EFFECTS OF AN IMMERSIVE, MULTILINEAR FUTURE SCENARIO FOR EDUCATION PURPOSES

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ABSTRACT

This paper proposes a didactic design that is centered around an immersive, multilinear narrative in virtual reality as a means of illustrating human life on the edge of technological singularity. It explores the potential of narrative scenarios to trigger a discourse from users' perspective. Affective Computing is taken as a use case. It is a subfield of AI that focuses on identifying, understanding, and appropriately responding to human emotions. Its goal is to create more personalized and emotionally engaging human-machine interactions. To explore what life might be like if an emotionally intelligent AI became our best friend, a multilinear scenario was created. This scenario takes the reader through different stages of the protagonist's life, starting from the first day of secondary school and ending with the loss of a loved one in midlife. The systematic approach to create and validate the multilinear interactive scenario is described and the results of an experiment with 164 participants are presented. The ultimate goal is the application of this approach for educational purposes regarding ethical thinking and responsible innovations.

KEYWORDS

Affective Computing, Science-Fiction Prototyping, Technological Singularity, Human-Machine Interaction, Narrative Scenarios, Immersive Virtual-Reality

1. INTRODUCTION

Narrative scenarios that play on the edge of a technological singularity are seen as a suitable method to initiate a broad societal discourse on a common basis (Brucker-Kley & Keller, 2019). Singularity refers to a hypothetical time in the future when technology exceeds human capacity and creates a superior form of intelligence. In 1993, Vinge stated that the Singularity and its outcomes cannot be determined as positive or negative, as it involves numerous opportunities and risks (Vinge, 1993). Therefore, an active engagement with new technologies is of great importance for the development and shaping of our future (Brucker-Kley et al., 2021; Meinert, 2014). This research draws on the humanistic perspectives of technology criticism and technophilosophy (Poser, 2016; Taylor, 2011), which reject the notion of humans as "mindless victims of technology" and instead see them as "agents of cultural change" [7, p. 154].

One method that has gained increasing prominence in recent years is Science-Fiction Prototyping (SFP) (Burnam-Fink, 2015; Johnson, 2011; Merrie et al., 2018; Potstada & Zybura, 2014). Science-Fiction (Sci-Fi) Prototypes are short fictional artifacts, such as short stories, videos, comics, or plays, that are based on scientific facts. Their purpose is to stimulate discourse about the impacts, consequences, opportunities, and risks of technology and the future (Burnam-Fink, 2015). In addition, previous studies have applied SFP to capture student's attitudes toward a technology. Conventional approaches use textual or visual representations of Sci-Fi Prototypes, which primarily target the cognitive component of attitude formation (Brucker-Kley et al., 2021; Brunner et al., 2020). However, emotions play a significant role in attitude formation. For instance, research has revealed that an individual who experiences apprehension towards the potential consequences of a technology may opt not to utilize it, despite the numerous benefits it may entail (Lerner et al., 2015). According to (Somarathna et al., 2022), Virtual Reality (VR) has the potential to effectively and naturally elicit emotions. The present study integrates these two distinct research streams and supplements the SFP method with the immersive dimension of VR.

In Keller et al. (2021) the authors developed a Sci-Fi Prototype presenting future multilinear scenarios related to *Affective Computing and Friendship.* Humans have always been fascinated by the possibilities of computer interactions. In the past, we would sacrificially take care of our Tamagotchis, while today we simply ask Google Mini or Alexa for a joke. The purpose of this work is to enable people to explore scenarios of a fictional person and its relationship with a digital companion, allowing them to experience potential futures (Nisi & Haahr, 2006). The present study utilizes this existing Sci-Fi Prototype and adds an immersive dimension by building a VR environment. This research design aims to determine whether immersive, interactive SFP is a suitable method to comprehensively capture attitudes towards Affective Computing and to stimulate a discourse on the topic.

2. RELATED WORK

SFP is a practical guide to use fiction to imagine the future in entirely new ways (Johnson, 2011). It involves short fictional artifacts based on scientific facts, such as stories or videos, comics, plays, or audiobooks to stimulate a discourse about technology's opportunities and risks (Burnam-Fink, 2015). According to Johnson [9, p.3], we shape our own future, so discussing technology's impact is crucial. The process of SFP begins with the present and the recognition of an implied future based on sound science (Merrie et al., 2018). It shows how technologies shape people who use them and, in turn, are shaped by them. SFP doesn't provide predictions but highlights a possible interplay between people and technology.

In *plot-based* interactive storytelling, readers make decisions at selected key points in the plot, resulting in different storylines (Cavazza et al., 2002). This interactivity focuses on scenarios and narrative control, providing players with the opportunity to create their own stories and become more engaged in the narrative (Laurel, 2004; Nisi & Haahr, 2006). Interactive storytelling has proven to be a valuable tool in scenario planning by enabling decision-making and providing a platform for experiencing the potential outcomes (Gordon & Glenn, 2018). Several studies have highlighted its benefits, including its use in conjunction with SFP to intensify the scenario experience and encourage alternative thinking (Bell et al., 2013; Brucker-Kley et al., 2021; Brunner et al., 2020; Oberle et al., 2021).

VR has caught the attention of the scientific community because of its ability to create experiences that simulate real-world situations (Chicchi Giglioli et al., 2017). Simulations that represent a physical environment and an event that cannot be easily reproduced in the real world (as for example simulating a friendship with an artificial intelligent being) are of particular interest to researchers. VR enables researchers to examine these scenarios in a controlled laboratory environment (Vince, 2004). The distinguishing feature of VR from other means of information representation is its focus on immersion. Immersion is meant to convey the feeling that one has left the real world and is now "present" in the virtual environment. This notion of "being present" represents a central element in research on VR (Berkman & Akan, 2019; Lombard et al., 2009; Mestre et al., 2006). While immersion is a technology-related, objective aspect of VR systems, presence is a psychological and perceptual consequence of immersion (Mestre et al., 2006).

According to the Theory of Planned Behavior and Theory of Reasoned Action (Fishbein & Ajzen, 1977), the attitude of an individual is considered a reliable predictor. Attitude, in turn, is composed of feelings, beliefs, and actions, as described by the *Tri-component Model of Attitudes* (Pickens, 2005). This model suggests that an attitude towards a technology has a cognitive, an affective, and a behavioral component (Eagly & Chaiken, 1993). The behavioral component is particularly interesting because it can deviate from a person's attitude, values, and opinions, as Garms-Homolová (2020) notes. There are various reasons for this, such as social desirability or a lack of imagination of how one would react in a given situation. This inconsistency is the basis of the theory of cognitive dissonance (Festinger, 1957).

3. RESEARCH OBJECTIVES

This paper investigates whether immersive, multilinear SFP is a suitable method to challenge a student’s attitude. It is investigated whether the experience of a Sci-Fi Prototype with VR (high immersion) causes a stronger attitude change than a hypertext (HT), web-based Sci-Fi Prototype (low immersion). The main difference from the VR Sci-Fi Prototype and the HT Sci-Fi Prototype is the perceived presence (Lemmens et al., 2022). The

more immersive the experience, the stronger the perceived presence (Diemer et al., 2015). It is essential to the research design that the study is not based on a directional hypothesis. The question is not whether high immersion increases the imaginability/desirability of Affective Computing, but whether the high immersion causes a bigger change in attitude.

Studies have shown that VR experiences are useful for the acquisition of cognitive skills such as memory, comprehension of spatial and visual information, and knowledge acquisition. such as memory (Jensen & Konradsen, 2018; Krokos et al., 2019). Therefore, it is hypothesized that VR will be more responsive to the cognitive component of an attitude than HT. The behavioral component is assessed by analyzing decisions made within the multilinear scenario. It is demonstrated in (Alshaer et al., 2017) that display mode (computer screen vs. VR glasses) influences user's behavior. It is therefore reasonable to expect that this effect would be even more pronounced when comparing VR with HT.

4. METHODOLOGY AND APPROACH

The empirical research employs a mixed-methods approach, which includes quantitative and qualitative methodologies. It follows the in-depth model, where quantitative study (standardized questionnaire survey) is followed by a qualitative study in which a few selected respondents from the questionnaire survey are interviewed again in detail (Bortz & Döring, 2016). Since the same subjects are examined in both studies, the findings can be directly compared with each other and interpreted in their entirety (Bortz & Döring, 2016).

This research has two parts: the first involves an experiment based on A/B testing to compare how attitudes towards *Affective Computing and Friendship* change when using different types of media (VR vs. HT) in a multilinear scenario, while the second part involves assessing the quality and impact of the VR experience through both quantitative and qualitative methods.

The experiment in this study is based on the research in (Keller et al., 2021). They developed a HT Sci-Fi Prototype exploring *Affective Computing and Friendship* and presented the multilinear scenario to 145 participants to test its effectiveness in stimulating a discourse on the topic. The multilinear story presents the user with a total of 5 decisions, each of which can be chosen between a high-tech option and a low-tech option.

The VR prototype underwent two rounds of validation to ensure technical functionality, identify any elements of the VR environment perceived as disturbing, assess comprehensibility of the narrative, and detect any spelling errors in the script. Test subjects experienced the story while providing feedback on their observations, which was recorded, consolidated, and processed.

4.1 Experiment

The experiment is conducted with two groups experiencing the Sci-Fi Prototype in a different media format (VR vs. HT). The authors in (Keller et al., 2021) presented the HT Sci-Fi Prototype to 145 participants and assessed their attitudes in terms of cognitive, affective, and behavioral components. For this study, we use their dataset to compare the results of the VR Prototype (developed in this research) to the HT Prototype.

The VR group is conducted as a laboratory study in a classroom, which allows control of confounding variables. The HT group, on the other hand, is a field study conducted via online questionnaires at home, chosen for convenience (Keller et al., 2021). The combination of laboratory and field studies, although not ideal, was the most efficient approach.

The present experiment follows the within-subjects design, as a pre- and a post-test is conducted for both groups. For comparability, exactly the same questions were asked as in (Keller et al., 2021). The duration of the experiment is around 30 minutes including the pre-survey, the VR experience using a head-mounted display (HMD), and a post-survey. A small number of selected subjects were then given another semi-structured interview of approximately 10 minutes each. For the remaining subjects, the experiment was finished at this point.

The pre-test collects demographic data, such as gender, age, field of study, technical affinity, and VR experience. Technical affinity is measured using a 5-item battery with a 5-point Likert scale, as in the research in (Keller et al., 2021) and participants can score between 5-25 points. This construct is based on a questionnaire developed in (Karrer-Gauß et al., 2009) to measure technical affinity.

To asses attitudes towards *Affective Computing and Friendship* an existing construct from the literature is

applied, which has been previously used in the context of SFP in (Brucker-Kley et al., 2021). The cognitive component is evaluated through the dimension of imaginability, that is, how realistically and tangibly participants can imagine a technology. The affective component is assessed through the dimension of desirability, that is, to what extent participants consider a new technology desirable in their lives. Responses are collected on a 5-point Likert scale and are both assessed in the pre-test and post-test to detect any changes. The behavioral component is extrapolated from the decisions that participants make during the multilinear story. Points are assigned to each decision for behavioral analysis. The points range from 0-2, with a score of 2 representing a strong high-tech decision, 1 indicating a high-tech decision, and 0 indicating a low-tech decision.

4.2 Quality of the VR Science-Fiction Prototype

In addition, this research aims to investigate the quality and effect of the newly created VR Prototype through an exploratory study. Semi-structured interviews are conducted with selected participants to generate new hypotheses on how to improve the prototype. A smaller quantitative study supplements the exploratory study, with questions about the feeling of presence. Based on a comprehensive literature review on presence, the authors in (Lombard et al., 2009) developed and validated a questionnaire to measure presence. The questions used in the survey draw on their definition and addresses four types of presence: *Engagement*, *Spatial Immersion*, *Social Immersion*, and *Social Richness*. The post-test includes inquiries about these four categories which allows to assess all the VR participants.

5. RESULTS

The sample sizes of the two groups are significantly different (n=41 in the VR group vs. n=123 in the HT group), nevertheless, according to (Universität Zürich, 2022) this does not affect the statistical analysis. The HT dataset in (Keller et al., 2021) was filtered for participants aged between 18-35, resulting in 123 remaining participants. The VR group consisted of 73% (30) male and 27% (11) female students, while the HT group had an equal gender distribution. Most participants (78%) have already had some VR experience prior to participating in this experiment. The technical affinity was equally distributed in both groups.

5.1 Cognitive and Affective Aspects of Attitude

Based on the participants' responses to the pre- and post-survey the effect of the VR experience on the attitudes towards *Affective Computing and Friendship* was analyzed. First, the cognitive aspect of attitude, i.e. how well participants can imagine the portrayed technology and its consequences, was compared before and after the interaction with the Sci-Fi Prototype. Second, the desirability, i.e., how much the participants would like to have the portrayed PDA in their everyday life, was analyzed pre and post. The verbal qualifiers of the 5-point Likert scale were recoded into numerical values. Significance of changes within the groups were tested using the Wilcoxon signed ranked test, with a 0.05 significance level. The Wilcoxon test is used when the data are not normally distributed. To compare and evaluate effect sizes in a standardized manner Pearson's r value was calculated. The taxation of the strength of the effect was based on the classification of Cohen (1988).

Table 1. Results Wilcoxon Test (Desirability & Imaginability)

	Aspect of Attitude	Asymp. Sign. (2-tailed)	Sign. (<=0.05)	Effect size (r)
HT	Desirability	0.308	No	0.092
	Imaginability	< 0.001	Yes	0.452 (strong*)
VR	Desirability	0.782	No	0.043
	Imaginability	0.297	No	0.163 (small*)

**(Cohen effect size classification r= 0.10 small, r=0.25 medium, r=0.40 large)*

Only one significant change in attitude was observed, that was in the HT group on the question of imaginability. In the pre-test, participants, on average, considered a friendship with an AI as "possibly realistic" (ø = 3.29), whereas in the post-test their average rating increased to "rather realistic" (ø = 3.72) (Table 1).

The bubble diagram shown in Figure 1 depicts the changes of the response of the participant before (x-axis) and after (y-axis) the VR experience. The bubble size represents the number of participants. The bubbles along the diagonal of the diagram represent those participants whose attitudes remained the same before and after experiencing the Sci-Fi Prototype. The bubbles above the diagonal represent those participants who consider a technology more imaginable respectively more desirable after the narrative. The bubbles below the diagonal stand for negative changes in imaginability respectively desirability after the narrative.

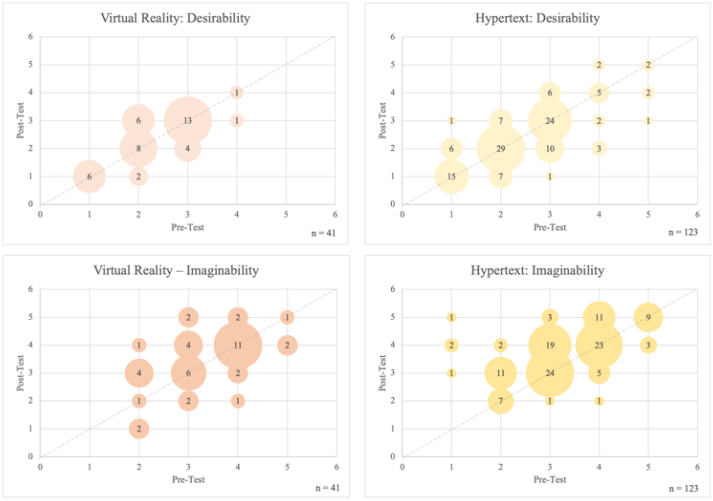

Figure 1. Bubble diagram displaying the change of attitude between pre- and post-test

Figure 1 reveals a comparable trend in attitude change between the two experimental groups. Overall, both groups rated desirability lower than imaginability. Regarding desirability, roughly a third of participants in each group (VR = 31%, HT = 39%) experienced a change in attitude (regardless of direction). For imaginability, the number of participants with attitude change was even larger (VR = 46%, HT = 49%).

The hypotheses predicted that the VR group would have a greater attitude change than the HT group. A Mann-Whitney U test was used to test for significant differences between the two groups, and absolute differences in pre- and post-test of attitude components were compared. However, no significant difference between the two groups was found.

5.2 Behavioural Component

The VR and HT groups had a similar distribution of paths chosen in the multilinear story, which were categorized into three groups based on the level of technology (Figure 2). Statistically, the analysis did not show a significant difference between the groups.

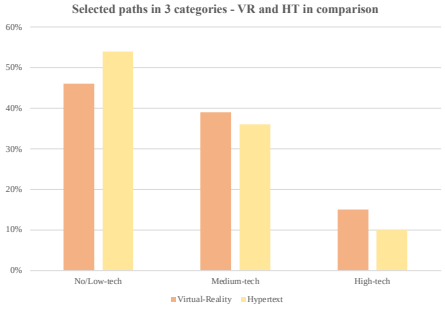

Figure 2. Distribution of paths taken in the multilinear narrative

5.3 Quality of the VR experience

To validate the quality of the VR Sci-Fi Prototype, questions were asked about perceived *Presence*. The three categories of *Engagement* (ø = 3.93), *Spatial Presence* (ø = 4.25), and *Social Presence* (ø = 3.78) averaged a 4, or "agree," on a 5-point Likert scale. The category *Social-Richness* scored the lowest with an average of 4.23 on a 7-point Likert scale. Within this category, the dimension *Natural/Unnatural* received the lowest rating, while the dimension *Personal/Impersonal* received the highest.

After experiencing the VR experience, a brief interview was conducted with 12 subjects. The key questions and findings are presented in Table 2. The number within the parentheses represents the overall count of subjects who expressed the corresponding statement. Multiple answers were possible.

Table 2. Key Questions & Findings from the interviews

Interview Question/ Topic	Findings
What triggered the VR experience in you?	Amazement, Excitement, Curiosity, Fun (7) Thought-Provoking, Ambivalent Feeling (7) Uncertainty, Scariness, Shocking, Worries, Fear (6)
How was the combination of low and high poly perceived?	Combination was good, did not bother (7) Combination was not noticed at all (6) Prefer high poly than low poly (2)
Social Presence: Photorealistic people vs. cartoon people	VR Prototype wouldn't improve with photorealistic people (9) The effect remains the same whether using photorealistic people or cartoons. The identification and level of empathy is equally strong (4) Probably slightly better effect, if photorealistic people, but effort is not worth it (8) Photorealistic people, not appearing to be real, are worse than using cartoons (4) Improvement not in the appearance, but in the facial expressions & gestures of cartoons (6)
Personal opinion: is it more effective to assess the attitude towards a technology with VR SFP or with HT SFP?	Preference of VR → high immersion (8) VR has intensified initial attitude towards the technology, but not changed it (8) The more intense the experience, the greater the chance of an attitude change (4) VR is a lot more emotional than text (2)

6. CONCLUSIONS

There are four limitations to consider when interpreting the results. First, the sample size of the VR group is small, making it difficult to generalize the findings. Second, the groups were quasi randomized, which increases the risk of confounding factors. Third, the VR and HT narratives were not completely identical, which introduces uncertainties in comparing the results. Fourth, it is questionable whether the Wilcoxon test was the appropriate statistical method chosen. The Wilcoxon test analyzes whether two related samples differ significantly from each other, i.e., whether one group shows a clear trend up or down. However, in this study, the hypotheses were stated as non-directional, which means that only the absolute change is relevant.

In general, people can imagine a future where they have friendships with artificially intelligent machines, but they don't necessarily approve of it. They worry about the control that AI could have over us, as seen with examples in the VR experience such as digital footprints, PDA dating app, and the invasion of the PDA in everyday life situations. This is a dilemma known as *malum technologicum*, where new technologies are developed to improve our lives (*bonum technologicum*) but can also lead to dependence, loss of skills, and social isolation (Poser, 2016). However, early awareness and responsibility can help mitigate these risks. The SFP aims to identify the use and impact of a technology and to initiate a discourse about it. The findings of this study are in line with (Brucker-Kley et al., 2021; Brucker-Kley & Keller, 2019; Keller et al., 2021; Oberle et al., 2021) that SFP is a suitable method for triggering a broad social discourse especially in education.

Overall, the VR prototype was positively rated for its presence, despite being a mix of low and high-poly elements. Most of the participants did not seem to notice the combination, or at least it did not bother them. Authors in (van Gisbergen et al., 2019) confirm this result by demonstrating that the level of photorealism in characters has no impact on the VR experience. Participants criticized the avatars' facial expressions and gestures for not feeling authentic and being hard to read. They suggested that improving these aspects would significantly enhance the VR prototype. This is supported by the quantitative study, as the questions about realistic feeling

and interaction with the avatars scored the lowest.

The VR experience doesn't elicit stronger emotions than the HT narrative. According to the interviewees, the VR experience has promoted engagement with the technology and the topic of *Affective Computing and Friendship*. Many participants were observed to discuss the topic after the VR experience, and several mentioned that they would like to experience the game again with different decision paths. The interviews highlighted both the advantages and disadvantages of using a PDA, with some interviewees expressing a sense of conflict or uncertainty. This demonstrates the effectiveness of the immersive, multilinear SFP approach in evaluating the potential benefits and drawbacks of new technologies, nevertheless, VR did not show any stronger impact than the HT version.

The VR experience doesn't elicit a stronger impact on cognition than the HT narrative. On one hand, the results show some evidence that experiencing a VR experience may have an effect on attitudes towards Affective Computing. On the other hand, the Wilcoxon test did not show significant differences. The ambiguous findings align with the outcomes of previous research (Brucker-Kley et al., 2021; Keller et al., 2021).

Overall, the level of immersion (VR vs. HT) showed no significant difference in attitude change. Both groups exposed similar results. Even though the quantitative analysis did not uncover any disparities between the two groups, all respondents in the qualitative study favored the VR experience in response to the final question, stating that it was better suited for engaging with a topic. The fun factor was often mentioned, as well as the lasting impression of the VR experience. It would be interesting to investigate whether these statements result in a longer-lasting effect of the VR experience when compared to the HT narrative. This would imply that although an immediate difference may not be apparent between the two media, over a longer period of time, the VR group may engage with the topic for a longer duration or more intense compared to the HT group. Evidence for such an effect is provided in (Park et al., 2019).

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