews and possible correlations from the perceived immersiveness will be considered in a next step.**

Keywords - Virtual Learning Environments; Online Teaching; Tertiary Education; 2D and 3D Avatar-Based Desktop Environments; Desktop virtual reality; Zoom Fatigue; gather.town; framevr.io

I. INTRODUCTION

This paper directly follows on from the study published in June 2025 [1]. It was investigated there whether Zoom Fatigue in online higher education teaching could be alleviated by using avatars instead of the classic video camera. Online teaching remains a frequently used form of teaching at universities even after the coronavirus pandemic and is usually implemented using traditional video conferencing systems [2][3]. However, frequent and prolonged use of video conferences can lead to specific symptoms of exhaustion, referred to as "Zoom Fatigue," which can lead to symptoms, such as declining motivation, decreasing ability to concentrate, and even headaches and visual disturbances [4]-[6]. Some of these factors, such as the discomfort of always seeing yourself as a camera image or the feeling of always being watched by others, could be avoided or mitigated using avatar-based virtual learning environments. In the first case study, students therefore used avatars instead of traditional video cameras within the Zoom video conferencing system. This feature of using avatars as participants can be selected within the Zoom video conferencing system as an alternative to the traditional camera [7]. In this first case study, significantly lower levels of perceived general Fatigue were measured when using these Zoom avatars. Subsequently, this paper analyses the impact on Zoom Fatigue, also within the context of a case study with additional avatar-based virtual worlds. For this purpose, the desktop-based virtual environments Gather [8], and Frame [9], were used. Gather is a 2D desktop-based virtual environment, and Frame is a 3D desktop-based virtual world [9]. As in the first case study, the use of the virtual worlds should not only be analysed briefly and case by case, but over the entire period of a full lecture with the same students. Therefore, a lecture was chosen in which the same students changed between the different virtual environments at the same intervals over the course of the semester and were then interviewed.

For a description of the causes and symptoms of Zoom Fatigue, please refer to the paper from March 2025 [1]. In addition to the explanations in the first paper, Section II discusses the related work especially on the use of 2D and 3D desktop-based environments at universities. Section III introduces the two virtual environments used: the 2D desktop-based world Gather in Subsection A and Frame as a 3D desktop environment in Subsection B. Subsections C and D explain the measuring instrument, the experimental procedure, and the sample. The results are presented in Section IV and discussed in Section V. Finally, Section VI concludes the paper and outlines future work.

II. RELATED WORK FOR 2D AND 3D DESKTOP-BASED ENVIRONMENTS

While the use of Zoom at universities became increasingly important during the COVID-19 pandemic, prompting numerous researchers to examine the topic [10]-[12], there are only a few studies that look at the use of 2D and 3D desktop worlds at universities. Offenburg University of Applied Sciences integrates virtual worlds and game technologies into its curriculum, teaching students how to design immersive spaces for various teaching purposes [13]. Aschaffenburg University of Applied Sciences also uses 3D desktop worlds, particularly through its Virtual and Augmented Reality Laboratory, which researches and applies real-time visualizations and virtual learning spaces in a university context [14]. The Technical University of Ilmenau relies on the use of virtual spaces in its field of virtual worlds and digital games to support didactic concepts in various courses [15]. Another example is the University of Bayreuth, which uses 3D and XR media in its "XR Campus" project to supplement university teaching with immersive experiences and to test new approaches to teaching [16].

The case study by McClure et al. [17] examines how Gather can be used as a synchronous virtual learning environment to promote self-directed learning in an interactive setting. The results show that the spatially organized platform gave students greater flexibility in choosing learning materials and interacting with instructors. In addition, the visual and spatial layout facilitated more natural communication, which is often limited in traditional video conferencing systems.

The review paper by Lo and Song [18] summarizes 11 empirical studies on the use of Gather in various educational contexts. The analysis shows that Gather is particularly beneficial for social interactions, group work, and informal exchanges. However, it notes that there is still a lack of long-term studies on the platform's effectiveness across academic disciplines. The authors also highlight technical and organizational challenges that should be addressed in future research.

In addition to these studies, the Rady School of Management at the University of California, in collaboration with Waseda University in Tokyo, has launched a micro-MBA program that uses Virbela's virtual environment [19] to create a purely digital campus. Thanks to this collaboration, the Rady School of Management was able to replicate its physical university environment in a virtual world. This gave students, professors, and executives from around the world the opportunity to network, further their education, and acquire knowledge in a custom-designed and inspiring digital space [20].

The Technical University of Würzburg-Schweinfurt has been researching this topic for several years and has published various articles on the subject [23]-[25]. These articles examined the suitability of immersive 2D learning environments in comparison to traditional video conferencing systems. It was shown that the 2D desktop-based environment is suitable for university teaching in the tertiary sector and is preferred by students [22]. According to Ratan, using an avatar instead of one's own video image reduces self-referential attention, which can significantly reduce fatigue [24]. The use of avatars has been proposed as a method to address students' social anxiety and hesitancy to interact with other people through video conferencing tools [25]. A study with students showed that the avatar-based interaction effectively alleviated students' concerns and negative emotions. The current findings support the potential mitigation effect of avatar-based interaction on social anxiety during video conferencing-based online learning [26]. In a study, Lee compared the use of Zoom versus Gather for project work by undergraduate students. Zoom fatigue was not explicitly measured, but the results showed that Gather significantly increased the sense of presence, group cohesion, and emotional involvement [27]. To the best of our knowledge, no previous studies have investigated the effects of avatars within 2D and 3D desktop-based virtual environments on Zoom fatigue in direct comparison in tertiary education.

III. Method

In the following, we present the environments used in this study. Subsection A introduces Gather as a 2D desktop-based environment, while Subsection B describes Frame as a 3D desktop-based environment. Subsection C presents the measuring instruments, Subsection D outlines the experimental procedure, and Subsection E explains the sample.

A. Gather.town

Gather, combines virtual rooms with an interactive platform that also allows for gamification. As a virtual learning environment, Gather stands out thanks to its combination of video communication and a two-dimensional, spatial representation in which users can move around with the help of avatars [8].

Figure 1. Virtual lecture room for the I2M master's program in Gather

The tool differs from Zoom and Frame primarily in its two-dimensionality and the ability to not only see each other via video, but also to move around the rooms at the same time. Using a simple avatar that represents each user, they can move around in the so-called space, the tool's environment. Gather integrates many gamification elements that can be incorporated into the virtual environment, for example through special movement and interaction options. It is also possible to create small games or design special rooms imaginatively and use them for special events or activations. Interaction is context-dependent: users can only communicate with people or objects in their vicinity. Gather offers synchronous interactions for this purpose, such as live video communication or the chat function. The communication radius is defined by the proximity of the avatars. In Gather, users can customize and adapt their own avatars to represent themselves in the virtual environment. The avatars are pixelated figures that can navigate a 2D space, like classic video games. Various features, such as skin colour, hairstyle, clothing, and accessories, can be customized to give each participant a unique appearance (see Figure 2).

Figure 2. Ways to design avatars [28]

In addition, users can add animations and movements to their avatars to make their presence in meetings or events more dynamic. For example, avatars can be made to clap, and when several avatars participate, a loud clapping and cheering sound audible to everyone is heard [28].

In addition to the lecture room (see Figure 1), workshop rooms can also be used in Gather. Workshop rooms are smaller rooms that provide fewer seats than the large seminar rooms. Here, there are tables with seats and a whiteboard. Thus, 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 presentations (see Figure 3).

The environment includes various interactive objects. In the entrance area, a blackboard displays the timetable, and a video tutorial explains the platform's functions. A bookcase provides access to the university's online catalogue for literature searches (Figure 4).

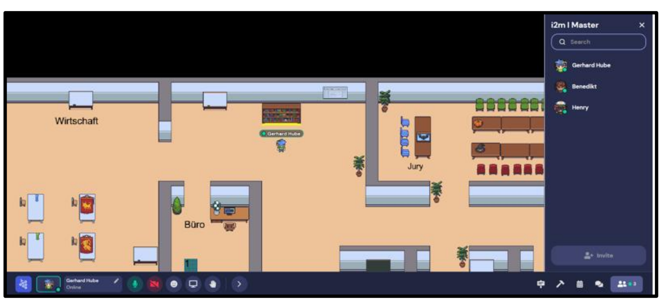

Figure 3. A small workshop room with several seats and a whiteboard in the room.

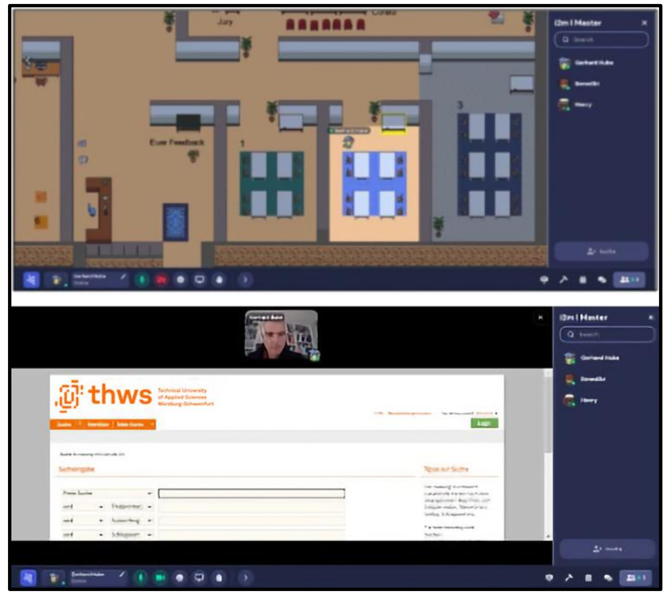

Figure 4. Bookcase and online catalogue

B. Frame

Frame as a Virtual Learning Environment is a platform specializing in virtual reality. Frame's functions lie in the communication of content through an immersive game world, where meetings can be supplemented with extensive gamification tools. The fundamental difference to Gather lies in its three-dimensionality. Users can create their own worlds and depict them realistically [9].

The environment can be designed interactively to seamlessly embed learning materials, such as videos, presentations, whiteboards, or 3D models. Figure 5 shows how lecture slides are presented as interactive objects in a virtual 3D space. The avatars, in this case the students, can move around the environment and view the content from different perspectives.

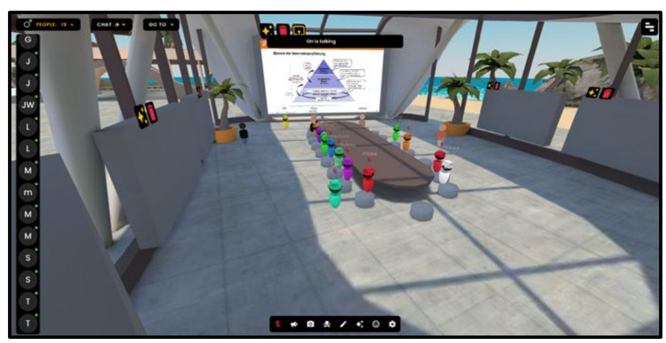

Figure 5. Virtual lecture room for the I2M master's program in Frame

Frame offers various types of avatars that serve to support user interaction and identification in the virtual environment. Options include simple avatars consisting of minimalist representations that convey a basic presence in the room. For greater personalization, standardized 3D avatars are available that are animated and enable movements, such as walking or gesturing. In addition, there are customizable avatars that

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allow users to individually design aspects, such as clothing, colours, hairstyles, or facial features. It is also possible to integrate avatars from the "Ready Player Me" platform [29], which is widely used in the gaming world. Only the avatars offered by Frame were used in this study (Figure 6).

Figure 6. Different avatar types in Frame: Android, humanoid and Ready Player Me

Various gamification options are possible in Frame. These can be personalized and designed in detail and interactively. Various games were used in the module to supplement the lecture content. Figure 7 shows a quiz that was designed in the virtual environment and used to activate questions about the lecture content. First, a knowledge question about the lecture content was asked and displayed across the three large fields. Each of the three fields now represented an answer, but only one of them was correct. The students were then asked to run with their avatar to the field with the answer they thought was correct within a specified time. The correct answer was then revealed by a shower of confetti falling on the correct field.

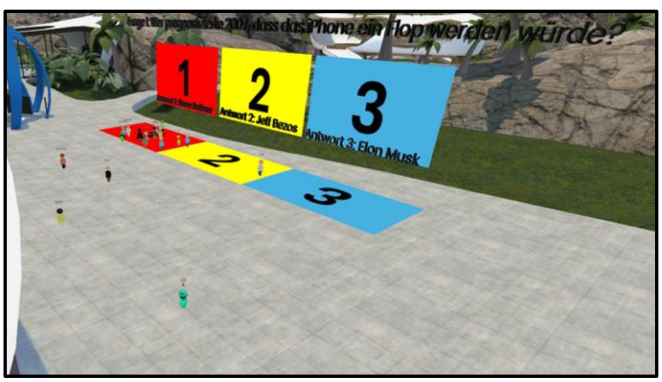

Figure 7. Gamification element: Quiz

C. Measuring Instrument

The Stanford Virtual Human Interaction Lab developed a scale (ZEF scale) that aims to systematically assess the specific stress and Fatigue symptoms that arise from the intensive use of video conferencing [30]. The ZEF scale is divided into 5 "Constructs" and 3 questions each. Based on this scale, 5 questions were selected, one from each "Construct", to obtain a comprehensive impression but, at the same time, to limit the scope of the questions. To include also Zoom Fatigue causes four questions were added. The first asks about the lack of opportunities for informal communication and the second about stimulating and inspiring aspects of the environment [31]. The third question is about the discomfort of constantly seeing one's own image in the video tile, and the fourth addresses the feeling of being watched by others. All items were measured using a 5-point Likert scale. The whole questionnaire is shown in Table I.

TABLE I. QUESTIONNAIRE FOR ZOOM FATIGUE SYMPTOMS AND CAUSES

Zoom fatigue symptoms			
Item/Question	1	General fatigue	I felt exhausted after a lecture
Item/Question	2	Visual fatigue	I had visual problems after a lecture
Item/Question	3	Social fatigue	After a lecture, I avoided social situations
Item/Question	4	Motivational fatigue	After a lecture, I felt like doing nothing
Item/Question	5	Emotional fatigue	I felt emotionally drained after a lecture
Zoom fatigue causes			
Item/Question	6	Networking Opportunities	In the virtual environment, I had opportunities for informal exchange and networking.
Item/Question	7	Stimulating environment	I found the virtual environment stimulating and inspiring.
Item/Question	8	Self-mirroring	I found it uncomfortable to constantly see myself on the screen.
Item/Question	9	Feeling observed	I feel uncomfortable thinking that others are observing my video image.

D. Experimental procedure

The study was done within the lecture "scenario-based strategy development" (from here just "strategy") of the master study program "Integrated Innovation Management" at the Technical University of Applied Sciences Würzburg-Schweinfurt Germany. The lecture was given in the winter semester 2024 from December 2024 until January 2025 on 6 days. The seminar duration was always from 9:00 am to 13:15 pm. The first two lecture dates were given in the virtual environment Gather. The following two lecture dates were given also online with Frame using the non-humanoid avatar given by Frame and called "Android avatar". The last two lecture dates kept within the Frame environment, but the avatars were switched to the humanoid appearance also given by Frame. The total of three measurement time points always took place directly at the end of the three different sections of learning environments as online questionnaire. The questions were given in German language.

E. Sample

A total of 17-20 subjects participated in the three measurement time points (average of 18.33). The average age of the subjects is 24.88 years, with a minimum of 22 years and a maximum of 31 years. The gender of the participants was divided into 8–9 male and 9–11 female.

IV. Results

The results section is divided into different areas. First, there is an analysis for the descriptive statistical data in Section A. Section B contains several variance analyses to see if there are significant differences between the three different learning environments in terms of Zoom Fatigue items based on the ZEF scale. To analyse possible relationships between the symptoms and causes of Zoom Fatigue, the results of a regression analysis are presented in Section C.

A. Analysis of Descriptive Statistics

As described in Section III, three different learning environments were used in the lecture strategy, Gather, Android avatar without camera and humanoid avatar without camera. All environments were used within two lecture dates each from 09:00–13:00 pm. Generally, the level of Fatigue is not quite high regarding the maximum scale of 5. Only one item gets above 3.5 as shown in Table III. This is General Fatigue at Android avatar teaching with 3.67. All the other Fatigue items are between 2.20 for Social Fatigue with Gather teaching and 3.29 for General Fatigue with humanoid avatar. Looking at the average values for each Fatigue item above the three different environments, the range is between 3.35 for General Fatigue and 2.25 for Visual Fatigue. Overall, it can be said that only a moderate level of exhaustion could be measured with almost always under 3.00 except the general Fatigue.

TABLE II. DESCRIPTIVE ANALYSIS ZOOM FATIGUE SYMPTOMS

Learning environment	N	Mean	Standard Deviation	Minimum	Maximum
General fatigue					
Gather.Town	19	3.11	0.809	2	4
Android Avatar	18	3.67	0.907	2	5
Humanoid Avatar	17	3.29	1.263	1	5
Total	54	3.35	1.012	1	5
Visuell fatigue					
Gather.Town	20	2.20	1.005	1	4
Android Avatar	18	2.33	1.188	1	5
Humanoid Avatar	17	2.24	1.091	1	4
Total	55	2.25	1.075	1	5
Social fatigue					
Gather.Town	20	2.20	0.834	1	3
Android Avatar	18	2.94	1.259	1	5
Humanoid Avatar	17	2.53	0.943	1	4
Total	55	2.55	1.051	1	5
Motivational fatigue					
Gather.Town	20	2.40	0.940	1	4
Android Avatar	18	2.89	1.079	1	4
Humanoid Avatar	17	2.94	1.029	1	4
Total	55	2.73	1.027	1	4
Emotional fatigue					
Gather.Town	20	2.30	0.865	1	4
Android Avatar	18	3.17	0.924	1	4
Humanoid Avatar	17	2.94	0.899	1	4
Total	55	2.78	0.956	1	4

B. Analysis of Variance for significant differences

In the following, the five items relating to zoom fatigue symptoms are tested for differences between the mean values of the three surveys using a one-factor analysis of variance (ANOVA). Since the number of test subjects is less than 30, in addition to the one-factor analysis of variance, the Kruskal-Wallis rank variance analysis (H-test) was also calculated [32]. In the one-factor analysis of variance, only the assessment of emotional exhaustion is significant ($p = 0.012$). The effect size η^2 is 0.157 and can therefore be classified as large, as shown in Table III.

TABLE III. UNIVARIATE ANALYSIS OF VARIANCE

Emotional fatigue	Sum of squares	df	Mean of the squares	F	P =	η^2 =
Between groups	7.741	2	3.870	4.833	0.012	0.157
Within groups	41.641	52	0.801			
Total	49.382	54	0.914			

The result of the ANOVA is confirmed by the Kruskal–Wallis H-test. Here, too, only the omnibus test for emotional exhaustion is significant with $p = 0.013$. Both tests therefore conclude that there are significant differences between the three groups overall. The subsequent post hoc tests show, both in the ANOVA and in the H-test, that the groups differ significantly in their use of Gather and Android avatar.

The p-value for the comparisons with these two environments is clearly significant at 0.012 (ANOVA) and 0.014 (H-test), as can be seen in Table IV. In the ANOVA, a large effect size ($d = 0.971$) is measured, while in the H-test, the effect size r is slightly below 0.5 at 0.460 and is therefore only moderately pronounced. Thus, it can be said that emotional exhaustion is significantly higher when using Android avatar than when using Gather. In addition, the greater emotional exhaustion is significant in practice.

TABLE IV. ANOVA AND KRUSKAL–WALLIS H-TEST

Emotional fatigue							
Post Hoc Tests: Anova Group combinations	**N 1**	**N 2**	**Mean 1**	**Mean 2**	**Mean difference**	**p =**	**Power d =**
Gather.Town (4) & Android Avatar (5)	20	18	2.30	3.17	0.87	0.012	0.971
Gather.Tow (4) & Humanoid Avatar (6)	20	17	2.30	2.94	0.64	0.086	0.728
Android Avatar (5) & Humanoid Avatar (6)	18	17	3.17	2.94	-0.23	0.738	-0.247
d > 0.8 = large power							
Emotional fatigue							
Post Hoc: Kruskal & Wallis H-Test Group combinations	**N 1**	**N 2**	**Average rank 1**	**Average rank 2**	**Average difference**	**p =**	**Power r =**
Gather.Town (4) & Android Avatar (5)	20	18	20.25	34.33	14.08	0.014	-0.460
Gather.Tow (4) & Humanoid Avatar (6)	20	17	20.25	30.41	10.16	0.132	-0.331
Android Avatar (5) & Humanoid Avatar (6)	18	17	34.33	30.41	-3.92	1.000	0.128
r > 0.3 = medium power							

C. Analysis Zoom Fatigue causes

As explained in Section I, a distinction can be made between symptoms and causes of Zoom fatigue. For the symptoms of Zoom fatigue, a selection of five items from the ZEF Scale was chosen and used in the questionnaire. For the causes of Zoom fatigue, as explained in Section I, two positive and two negative aspects were selected that specifically address the differences between virtual learning environments and traditional video conferencing systems. Positive aspects are item 6, the opportunity to exchange ideas and network informally, and item 7, an inspiring environment. Negative aspects include item 8, having to observe oneself, and item 9, discomfort with others seeing one's own video image. Since neither Gather nor Frame Video were used, the latter two variables are ruled out as possible causes.

Now we will examine whether items 6 and 7 could be the cause of emotional exhaustion. First, we will provide a descriptive overview of items 6 and 7. Second, these items are correlated with emotional exhaustion. Since the number of cases is very low, both Pearson's r and Spearman's rho are used, as shown in Table V. Third, a multiple linear regression is calculated. With this method, it is possible to calculate not only correlations, as in a correlation, but also the directed influences of these two items on emotional exhaustion.

TABLE V. DESCRIPTIVE ANALYSIS ZOOM FATIGUE CAUSES

Zoom fatigue causes	N	Mean	Standard Deviation	Minimum	Maximum
Item 6: I had the opportunity for informal exchange and networking in the virtual environment					
Gather.Town	20	3.30	1.281	1	5
Android Avatar	18	3.33	1.320	1	5
Humanoid Avatar	17	3.29	1.302	1	5
Total	55	3.31	1.298	1	5
Item 7: I found the virtual environment stimulating and inspiring					
Gather.Town	20	3.20	0.914	1	5
Android Avatar	18	2.72	0.996	1	5
Humanoid Avatar	16	2.69	1.093	1	5
Total	54	2.89	0.974	1	5

As the table above shows, the mean values for item 6 for the individual learning environments are all between 3.30 and 3.33. It can be assumed that there are no significant differences between the three learning environments in terms of networking opportunities. The situation is different for item 7, where the mean values are somewhat further apart. The Gather learning environment has a mean value of 3.20, while the other two learning environments have a mean value of approximately 2.7. Gather is rated as more stimulating and inspiring than the other environments. However, variance analyses (ANOVA, Kruskal–Wallis) show no significant differences for either item 6 (p = 0.993/0.989) or item 7 (p = 0.408/0.382). Post hoc tests were likewise not significant, so no tables are provided. The next section examines correlations with emotional exhaustion.

TABLE VI. CORRELATION TO EMOTIONAL FATIGUE

	Gather.Town		Android Avatar		Humanoid Avatar	
	r	Rho	r	Rho	r	Rho
Item 6: I had the opportunity for informal exchange and networking in the virtual environment						
Correlation	-0.299	-0.313	0.309	0.186	0.545	0.512
p =	0.201	0.180	0.211	0.459	0.024	0.036
N =	20	20	18	18	17	17
Item 7: I found the virtual environment stimulating and inspiring						
Correlation	-0.010	-0.066	0.137	0.146	0.253	0.146
p =	0.968	0.781	0.588	0.562	0.344	0.589
N =	20	20	18	18	16	16

r = Pearson's r
Rho = Spearman's Rho

Only item 6 correlates significantly with emotional exhaustion at the event with humanoid avatars. All other correlations have p-values > 0.05. The correlations are both above 0.5 (Pearson's r = 0.545; Spearman's rho = 0.512). This shows a strong correlation between the two items. In terms of content, using the "humanoid avatar" increases emotional exhaustion due to the opportunity for informal exchange and networking.

This raises the question of why this connection cannot be found in the other two learning environments. Looking at the level of correlations, these range from 0.186 to -0.313, which is in the range of mild to moderate correlations. Apparently, coordination in virtual space with human avatars requires a systematically higher degree of emotionality than in the other two virtual environments. To measure more than just the correlation between individual variables, as in the correlation analysis above, multiple linear regression is also used. This makes it possible to measure the simultaneous effect of items 6 and 7 on emotional exhaustion (item 5). The independent influences of the individual variables on the dependent variable are measured. Item 5 is the dependent variable, Items 6 and 7 are the independent variables. Since Item 6 varies by learning environment, two dummy variables were added to control for these effects. The goodness-of-fit test for multiple linear regression yielded the following results: N = 54, R = 0.432, $R^2 = 0.187$, adjusted $R^2 = 0.120$, the model is significant with p = 0.035. The R^2 of 0.187 means that 18.7% of the variance of item 5 is explained by the two variables 6 and 7 and the two dummy variables. With R = 0.432, the model has a moderate explanatory power. The results for the individual influences are shown in Table VII.

TABLE VII. MULTIPLE LINEAR REGRESSION FOR ITEMS 6 AND 7 ON ITEM 5 (EMOTIONAL FATIGUE)

Coefficients	Non-standardized coefficients B	Standard Deviation	Standardized coefficients β	T	p =
Constant	2.654	0.429		6.188	0.000
Item 6	0.175	0.160	0.201	1.092	0.280
Item 7	-0.026	0.137	-0.035	-0.187	0.853
Dummy: Gather	-0.849	0.298	-0.435	-2.850	0.006
Dummy: Humanoid Avatar	-0.278	0.306	-0.135	-0.907	0.369

Dependent Variable: Item 5 Emotional Fatigue
Item 6: I had the opportunity for informal exchange and networking in the virtual environment
Item 7: I found the virtual environment stimulating and inspiring
Dummy: Gather (Gather.Town = 1, Android Avatar & Humanoid Avarar = 0)

Looking at the p-values across all variables, only the dummy variable "Gather" shows a significant influence with p = 0.006. It is interesting to compare this with the results of the ANOVA, or rank variance analysis according to Kruskal & Wallis (Table IV). This showed that the mean values of the two learning environments Gather and Android avatar differ significantly. This result can also be found here. Since the Android avatar learning environment was not included in the analysis as a dummy, it forms the contrast to the Gather and Humanoid Avatar learning environments. The term "contrast" here means that the Android avatar learning environment is included in the constants and is therefore not shown separately. The results of the two dummies can therefore be interpreted in comparison to Android avatar. In terms of content, this means that the Gather learning environment significantly reduces emotional exhaustion compared to the Android avatar learning environment (p = 0.006). The Humanoid Avatar learning environment also reduces emotional exhaustion compared to the Android avatar learning environment, but not significantly (p = 0.369). This shows that the Gather learning environment has an independent and reducing influence on emotional exhaustion. The causes (items 6 & 7) of emotional exhaustion do not show any significant influences on emotional exhaustion.

V. Discussion

This study examined the phenomenon of “Zoom fatigue,” i.e., symptoms of exhaustion caused using online courses. Applied to academic courses, the question arose as to whether the severity of exhaustion symptoms varies depending on the learning environment. In addition to previous studies, this study investigated whether there are significant differences between different avatar-based virtual courses.

This is the case. Both the post-hoc tests of the ANOVA and the H-test, as well as the multiple linear regression, showed that the emotional exhaustion between Gather and Android avatar differs significantly. On a scale of 1-5, emotional exhaustion in Gather has a mean value of 2.30, while in Android avatar it has a mean value of 3.17. The difference of 0.87 scale points is significant and corresponds to a large effect with Cohen's d = 0.971.

However, the overall level of exhaustion is not particularly high. The five items of Zoom Fatigue according to the ZEF scale could be rated on a scale from 1 “does not apply at all” to 5 “applies completely.” Although the courses lasted more than 4 hours at a time on the respective days, the mean values of the items across all three teaching environments ranged between 2.20 and 3.67. For the individual items, the highest mean value for general exhaustion (item 1) was 3.67 for the Android avatar, followed by the humanoid avatar with 3.29.

The correlations showed that there is a significant relationship between networking (item 6) and emotional fatigue. The more intensely the positive aspect of informal exchange and networking is perceived, the higher the perceived exhaustion. However, this could not be confirmed in the multiple linear regression. Instead, it appears that this item has no independent influence on emotional exhaustion. Rather, the use of Gather reduces emotional exhaustion ($\beta = -0.435$).

This study thus reveals two opposing trends: On the one hand, emotional exhaustion correlates strongly with the opportunity to network in the humanoid avatar learning environment. However, when this individual observation is incorporated into a multiple linear regression, this effect disappears. Instead, the Gather learning environment has a reducing effect on emotional exhaustion compared to the use of the Android avatar.

VI. Conclusions and Outlook

As described in the previous sections, a relatively low level of fatigue was observed in the various learning environments. This confirms the results of the previous study, which also measured a low overall level when using Zoom [1]. It is possible that the relatively young age of the test group makes them more resilient and better able to maintain concentration and receptiveness in courses. It is also possible that the intrinsic motivation of students in a master's program is generally high, as the choice of master's program is usually made deliberately. Gather is perceived by students as the environment with the lowest level of exhaustion in all types of exhaustion. Within the three-dimensional environment Frame, the use of the non-humanoid avatar (“Android” avatar) is perceived as particularly emotionally exhausting. Gather, on the other hand, significantly reduces this emotional exhaustion ($\beta = -0.435$). It is assumed that the three-dimensional environment Frame was perceived as more strenuous to use overall, as the controls are more diverse and complex, and movement and orientation in three-dimensional space require greater attention. In comparison, Gather is relatively easy to use and control and offers a simple and quick overview of the world used. Nevertheless, the opportunity for informal communication and networking is rated equally highly in all three variants. However, the surprising result was that Gather, as a two-dimensional environment, was perceived as more stimulating and inspiring than Frame. It was expected that Frame would have a more stimulating effect due to the expanded spatial impressions of a three-dimensional environment. Perhaps here, too, a certain “overload” of functional and visual possibilities is more overwhelming than stimulating. This result, as well as the specific influences of avatar appearances on emotional exhaustion and the possibility of informal work, will be analysed in depth in a further paper with the help of the results from the qualitative interviews.

References

[1] G. Hube, N. H. Mueller, C. Moellmann, and H. Arda, “Using Zoom avatars to weaken Zoom fatigue in tertiary education,” in Proc. eLmL 2025 – 17th Int. Conf. Mobile, Hybrid, and On-line Learn., 2025.

[2] G. Q. Hu, “Qualitative analysis of students’ online learning experiences after the university reopening,” J. Educ. Humanit. Soc. Sci., vol. 7, pp. 115–134, Jan. 2023, doi:10.54097/ehss.v7i.4074.

[3] DIW Berlin, “Remote work remains widespread even after the end of pandemic measures,” [Online]. Available from: https://www.diw.de/sixcms/detail.php?id=diw_01.c.923317.de [retrieved: Sept., 2025].

[4] A. Carțiș, “Zoom fatigue in higher education: Videoconferencing impact on students’ fatigue,” in Education Facing Contemporary World Issues - EDU WORLD 2022, vol. 5, pp. 1355–1364, 2023, doi:10.15405/epes.23045.138.

[5] L. Knox, S. Berzenski, and S. Drew, “Measuring Zoom Fatigue in college students: Development and validation of the meeting Fatigue scale for videoconferencing (MFS-V) and the meeting Fatigue scale for in-person (MFS-I),” Media Psychology, advance online publication, 2023, doi:10.1080/15213269.2023.2204529.

[6] A. Ngien and B. Hogan, “The relationship between Zoom use with the camera on and Zoom Fatigue: Considering self-monitoring and social interaction anxiety,” Inf. Commun. Soc., vol. 26, no. 10, pp. 2052–2070, 2023, doi:10.1080/1369118X.2022.2065214.

[7] Zoom Video Communications, Inc., [Online]. Available from: https://zoom.us [retrieved: Sept., 2025].

[8] Gather.town, Product Overview, 2023, [Online]. Available from: https://www.gather.town [retrieved: Sept., 2025].

[9] Frame VR, Introduction to Virtual Reality Learning Environments, 2023, [Online]. Available from: https://www.framevr.io [retrieved: Sept. 26, 2025].

[10] N. Hopf and E. Berger, “Zoom Fatigue – A phenomenon in distance learning: Two studies using value-differentiated quantitative and qualitative analyses,” R&E-SOURCE, 2022, [Preprint], doi:10.53349/resource.2022.iS22.a1058.

[11] University of Ulm, “Fatigue caused by online meetings? Study explores the phenomenon of ‘videoconference fatigue’,” Uni-Ulm.de, 2022, [Online]. Available from: https://www.uni-

ulm.de/in/fakultaet/in-detailseiten/news-detail/article/videokonferenz-muedigkeit/ [retrieved: Sept., 2025].

[12] V. Charoenporn t., “Zoom fatigue related to online learning among medical students in Thailand: Prevalence, predictors, and association with depression,” F1000Research, vol. 13, p. 617, 2024, doi:10.12688/f1000research.146084.2.

[13] Offenburg University of Applied Sciences, “Virtual Worlds and Game Technologies,” [Online]. Available from: https://www.hs-offenburg.de/studium/studiengaenge/bachelor/virtuelle-welten-und-game-technologies/studieninteressierte?utm [retrieved: Sept., 2025].

[14] Aschaffenburg University of Applied Sciences, “Laboratory for Virtual and Augmented Reality,” [Online]. Available from: https://www.th-ab.de/hochschule/organisation/organisationseinheiten/labor-fuer-virtual-und-augmented-reality?utm [retrieved: Sept., 2025].

[15] Ilmenau University of Technology, 2023, [Online]. Available from: https://www.tuilmenau.de/universitaet/fakultaeten/fakultaet-wirtschaftswissenschaften-und-medien/profil/institute-und-fachgebiete/fachgebiet-virtuelle-welten-und-digitale-spiele/lehre?utm [retrieved: Sept., 2025].

[16] University of Bayreuth, 2023, [Online]. Available from: https://www.zhl.uni-bayreuth.de/de/projekte/xrcampus/index.html?utm [retrieved: Sept., 2025].

[17] C. D. McClure and P. N. Williams, “Gather.town: An opportunity for self-paced learning in a synchronous, distance-learning environment,” *Compass: J. Learn. Teach. High. Educ.*, vol. 14, no. 2, pp. 1–17, 2021.

[18] C. K. Lo and Y. Song, “A scoping review of empirical studies in gather.town,” in Proc. 11th Int. Conf. Inf. Educ. Technol. (ICIET), Fujisawa, Japan, 2023, pp. 1–5, doi:10.1109/ICIET56899.2023.10111430.

[19] Virbela LLC, [Online]. Available from: https://www.virbela.com [retrieved: Sept., 2025].

[20] UC San Diego, “Virtual learning case study: Virbela,” [Online]. Available from: https://www.virbela.com/case-studies/ucsd [retrieved: Sept., 2025].

[21] G. Hube, K. Pfeffel, and N. H. Müller, “2D virtual learning environments for tertiary education,” *Int. J. Adv. Syst. Meas.*, vol. 15, no. 3 & 4, pp. 81–92, 2022.

[22] G. Hube, K. Pfeffel, and N. H. Müller, “Comparison of 2D virtual learning environments with classic video conferencing systems for tertiary education,” in Proc. IARIA Congr. – Int. Conf. Tech. Adv. Human Consequences, 2023, pp. 1–5.

[23] G. Hube and N. H. Müller, “Further comparison of 2D virtual learning environments with classic video conferencing systems for tertiary education,” in Proc. ACHI 2024 – The Seventeenth Int. Conf. on Advances in Computer-Human Interactions, May 26–30, 2024, Barcelona, pp. 7–9.

[24] R. A. Ratan et al., “Facial appearance dissatisfaction explains differences in videoconferencing fatigue,” Cyberpsychol. Behav. Soc. Netw., vol. 25, no. 8, pp. 491–499, 2022, doi:10.1089/cyber.2021.0112.

[25] I. Park, Y. J. Sah, S. Lee, and D. Lee, “Avatar-mediated communication in video conferencing: Effect of self-affirmation on debating participation focusing on moderation effect of avatar,” Int. J. Hum.–Comput. Interact., vol. 39, no. 30, pp. 464–475, 2023, doi:10.1080/10447318.2022.2041897.

[26] J. Lim and M. Lee, “The buffering effects of using avatars in synchronous video conference-based online learning on students’ concerns about interaction and negative emotions,” Educ. Inf. Technol., vol. 29, no. 12, pp. 16073–16096, 2024.

[27] Y. Lee, J.-H. Jung, H. Kim, M. Jung, and S.-S. Lee, “Comparative case study of teamwork on Zoom and gather.town,” Sustainability, vol. 15, no. 2, Art. no. 1629, 2023, doi:10.3390/su15021629.

[28] Gather.town, “Customize your avatar,” 2023, [Online]. Available from: https://support.gather.town/hc/en-us/articles/15910013784852-Customize-Your-Avatar [retrieved: Sept., 2025].

[29] Ready Player Me, [Online]. Available from: https://readyplayer.me/de [retrieved: Sept., 2025].

[30] G. Fauville, M. Luo, A. Queiroz, J. N. Bailenson, and J. Hancock, “Zoom exhaustion & fatigue scale,” 2021, [Online]. Available from: http://dx.doi.org/10.2139/ssrn.3786329 [retrieved: Sept., 2025].

[31] J. Rump, “Zoom fatigue: When tiredness occurs in virtual meetings,” Haufe.de, 2021, [Online]. Available from: https://www.haufe.de/personal/hr-management/zoom-fatigue_80_542234.html [retrieved: Sept., 2025].

[32] W. H. Kruskal and W. A. Wallis, “Use of ranks in one-criterion variance analysis,” J. Am. Stat. Assoc., vol. 47, no. 160, pp. 583–621, 1952, doi:10.1080/01621459.1952.10483441.