Increasing User Engagement in Virtual Reality:The Role of Interactive Digital Narratives to Trigger Emotional Responses

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ABSTRACT

Immersive multimedia technologies such as virtual reality (VR) create narrative experiences in the digital medium, thus revolutionizing how people communicate, learn, and think. These Interactive Digital Narratives (IDN) shape end-users' experience with a broad potential for various applications. A fundamental aspect of achieving this potential is the establishment of a positive and engaging user experience. This study investigates how enabling the interactive narrative in a VR setting affects the engagement of the users. The study we base this work on involved thirty-two participants in a controlled experiment where they were asked to explore a designed VR environment, with and without a digital narrative. We observed a significant increase in the participants' level of engagement in the narrative-based environment compared to the non-narrative VR environment. The results showed how the IDN in VR generates an increased emotional response, strengthening the users' engagement, showing that IDN can be considered an essential factor in shaping the positive experience of end-users, thus shaping a better society.

CCS CONCEPTS

• **Human-centered computing** → **User studies**; **Virtual reality**; • **Hardware** → **Emerging tools and methodologies**.

KEYWORDS

Virtual Reality; Experience Design; User experience evaluation; User experience design; Immersive Multimedia Experiences; Interactive Digital Narrative; Engagement; presence

ACM Reference Format:
Shafaq Irshad and Andrew Perkis. 2020. Increasing User Engagement in Virtual Reality:The Role of Interactive Digital Narratives to Trigger Emotional Responses. In *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society (NordiCHI '20), October 25–29, 2020, Tallinn, Estonia.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3419249.3421246

NordiCHI '20, October 25–29, 2020, Tallinn, Estonia

ACM ISBN 978-1-4503-7579-5/20/10.
https://doi.org/10.1145/3419249.3421246

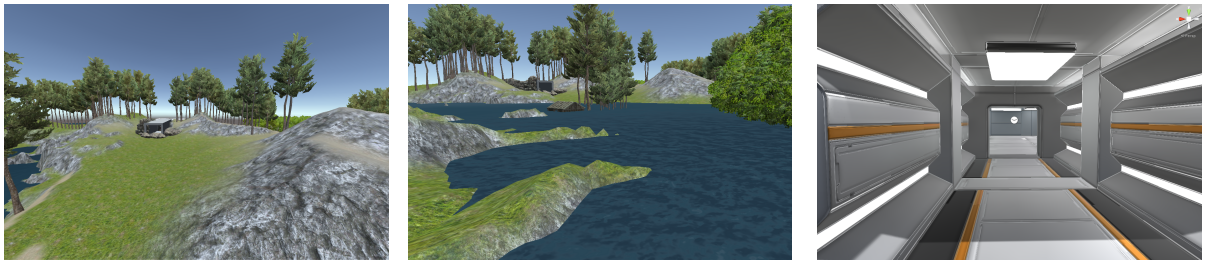
1 INTRODUCTION

Interactive Digital Narrative (IDN) is a form of digital interactive experience in which users create or influence the storyline through their actions [12]. These digitally augmented stories or narrations play an essential role in passing information through interactive digital media hence inaugurating a new form of storytelling called Interactive Digital Narrative [10]. IDN has revolutionized the way people communicate, learn, and think. When incorporated in modern-day immersive multimedia technologies such as Virtual Reality (VR), IDN can be used to enhance learning and training through various applications and platforms such as serious gamification.

VR is an interactive computer-generated experience taking place within a simulated virtual environment [16]. It incorporates auditory and visual feedback but may also allow other types of sensory feedback such as haptic. Because of this sensory feedback, the user becomes visually immersed in a computer-generated three-dimensional VR scene [14]. The past several decades have seen an onset of interest in VR technologies, with this multifaceted domain becoming a central concern in a wide range of disciplinary fields and research contexts [4]. VR has become inherently interactive, and their dependence on narrative has gradually increased [13]. VR can now be used to provide learners with a virtual environment where they can develop their skills through IDN without real-world consequences [5].

Several studies have been performed on evaluation of performance, quality modelling and assessment of VR [2, 3, 15]. Researchers have also proposed various strategies and metrics for VR systems evaluation[7]. Similarly, there is work on defining , designing and evaluating IDN in VR [1, 11]. Studies have been done in defining the dimensions and underlining concepts of VR experiences[16], however, few researchers have worked on modelling and assessing the experience resulting from using immersive and interactive digital narratives (IDN)[6] There are not many studies present that address the influence of IDN and storytelling on VR systems and how it shapes the end user experience. In order to produce positive VR , IDN needs to be incorporated in the design [6].

This research presents design and evaluation of a virtual reality serious game and demonstrates how incorporating IDN in VR serious gaming can shape a better experience and understanding for end users. The research study is part of a project where we intend to create digital twins of natural hazards with knowledge on interactive digital storytelling and human behavior to create immersive user experiences based on real data, realistic scenarios



(a) Non-narrative based VR experience (b) Narrative based VR experience (c) tunnel

Figure 1: Immersive environments showing non-narrative vs narrative VR setups

and simulations. Experiences derived from the VR will be used for preventive and emergency measures to save lives and cost thus shaping society in a better way. In the following paper our goal is to measures the influence of IDN on a VR environment through subjective user evaluation . The main objective of this research is to explore how IDN affect the user experience in an immersive VR environment in terms of user engagement. This is done through an experimental study where subjective evaluations are performed in VR with two groups i.e. non-narrative based controlled group (G1-NN) vs the narrative-based experimental group (G2-N). The following sections present the detailed methodology, results and discussion of the experimental study.

2 METHODOLOGY

2.1 Participants

Our research is done by using participants in a controlled experiment generating data to be analyzed. Our experiment comprised 32 participants between the ages of 25 and 44 (56.25% of them were male and 43.75% were females). Participants were recruited based on their familiarity with computer technologies such as VR. Almost all the participants were skilled in using the computer to some extent, with 43.8% being intermediate users.

2.2 Experimental Setup and Design

VR experience was delivered using a standalone Oculus Go head-mounted display (HMD). Although Oculus Go is a standalone HMD, it has all the components required to provide a fully immersive VR experience. The VR test environment was designed and developed in the Unity game engine installed on a high-performance DELL Opti-Plex 7060. A within-group or repeated measures experimental design was followed where the same participants (n=32) were asked to perform both experiments to test for the level of engagement inside G1-NN vs. G2-N. The independent variables of the study were narrative and non-narrative VR immersive environments. The level of engagement inside the VR was used as the dependent variable. To deal with the order effect, we altered the order in which the participants performed the experiment in each group. Therefore, the order of the two groups was counterbalanced [8].

Group 1 participated in a non-narrative based VR experience in which the user was presented with a real-world landscape designed in the Unity game engine. The landscape showcased part of a small village Utvik, located in Vestland county, Norway, as shown in Figure 1a. An audio track of natural surroundings was embedded in the VR environment to make it immersive and realistic. Participants were free to interact with the surrounding environment; however, they were not asked to perform any specific tasks. Group 2 participated in a narrative-based VR experience. It was the same landscape used in Group 1 (as shown in Figure 1b); however, a narrative was attached to it in such a way that the participants could perform the required tasks inside VR. The participants were presented with a scenario that they are in a small village where flooding is about to happen. Participants were asked to find and enter an underground tunnel and wait for the rescue team to extract them. In this VR test environment, the sound of emergency alarms was also embedded to strengthen the IDN presented to the users. Figure 1b and 1c show overview of the narrative-based VR environment.

The measures of engagement, determined by media content and media form variables (from the ITC-Sense of Presence Inventory questionnaire [9]), were used to evaluate the levels of engagement. The scale included several items about engagement i.e., user involvement, interest in the content of the displayed environment, their general enjoyment of the VR media experience, attention, involvement in the VR, the content of the presentation appeal, arousal, and emotions. Participants used a consistent scoring mechanism (1–5 point Likert scale ranging from "strongly disagree" to "strongly agree") to rate their experience after experiencing the VR.

2.3 Procedures

Volunteered participants were invited to take part in the study. Each participant filled a consent form and demographic information before starting the experiment. Participants were given detailed instructions and a brief demo on using the Oculus Go HMD and touch controller before continuing the experiments. However, they were not made aware of the goal of the experiment to prevent biased results. Participants were asked to wear Oculus Go headsets and explore two experimental conditions in random order. All the participants performed both the experiments. Participants in Group 1 were asked to explore and interact with the environment; however, no particular tasks were assigned. Participants in Group 2 were asked to perform a set of tasks i.e., find an underground tunnel and remove the obstructions to enter the tunnel to save themselves from the flood. After the experiment, they were asked to fill the questionnaire. Approximate time for each experiment per user with the questionnaire took 25-30 minutes to complete. At the end of

Table 1: Summary statistics for two groups (N=32) with 95% confidence interval (where LB stand for lower bound and UP stands for upper bound).

	N	Mean	Std. Deviation	Std. Error	95% CI for Mean		Min.	Max.
					LB	UP		
Group1	32	3.2212	0.66768	0.11803	2.9804	3.4619	1.85	4.62
Group2	32	3.8654	0.63583	0.11240	3.6361	4.0946	2.08	4.85
Total	64	3.5433	0.72367	0.09046	3.3625	3.7240	1.85	4.85

Table 2: Results of Independent Samples T-Test with 95% Confidence Interval (CI)

Independent Samples Test										
		Levene's Test		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff	Std. Error	95% CI of Diff	
									LB	UP
Engagement	Equal variances assumed	0.609	0.438	3.953	62	0.00	0.644	0.162	0.970	0.318
	Equal variances not assumed			3.953	61.85	0.000	0.644	0.162	0.970	0.318

the experiment, all subjects were debriefed about the experiment's aim and rewarded with a cinema ticket.

3 RESULTS AND DISCUSSION

Outliers were removed from the obtained data before performing the statistical analysis. Summary statistics of the data was computed, as shown in Table 1 with a 95% confidence interval. An independent Sample T-Test was performed to compare engagement in Group 1 (controlled) and Group 2 (experimental) VR test environment. Results showed that there was a significant difference in the mean scores for G1-NN with Mean=3.2212 and SD=0.11803; and controlled group (G2-N) with Mean=3.8654 and SD=0.11240 with t (62)=3.953 and p = 0.00000052. Results show that engagement for the two groups significantly differed in almost all the analyzed dependent variables. Table 2 shows the detailed results of independent Sample T-Test performed for the two groups.

To determine whether the differences between group means were statistically significant, we compared the p-value to the significance level (α = 0.05) to assess the null hypothesis (H0). H0 states that engagement means are equal for the two groups. The p-value was less than the significance level, so the null hypothesis was rejected. It was concluded that the level of engagement for narrative vs. non-narrative VR experiences is not equal. By examining the group means to check if the differences were statistically significant, confidence intervals for the differences of means were assessed. From the results, it was concluded that participants experienced more significant levels of engagement in the VR experience with IDN. From Figure 2 (see appendix A), it was observed that involvement, enjoyment, and appeal had the most significant difference in means with G1-NN having a less mean value than G2-N VR test environment. The level of attention had the smallest mean difference between the two conditions, which depicts that IDN did not influence it.

4 CONCLUSION

This study aimed to investigate the impact of Interactive Digital Narrative (IDN) in VR and its influence on users' engagement. A controlled with-in subject study was designed to compare measures of engagement in narrative and non-narrative virtual environments. Results showed a significant increase in the overall level of engagement in a narrative-based VR environment giving the users an increased sense of presence. In consequence, to obtain a high sense of presence, the VR environment should be associated with a contextualized and interactive digital narrative, and IDN should be incorporated in VR design. This study was limited to measuring engagement as part of the VR user experience only; however, further studies will be designed to measure the overall experience of end-users in IDN based VR. By carrying these results forward, we also intend to perform research on IDN's essential design elements than can result in an engaging and satisfactory VR experience for end-users.

ACKNOWLEDGMENTS

This work is supported by NTNU through World of Wild Waters, a project under the NTNU Digital Transformation initiative.

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A RESULTS

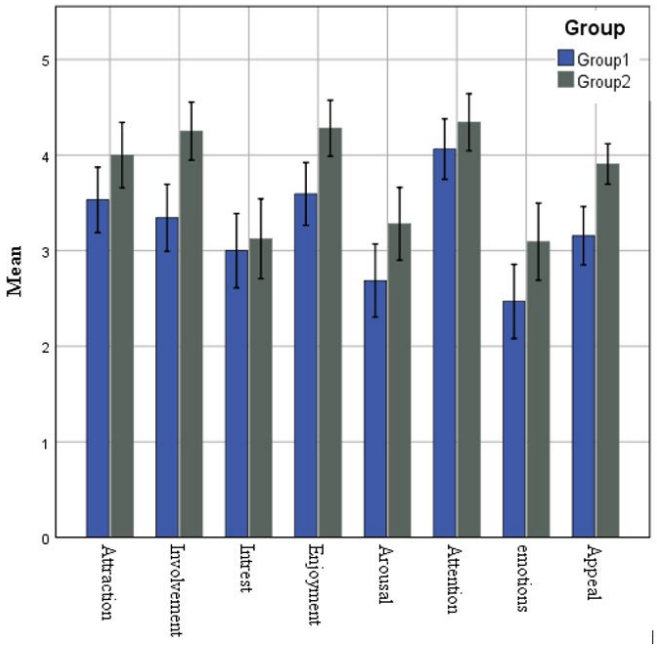

Figure 2: Bar-plot demonstrating the mean with 95% confidence interval for engagement