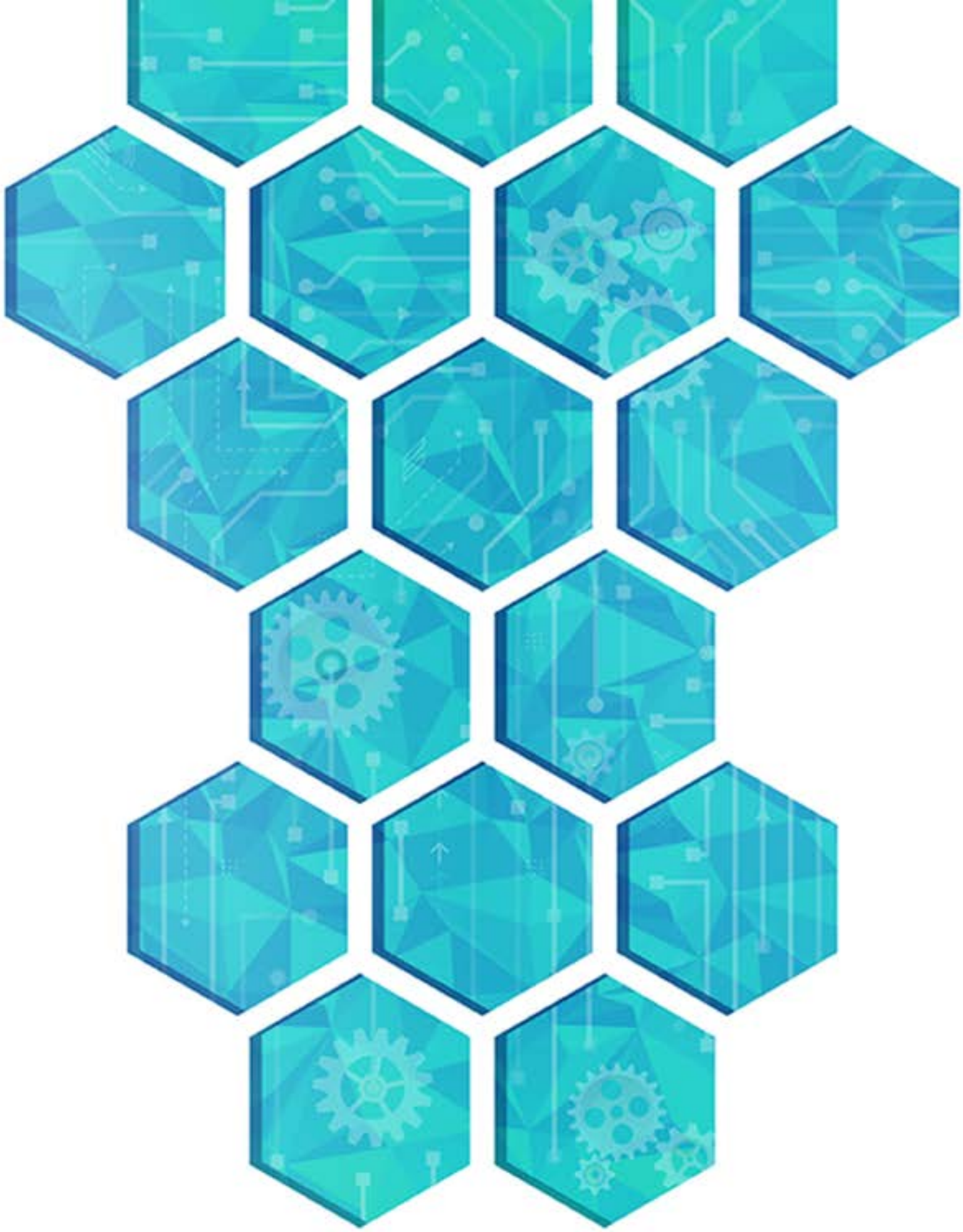

GAMES FOR CHANGE

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EDITED BY:
KATHLEEN YIN
GILLIAN VESTY
STEFAN SCHUTT
DALE LINEGAR
VIKTOR ARITY

Games for Change Asia-Pacific Journal 2023

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KATHLEEN YIN, GILLIAN VESTY, STEFAN SCHUTT, DALE LINEGAR, & VIKTOR ARITY

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Introduction

Games for Change Editorial

Following the inaugural Games for Change Asia-Pacific Festival in October 2021, the first volume of the Games for Change Asia-Pacific Journal was released with the generous assistance of ETC Press at Carnegie Mellon University. Since then, the first volume of the journal has demonstrated significant impact, with almost 1500 views in its first year and a current Altmetric score of 19, which places the journal in the top 10% of all research outputs ever tracked by Altmetric, and the top 6% of research outputs tracked from Carnegie Mellon University. This data shows that the journal is playing an important role in the ongoing dialogue around how games can be used to make the world a better place.

We would like to thank all of the authors from both last year and this year for the important contribution your research is making to this burgeoning body of knowledge.

This second issue of the Games for Change Asia-Pacific Journal embodies one of the key themes presented at the inaugural 2021 Festival. That is, the use of games in drawing attention to the United Nations Sustainable Development Goals (UN-SDGs). The 2030 Agenda which introduced the seventeen Sustainable Development Goals (SDGs) was agreed to by all 193 member states of the United Nations (UN) in 2015. The 2030 Agenda called for global action on some of the world's most pressing problems related to poverty, inequality, health, climate change, peace and prosperity (UN, 2020). The seventeen unique goals are detailed in Figure 1. In this editorial, we highlight how each of the nine papers contribute to the mission and

values of the Games for Change organisation as well as foster the UN 2030 SDG Agenda.

As we will highlight in this second issue, gamified immersive technologies can forefront the world's wicked and sometimes cognitively challenging problems. Games provided opportunities to problem solve and show, through their design features, how they would deal with the challenges posed by the seventeen unique but interrelated SDGs. While each article, in its own way, contributes toward one or more of the seventeen sustainable development goals (SDGs), we argue that the Games for Change mission to make the world a better place is largely accomplished through the aims of *SDG 4: Quality Education*.

Games offer a unique educational medium to help to "ensure that all learners acquire the knowledge and skills needed to promote sustainable development … human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development" (UN SDG, Target 4.7). The insightful and provocative articles in this issue can be analysed through the lens of the UN SDG to help demonstrate the impact of games to society more broadly.

The notion of predictability being beneficial for trust is a theme captured in several papers including *Embodied Conversational Agents for Health: A Comparison of Empathic versus Neutral Dialogue* by Sana Salman, Deborah Richards and Mark Dras. These authors find that patients engage more with digital agents who embody a humanlike appearance and exhibit humanlike verbal and non-verbal behaviours. By promoting the use of empathetic Embodied Conversational Agents (ECAs) in digital apps for mobile phones, these authors suggest that there are improved opportunities for changing the behaviours of users for improved health outcomes. This theme links nicely with *Goal 3: Good Health and Well-Being* which is evident across a number of papers in this issue. The findings in each of these papers suggest that serious games have the capacity to manage national and global health risks through more effective and targeted communication that will strengthen the capacity of all countries for early warning, risk reduction and management of national and global health risks. Given the growing accessibility of mobile phones and

transferability of health concerns through mobile applications, developing countries and patients in remote regions can potentially benefit from these health-based digital interventions.

An aligned theme is explored by Kathleen Yin, Matthew Lee, Charbel Kisrwani, Kiran Ijaz, James Smith and Louise Ellis in their paper *Fit to Game*: *The experience of exercising indoors using games during the COVID-19 pandemic.* The authors investigate the use of video games for exercise during the pandemic isolation. They identify certain factors that limit the effectiveness of such games including design features, monotonous exercise types, and contextual limitations of the space and time involved. They argue for software design features to inspire a purpose behind the exercise journey as well as engage in social connections. They also propose innovative hardware that incorporates a holistic regimen of fitness activities. While beneficial for people isolated through COVID-19, improved video games can also support the health and wellbeing of a percentage of the populations who find themselves in other forms of isolation.

In considering the way serious games promote decent work and economic growth as in *SDG 8: Decent Work and Economic Growth,* there is a focus on promoting sustained, inclusive, productive employment, ensuring decent work for all. Leadership can play an important role in ensuring labour rights are protected and there is a safe and secure working environment for all workers (SDG 8, Target 8.8). The authors of *A Fine Balance: Cultivating Compassion and Leadership through Games*, Anurati Srivastva, Sai Siddartha Maram and Magy Seif El-Nasr, consider leadership styles that are important for building such a culture. These authors claim that serious games can be used to cultivate leadership competencies cultivated qualities critical to leadership, such as self-compassion, empathy, and emotional management and present game elements, themes, and mechanics to support. They suggest the following features in game design: (1) Eudaimonic Game Design, (2) In-Game Reflection, (3) Non-competitive Gameplay, (4) Limited Agency and Forced Failure, (5) Digital Companion, and (6) Dialogue-based Responses can be used to draw out the skills of empathy, self-compassion, and emotional management can foster compassionate leaders and decent work environments.

Author Matthew John Dyet also promulgates the notion of decent work

through his article *Tabletop Games for Training: Teaching Soft Skills to Game Development Students.* In this paper Dyet promotes soft skill development through his action research which resulted in the development of a tabletop card game, *Trial by Fire.* This paper provides a narrative of the three year iterative process of game testing and revision. The author found that following gameplay, students had a clearer understanding of how soft skills are essential for their careers.

SDG 9: Industry, Innovation and Infrastructure is about building resilient infrastructure and fostering innovation through supporting technology development and research. This goal is measured by the extent of high-tech industry value added to society. The paper by Matt Cabanag and Christopher Stanton, *Towards Understanding the Cognitive Aspects of Transparency in Human-Autonomy Teaming,* embodies SDG 9 by providing insights for designers of autonomous agents and the ways they share information with human users. In this paper the authors investigate the actions of autonomous agents in a computer-based game experiment where students were given the role of air-traffic controllers. Provided with an autonomous teammate and different types of visual and other workload information, students were required to safely land aeroplanes for cargo rewards. The researchers examine the information flows (user workloads) between the student and the autonomous agent in terms of trust and agent predictability and argue that cognitive fit theory is an important guiding principle. They agree that transparency in relation to the understandability of a system is not necessarily about the amount of visualisations presented to the user, but the human cognitive load limit in managing the information. Rather than aim for cognitive fit through efficient information displays, they propose more practical heuristics where domain expert knowledge plays an important role. With information flows between human and autonomous agents increasing in innovative industrial designs, this study has implications for transparency design in self-driving cars, domestic household robots, as well as other industrial applications where autonomous systems and agents are used.

The paper by authors Vedant Sansare, Malcolm Ryan and Mitchell McEwan, *An Oscillatory Model for Developing Narratives for Serious Games,* also focuses on game design elements. In supporting innovation in game design, the

authors aim to bridge the gap between scripted and systemic approaches in narrative designs. This work helps to emphasise games as an interactive medium and highlights how the conflict between procedural and semiotic layers can be used in conjunction with the pros of the scripted approach to developing a systems-based narrative.

Serious Games, Stealth Interventions and Accounting Ethics: A reflective essay, by Dale Linegar, Gillian Vesty and Eva Tsahuridu draws on the essence of *SDG10: Reduced Inequalities* to "Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard" (UN SDG Target 10.3). The authors do this through the design features of their game *Bogart*, which uses intermixing, obfuscating and distancing strategies so the player potentially ignores or is diverted away from some of the key messaging in the game. By creating a fictitious, future-focused workplace the player is psychologically distanced from reality but this all culminates in the final scenes of gameplay when the (un)ethical aspects are revealed and the character is fired/promoted as a result of their choices. The stealth interventions designed in the game aim to drive home the ethical impact on society when leaders do not comply with policy. The dilemma of ethical principles in the workplace similarly takes precedence in the article *Providing alternative ethical perspectives through intelligent agents in a serious game for cybersecurity ethical training by authors* Muhammad Hassan Ali Bajwa, Deborah Richards and Paul Formosa. They also use a serious game to provide a training medium for undergraduate cybersecurity students. They use non-player characters (agents) to present different ethical choices and issues through the gameplay dialogue. They found that through comparison of pre- and post-game responses to other cyber-ethical scenarios, that the students who played their game had a greater understanding of ethical principles in cybersecurity.

Climate resiliency for our habitat through Cross-Reality technologies by Yétindranathsingh Vipin Dhunnoo, a concerned author from Mauritius, highlights the importance of Cross Reality (XR) technologies, such as Virtual Reality (VR) and Augmented Reality (AR) as climate change communication tools to better understand climate ramifications to mitigate and adapt the

built environment. With the effects of Climate Change leading to adverse repercussions such as soil erosion, flooding and coastal displacement, there is an urgent need to model, illustrate and communicate climate change impacts. People living in vulnerable regions and coastal areas are at the ones at greater risk of climate change, particularly exposed small island developing states and coastal areas.

Together these articles continue the creative journey in positioning games and game making as world changing and impactful. We are delighted to follow the first issue of this new journal with our second exciting volume and look forward to receiving further contributions to our subsequent issues.

CHAPTER 1

Embodied Conversational Agents for health

A comparison of Empathic versus Neutral Dialogue

SANA SALMAN; DEBORAH RICHARDS; AND MARK DRAS

ABSTRACT:

Games technology can be used to build Embodied Conversational Agents (ECAs) that tend to have a humanlike appearance and exhibit humanlike verbal and non-verbal behaviours. When it comes to digital health, ECAs can provide vital support to patients by being more reachable through their smart phones or other digital gadgets like IPad/computers. To encourage users to follow the advice given, the use of empathy and development of a working alliance is recommended. While researchers have looked at expression of empathy via non-verbal cues and certain characteristics of the patient, this study focuses on making ECAs more effective by using human-like empathy expressed during conversation through relational cues. Relational cues are the empathic utterances that build a more long term alliance among the patient and the therapist, for example, the choice of words in social dialogues or being polite during a conversation. The goal of this study is to measure the working alliance with a neutral versus an empathic ECA. Furthermore, we evaluate the impact of the relational cues on the change in the behaviours recommended by the agent. The main findings of the study establish that empathic Alex is able to change the behaviours of the users more than the neutral Alex. The likability and

working alliance with the virtual coach is rated high by most of the users. Future work has been derived through the feedback received from the users revolving around having more personalised and advanced content as well as more interactivity.

KEYWORDS:

Game technology, Embodied Conversational Agents, relational cues, working alliance, empathic versus neutral

1. INTRODUCTION

Motivating individuals to follow a health regime can be difficult. In healthcare, effective face to face therapy is frequently underpinned by the development of collaborative rapport between a therapist and a patient, this is often referred to as a working or therapeutic alliance (Abdulrahman et al., 2021). The strength of this working alliance has been found to significantly influence the success of behaviour change interventions (Tremain et al., 2020). However, face to face therapy is costly. We propose the use of games technology to create an embodied conversational agent that provides health advice in a manner that motivates the user to follow the advice. Serious games are a technology that can be used to train and educate people while keeping them engaged through active learning and feedback. Apart from user experience and digital engagement, serious games must have an outcome associated with them that the users need to work through during the game.

Evidence exists that working alliances can be established between users and digital embodied conversational agents (Bickmore et al., 2005; Tremain et al., 2020). By using a conversational style of dialogue, an embodied conversational agent can create a social environment, which provides an opportunity to develop a relationship with the user. Studies have found that relationships with embodied conversation agents can be enhanced through the agent providing empathic and relational cues (Abdulrahman et al., 2021; Moore, 2021). Research on empathic agents has also shown that these agents are perceived to be more likeable, trustworthy and caring

(Brave et al., 2005) and can increase the interaction length and user engagement (Yalcin, 2019).

In our domain of health behaviour change, we are using games technology to create a virtual coach, known as Alex. Alex's dialogues were designed with a goal of establishing a working alliance with players. Alex aims to engage players through their own choice of responses; hence, it contains content for both highly motivated and also non-motivated players and takes them through a journey of self-discovery and routine establishment. It represents an ideal instrument for continuous health education also in terms of costs because it is cheaper than traditional training methods.

This paper reports a study which compares an empathic version of Alex with a neutral version of Alex to determine the impact of these conversational styles on working alliance and intended health behaviour change. Our study asks the following research questions.

Research Question 1 (RQ1): Do ECA's empathic dialogues motivate the player to change their health behaviours more than the neutral dialogues?

Research Question 2 (RQ2): Do ECA's empathic dialogues build a stronger working alliance with the player than the neutral dialogues?

Research Question 3 (RQ3): What is the player's experience of the empathic ECA compared to the neutral ECA?

In the next section we present some background literature. Section 3 presents our methodology followed by results in Section 4. Section 5 discusses our findings. Conclusions and future work are provided in Section 6.

2. BACKGROUND LITERATURE

2.1 MOTIVATIONAL COACHING IN THE HEALTH DOMAIN

There are several key components (Levensky et al., 2007) of motivational interviewing that can be used to successfully conduct clinical practices of counselling patients:

1. Express empathy for the patients.

2. Develop a discrepancy
3. Roll with resistance
4. Support self-efficacy

There are certain therapeutic skills (McCarley, 2009) that need to be applied to act upon the core components which are:

1. Resist the righting reflex-describe this
2. Use reflective listening
3. Ask open ended questions
4. Affirm and summarize

According to (Hall et al., 2012), these four skills are grouped into a motivational counselling method called RULE (Resist the righting reflex; Understand the patient's own motivations; Listen with empathy; and Empower the patient), described further below.

The righting reflex describes the tendency of health professionals to advise patients about the right path for good health. Essentially, most people resist persuasion when they are ambivalent about change and will respond by recalling their reasons for maintaining the behaviour. Motivational interviewing in practice requires clinicians to suppress the initial righting reflex so that they can explore the patient's motivations for change and also build long term working alliance with the patient.

Understand your patient's motivations involves knowing what is the patient's own reasons for change, rather than the practitioner's, that will ultimately result in behaviour change. By approaching a patient's interests, concerns and values with curiosity and openly exploring the patient's motivations for change, the practitioner will begin to get a better understanding of the patient's motivations and potential barriers to change.

Listen with empathy requires effective listening skills that are essential to understand what will motivate the patient, as well as the pros and cons of their situation. A general rule-of-thumb in motivational counselling is

that equal amounts of time in a consultation should be spent listening and talking.

Empower your patient is driven by the recognition that patient outcomes improve when they are an active collaborator in their treatment. Empowering patients involves exploring their own ideas about how they can make changes to improve their health and drawing on the patient's personal knowledge about what has succeeded in the past. A truly collaborative therapeutic relationship is a powerful motivator. Patients benefit from this relationship the most when the practitioner also embodies hope that change is possible.

In summary we can see that the first three involve active listening where you get the player to speak and the final element is providing education and options to the player to choose from.

2.2 SERIOUS GAMES FOR HEALTH COACHING

Drummond, Hadchouel, and Tesnière (2017) describes a research based conceptual process for serious games design upon which our project is built. This idea consists of motivational convergence and evidence based education and was also utilized in other medical related serious games including virtual simulation for emergency medicine departments (McGrath et al., 2018) in which active learning and feedback are the core components used in the situational context of emergency patient treatments. Other serious games for health coaching include: LISSA that is used in nurses training where Cardiopulmonary resuscitation (CPR) is used as a first aid technique for keeping the blood flowing (Boada et al., 2015) and training surgical residents on treating biliary tract disease (Graafland et al., 2014).

Three main steps are involved during the development of a serious game like a health coaching application: Motivating effect, learning effectiveness and evaluation. First is building the learning activity on the extrinsic motivation of the user which is the desire to achieve a certain outcome and then intrinsically motivating the user through a series of desirable steps. This phenomenon is called "convergence of motivations". Second

is utilizing the four pillars of learning framework referred to in cognitive science findings as active learning, attention, consolidation and feedback to enhance the learning potential of health applications. Finally comes the evaluation part which is critical to progress towards evidence based education through A/B testing and controlled trials.

3. METHODOLOGY

Our study uses a between subject experimental, pre-post study design to assess whether a socially engaging empathic embodied conversational agent (empathic Alex) is able to build a better working alliance than the neutral one (neutral Alex). The dialogues are built after extensive research on relational cues that are considered vital in conversations led by digital as well as human coaches. We obtained ethics approval from our university Human Research Ethics Committee.

3.1 RECRUITMENT

Recruitment is done through an online research participation portal at the host university. The students are undergraduates enrolled in a first year psychology course who belong to multiple discipline areas including psychology, computing, health sciences, business, arts and others. They receive course credit for their participation after completion of the survey. During a recruitment period of 36 days, 217 students registered on the portal for this activity.

3.2 MATERIALS

Alex was implemented using the Council of Coaches (COUCH) architecture containing the Windows Object Oriented Language (WOOL) dialogue engine. The conversation was displayed on the screen in text (Figure 1) through a web based front end which is built on top of COUCH and handles the dialogue exchange through Application Programming Interface (API) calls built using Python and JavaScript Object Notation (JSON) utilities. Further description of the dialogues, COUCH and WOOL are provided in the following subsections.

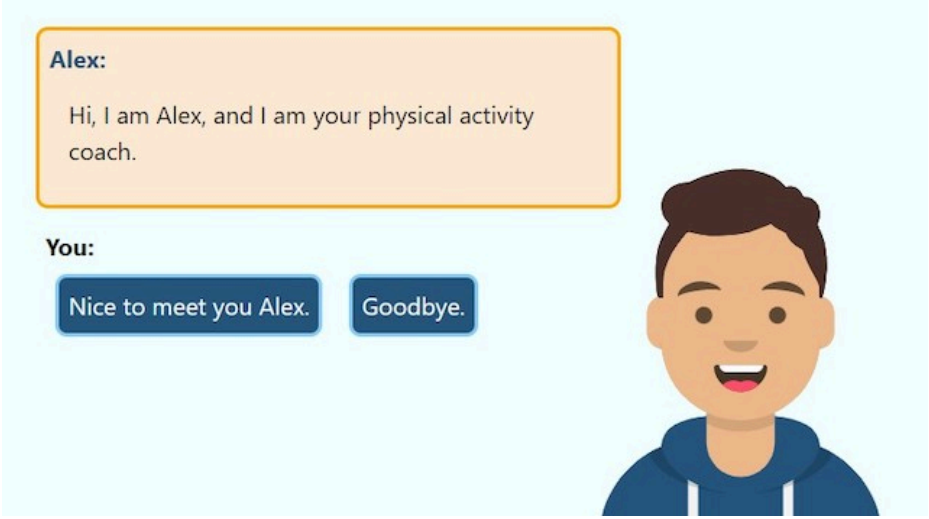

Figure 1: Example of. Alex's Interaction

3.2.1 Coaching strategy- Dialogue creation

We chose to adapt a set of health behaviour dialogues (Beinema et al., 2021) in which persuasion has been the key in building motivational dialogues. This persuasion first measures the motivation level in users and based on that either motivates them more or moves forward with healthy goal setting.

In our implementation of Alex, the persuasion dialogues are further enriched with relational cues that have been identified in the dialogue of skilled human empathic therapists who build a strong working alliance with their patients for improving patients intention to change their behaviour change (Levensky et al., 2007). There are three main motivational strategies that are used. Firstly the dialogue aims to build a working alliance through politeness, affirmation, empathic and encouragement cues. Secondly, the cues aim to empower the user by giving them options or clarifying consequences of each choice. Thirdly, the cues aim to build stronger social ties through adding non-task based social dialogues, particularly during the greeting and farewell phase, or through self-disclosure by the ECA. An

example of Alex's dialogue and the different types of relational cues can be found in Table 1. The example shows both the neutral dialogue version and the empathic version of the dialogue.

Empathic Alex	Neutral Alex
Nice to meet you too!	Let's continue!
I can help you…	I think you should…
I love spending time in nature	Spend time in nature
If you prefer to go outside…	Go outside

Table 1: Sample dialogue of empathic Alex and neutral Alex.

3.2.2 COUCH Features and Architecture

The council of coaches' baseline prototype consists of three components: Unity, ASAP (Articulated social agents platform) Realizer and Dialogue Manager. Unity renders the animation and Dialogue Manager waits for input from the user and also response from the ASAP Realizer. Dialogue Manager has multiple scenarios encoded as BML (Behavior Markup Language). After ASAP Realizer finishes execution of behaviours, the dialogue manager puts responses on top left for the user to choose from. After the user makes a selection, the dialogue manager will send the corresponding BML blocks to the ASAP Realizer to execute the behaviours. The scenarios are encoded in BML which is also stored as assets in Unity. In short, the dialogue manager interacts with the ASAP Realizer and Unity to select the next move in the dialogue.

3.2.3 Message/ Agent Dialogue through WOOL Platform

The WOOL dialogue framework allows domain experts to write and test WOOL dialogue scripts without extensive coding. The five stages of dialogue creation start with domain expert discussion with a technical expert on how to write the dialogues using the framework. In the second stage the domain expert actually writes down the dialogues in the WOOL framework. In the third stage, the technical expert corrects and modifies the content and flow of the dialogues according to the WOOL standards.

The fourth is the final validation of the flow and the content. Finally, the WOOL generated output can be translated into other languages.

3.3 PROCEDURE AND DATA COLLECTION

The procedure for data collection is divided into three modules using the research survey software Qualtrics (qualtrics.com). First is a pre-interaction survey in which participants provide information regarding gender, age and personality types. Participants answer ten questions to measure their personality using Ten-Item Personality Inventory abbreviated as TIPI (Gosling et al., 2003). Then participants answer eight questions about their health behaviours to provide baseline data on quantifying the user's intention to be healthy.

The second module of data collection involves interaction with Alex whereby the user goes through the whole coaching session which is either empathic or neutral, randomly selected by the Qualtrics research survey system. This interaction stores the duration, interaction screen information and the attempts made on accessing the app.

The third module is the post-survey where the user completes the same health behaviour questionnaire that was completed at baseline so as to see how much is the user willing to change the behaviour now. Additional standardised and customised measures which explored users' satisfaction with Alex and their interaction were captured. Each of the measures is described briefly below.

3.3.1 Behaviour change intention analysis

To establish the change in motivation towards health behaviours that comprise of the following 8 behaviours which were asked pre-interaction with Alex and then post-interaction. These are based on a Likert scale of 1-5 for each behaviour, ranging from Never to Always:

1. Keep track of your progress by using automatic step counter
2. Log your food choices in a food diary

3. Define a healthy activity goal for yourself
4. Tweak your daily activities to get closer to the goal
5. Decide and act on drinking additional glasses of water everyday
6. Set an exercise goal
7. Set a healthy eating goal
8. Link your healthy activities to specific moments in time

Van Velsen et al. (2019) talks about persuasive features that correlate with the motivation level of a user and are important in bringing a behaviour change. The above mentioned behaviours are examples of these persuasive features and can be categorized as follows:

1. Self-goal setting feature includes defining a goal, set an exercise goal or a healthy eating goal.
2. Showing progress feature includes the use of step counter, log food choices or tweak a goal.
3. Implementation intention feature include linking health activities to specific moments in time.

In our study, the goal setting included the health behaviours “Define a healthy activity goal for yourself.”,” Set an exercise goal” and “Set a healthy eating goal”, the showing progress included the behaviours “Keep track of your progress by automatic step counter”,” Log your food choices in a food diary.”,” Tweak your daily activities to get closer to the goal.” and “Decide and act on drinking additional glasses of water everyday”. Lastly, implementation intention had only one behaviour “Link your healthy activities to specific moments in time”. These groupings were already found in the original dialogue extracts of health coaching application (Beinema et al., 2021).

3.3.2 Working alliance analysis

Working alliance between Alex and users was measured through the Session Rating Scale Survey (SRSS). The SRSS consists of four 10-point scales. In our implementation in Qualtrics, participants could use a slider

from 0-10, where 0-4 indicated a negative sentiment and above 4 indicated a positive sentiment.. The software would click to the nearest number and record that integer. First, a relationship scale rates the session from "I did not feel heard, understood, and respected" to "I felt heard, understood, and respected." Second is a goals and topics scale that rates the session from "We did not work or talk about what I wanted to work on or talk about" to "We worked on or talked about what I wanted to work on or talk about." Third is an approach or method scale requiring the client to rate the session from "The therapist's approach is not a good fit for me" to "The therapist's approach is a good fit for me?" Finally, the fourth scale looks at how the client perceives the session in total: "There was something missing in the session today" to "Overall, today's session was right for me."

The SRSS is scored by summing the marks for each of the four lines. Based on a total possible score of 40, any score lower than 36 overall, or 9 on any scale, could be a source of concern and therefore prudent to invite the user to comment.

Psychometric testing of the measure has identified a Cronbach's alpha of 0.88 and reliability of 0.64 (Duncan et al., 2003). The measure has also been found to have a moderately strong correlation with the Working Alliance Inventory r=0.63 (Campbell & Hemsley, 2009).

3.3.3 System Usability Scale (SUS)

The SUS (Brooke, 1986) is a 10 item questionnaire with a 5 point Likert scale rating from strongly disagree to strongly agree. Recent confirmatory factor analysis identified that the total sum score of the SUS appears to be a valid and interpretable measure to assess the usability of internet-based interventions (Mol et al., 2020).

3.4 DATA ANALYSIS

The quantitative data generated from the study including the ratings on the health behaviours change intention and likability of the coaching application were analysed using kurtosis and skewness analysis of the health behaviour scores before and after interaction. The data was found

to be normally distributed as thus parametric tests have been chosen. The parametric test chosen to find any significant difference in health behaviours change data before and after using Alex is the two-tailed paired t-test. Comparisons between groups (empathic and neutral) used independent t-test. In our analysis, the p- value is considered significant if $p<0.05$. Bonferroni adjusted p-values have also been calculated and seen from the perspective of avoiding Type-I error but since the analysis is being done to determine future options for research the un-adjusted p values are given more preference. This also helps to reduce the downside of adjusted values (Nakagawa, 2004) and hence avoiding an increase in Type-II error which restricts the option for further exploration. The session rating scales survey (SRSS) and the system usability scale (SUS) along with the likability questionnaire will be examined to understand the user experience and to determine whether participants felt that they had established a therapeutic alliance with the conversational agent. For the users who rated less than 5 for the question "Alex's approach is a good fit for me" regarding the SSRS, feedback was collected which were summarized into themes using thematic analysis (Braun & Clarke, 2006; Joffe & Yardley, 2004) by the first author and reviewed by the second author.

4. RESULTS

The recruited users were first filtered on the condition if they had successfully interacted with Alex. The total users were 217, out of which 206 users were able to interact with Alex and hence were eligible for further analysis. Users are 64% psychology students, 2% a computing major, 18% are studying health sciences, 5% are business, 7% are arts and remaining 5% are enrolled in other subjects. These students were randomly distributed to both groups: 103 of these students were presented with empathic Alex and 103 were presented with neutral Alex.

4.1 INDIVIDUAL FACTOR ANALYSIS

Table 2 shows the descriptive statistics of gender and age with respect to empathic and neutral groups. Overall, 66% of the users are females and the mean age is 21.2.

Group	N	Female	Male	Age	
				mean	std
Empathic	103	73	30	21.5	7.7
Neutral	103	62	41	21.09	6.8
Total	206	135	71	21.2	7.2

Table 2: Gender and Age distribution across all groups

Cultural group based classification for both empathic and neutral Alex is given in the Table 3 which divides the users into nine cultural groups. We observe similar percentages represented in both treatment groups.

Group	Total	Empathic	Neutral
Oceania (Including Australia)	44%	37%	50%
North-Western European	3%	3%	4%
Southern-Eastern European	5%	6%	5%
North African and Middle Eastern	8%	11%	6%
South East Asian	12%	13%	12%
North East Asian	1%	1%	2%
Southern and Central Asian	6%	10%	3%
People of the Americas	2%	1%	3%
Sub-Saharan African	0%	0%	0%
I don't identify with any cultural	2%	3%	2%
I prefer not to answer	1%	2%	1%

Table 3: Cultural group based percentages

Using TIPI score calculations, five personality types were analysed in the context of users of empathic Alex versus neutral Alex. Tests for normality through kurtosis and skewness analysis between the two groups revealed that the data was normally distributed, hence parametric statistical tests were used. Table 4 provides the descriptive statistics and the t-test scores. Three personality types were found to be statistically significant different between the two cohorts (Extroversion, Emotional stability and Openness)

and the remaining two were not statistically significant (Agreeableness and Conscientiousness).

	Empathic		Neutral		
Personality Types	*mean*	*std*	*mean*	*std*	**p-value**
Extroversion	3.27	1.20	2.79	1.28	**0.01**
Agreeableness	2.68	1.25	2.78	1.13	0.56
Conscientiousness	3.77	1.06	3.52	1.09	0.10
Emotional Stability	2.33	1.14	2.78	1.12	**0.01**
Openness	2.36	1.13	2.78	1.12	**0.01**

Table 4: Analyzing variations in personality types through descriptive scores and t-test

4.2 BEHAVIOUR CHANGE INTENTION ANALYSIS

Before selecting a test to measure the change in behaviours the skewness and kurtosis of the user rating distribution was analysed and all of them were in a safe normal range which gave the confidence to go with the parametric test. Most of the distributions are either not skewed or slightly skewed both for neutral and empathic Alex users hence parametric tests are used for further analysis. Table 5 contains the before and after interaction analysis for individual behaviours. P-values shown in bold indicate significant differences. The paired T-test compares means before and after interaction and was performed for the empathic and neutral groups separately and also on the total responses that includes both groups. Table 5 also provides the p-value comparing the **change** (after minus before) in both groups.

Behaviour	Group	Before Interaction		After Interaction		Paired t-test
		mean	*std*	*mean*	*std*	*p*
Show Progress						
Keep track of your progress by automatic step counter	Empathic	2.57	1.41	2.97	1.29	**<.0001***
	Neutral	2.6	1.36	3.04	1.33	**<.0001***
	Total	2.58	1.39	3.00	1.31	**0.001***
Independent t-test p-value		0.88		0.67	change	0.71
Log your food choices in a food diary.	Empathic	2.03	1.09	2.49	1.21	**<.0001***
	Neutral	1.97	1.14	2.33	1.19	**.0007***
	Total	2.00	1.12	2.41	1.19	**.0003***
Independent t-test p-value		0.66		0.32	change	0.49
Tweak your daily activities to get closer to the goal.	Empathic 3.09		1.09	3.39	1.05	**0.003***
	Neutral	3.15	1.09	3.48	1.02	**0.0003***
	Total	3.11	1.09	3.43	1.03	**0.002***
Independent t-test p-value		0.61		0.46	change	0.82
Goal Setting						
Define a healthy activity goal for yourself.	Empathic	3.3	1.09	3.59	0.89	**.003***
	Neutral	3.53	1.03	3.58	1.08	0.64
	Total	3.41	1.06	3.58	0.98	0.103
Independent t-test p-value		0.11		1.0	change	0.11

Set an exercise goal	Empathic	3.44	0.98	3.61	0.96	**.03**
	Neutral	3.47	1.03	3.74	1.00	**.002***
	Total	3.46	1.07	3.67	0.98	**0.03**
Independent t-test p-value		0.84		0.32	change	0.39
Set a healthy eating goal	Empathic	3.31	1.08	3.54	0.96	**0.01**
	Neutral	3.28	1.19	3.63	1.05	**<.0001***
	Total	3.29	1.00	3.58	0.98	**0.003***
Independent t-test p-value		0.83		0.52	change	0.36
Drink an additional glasses of water everyday	Empathic	3.62	1.11	3.91	1.02	**.0001***
	Neutral	3.67	1.10	3.79	1.02	0.202
	Total	3.64	1.11	3.84	1.02	**0.04**
Independent t-test p-value		0.61		0.45	change	0.13
Implementation Intentions						
Link your healthy activities to specific moments in time.	Empathic	3.18	1.07	3.31	0.96	.210
	Neutral	3.18	1.19	3.41	1.05	**.03**
	Total	3.18	1.13	3.36	1.00	0.089
Independent t-test p-value		1		0.44	change	0.48

Table 5: Health behaviour change analysis
**Significant with adjusted p-value=p-value/total behaviours=0.05/8 = 0.006*

Table 6 combines the eight behaviours in Table 5 into three main categories of behaviours according to the three persuasive strategies for pre and post Alex interaction in both empathic and neutral

implementations and then the test is performed on the three categories' derived data.

Behaviour		Before interaction		After Interaction			
		mean	*std*	*mean*	*std*		*p*
Goal setting	Empathic	3.35	0.81	3.57	0.89		**.001***
	Neutral	3.43	0.91	3.63	1.00		**.03**
	Total	3.39	0.9	3.62	0.85		**<.001***
Independent t-test p-value		0.53		0.68		change	**0.82**
Showing progress	Empathic	2.82	0.82	3.18	0.83		**<.001***
	Neutral	2.85	0.81	3.41	1.05		**<.001***
	Total	2.84	0.82	3.18	0.81		**<.001***
Independent t-test p-value		0.79		0.08		change	**0.12**
Implementation intentions	Empathic	3.18	1.07	3.31	0.96		.210
	Neutral	3.18	1.19	3.41	1.05		**.03**
	Total	3.18	1.13	3.36	1.01		**0.01***
Independent t-test p-value		1		0.44		change	0.48

Table 6: Health behaviours strategies change analysis by behaviour category

A total of 35 comments were received from those who scored 4 or below to one of the SRSS question "Why do you feel Alex's approach was/ was not a good fit for you?". Thematic analysis on these led to Table 8.

Theme	Count	Example
Preference for Human Coaches	6	"well. I don't believe he knew enough about me to start and I would rather speak to an actual person this could be my age but interacting with a computer programme is at the forefront of my mind so if I care to lie to it I could. "
Limited answering options	6	"I like the idea of an interactive avatar, however the questions and the limited answering possibilities felt quite contrived. The questions didn't feel like they were linked to the available responses. It felt a bit prescribed rather than personal"
Not personalised	12	"Personal goals are very different to auto-mated generated response from Alex. I understand I need to eat healthy and drink more water, however what can be done for my BMI and other more specific related health related problems."
Features need enrichment	4	"Disadvantage of talking to an online bot with only given questions you can ask, and not being able to back track to ask a different question out of the two offered."
Need for Voice Assistance	1	"I think I understand better when things are verbally communicated to me."
No new information	6	"I believe I already have great knowledge about what Alex was trying to teach."

Table 8: Thematic analysis on empathic Alex's users

Theme	Count	Example
Preference for Human Coaches	6	"well. I don't believe he knew enough about me to start and I would rather speak to an actual person this could be my age but interacting with a computer programme is at the forefront of my mind so if I care to lie to it I could. "
Limited answering options	6	"I like the idea of an interactive avatar, however the questions and the limited answering possibilities felt quite contrived. The questions didn't feel like they were linked to the available responses. It felt a bit prescribed rather than personal"
Not personalised	12	"Personal goals are very different to auto-mated generated response from Alex. I understand I need to eat healthy and drink more water, however what can be done for my BMI and other more specific related health related problems."
Features need enrichment	4	"Disadvantage of talking to an online bot with only given questions you can ask, and not being able to back track to ask a different question out of the two offered."
Need for Voice Assistance	1	"I think I understand better when things are verbally communicated to me."
No new information	6	"I believe I already have great knowledge about what Alex was trying to teach."

Table 9: Responses to questions about Alex

Table 9 reports responses to the three questions concerning the players experience or attitude towards Alex on a Likert scale of 1 to 5 where 5 represents the best experience. The p-values for independent t-tests for all questions are also provided in the tables to determine any significant differences between the empathic and neutral groups.

Questions	Empathic		Neutral		p-value
	mean	*std*	*mean*	*std*	
I liked Alex	3.77	1.01	3.79	1.04	0.89
I found Alex empathic	3.53	1.25	3.38	1.15	0.35
I would recommend Alex to a friend or family member	3.26	1.28	3.38	1.28	0.51

4.3 USABILITY

The SUS statistical scores for empathic and neutral Alex are shown in Table 10. The average SUS for empathic Alex is 2.94 and neutral Alex is 2.98 which means that the application is easy to use and does not require technical support.

Question	Empathic		Neutral		
	Mean	Std	Mean	Std	p-value
I think that I would like to use this system frequently	2.77	1.17	2.77	1.28	1.00
I found the system unnecessarily complex	2.28	1.02	1.93	1.03	**0.008**
I thought the system was easy to use	4.26	0.78	4.46	0.78	**0.02**
I think that I would need the support of a technical person to be able to use this system	1.75	1.15	1.60	1.07	0.32
I found the various functions within this system were well integrated	3.56	1.07	3.60	1.06	0.77
I thought there was too much inconsistency in the system	2.35	1.02	2.28	1.04	0.62
I imagine that most people would learn to use this system very quickly	4.27	0.87	4.37	0.94	0.35
I found the system very cumbersome to use	2.40	1.19	2.50	1.20	0.56
I felt very confident using the system	3.99	0.99	4.36	0.77	**0.001**
I needed to learn a lot of things before I could get going with this system	1.81	1.01	1.96	1.19	0.33
Overall Average Mean	2.94	1.03	2.98	1.04	

Table 10: System Usability Scale Results

5. DISCUSSION

The main objective of our study was to determine the efficacy of an empathic coach to change health behaviours in comparison to a neutral one. The dialogue of the neutral coach was modified to include relational cues (Bickmore et al., 2005) that were extracted from previous work done in health coaching and support strategies for building working alliance, intention to change and likability of the coach (Abdulrahman & Richards,

2019). The study was designed to factor in gender, age and personality traits so as to determine which relational cues are liked more by the individual's attributes (Bickmore et al., 2005). This will establish traits that need to be built into the future versions of the coach along with the customization according to the most liked cues. This work is novel in its design because it implements an application that uses the COUCH architecture and relational cues found in theory but now to be seen in action in the serious gaming world. The previous applications of COUCH (Beinema et al., 2021) did not consider the enrichment of verbal dialogues through the empathic cues.

To measure the impact of the relational cues, our between-subject design exposed participants to a neutral dialogue or an empathic dialogue delivered by Alex. Random allocation resulted in equal numbers in both groups. Analysis of the individual factors of these two groups revealed similar distribution across gender and age. However, t-test comparison of the personality of the two groups revealed that the neutral group were more introverted, emotionally stable and open to new ideas. We might expect that individuals who are open to new ideas might be more willing to explore (Gosling et al., 2003; Heinstrom, 2004) and change their behaviours. Inversely, this potentially means it would be harder to change the behaviours of the empathic group. However, our analysis reports the opposite, adding further weight to our results.

The individual analysis of each health behaviour change led us to interesting insights that can help plan the future extensions of focus with empathic and neutral Alex. We can see from the independent t-tests before the interaction, that there are no significant differences between the neutral and empathic groups. Random allocation by Qualtrics to groups has thus successfully distributed participants so that both groups represent a similar spread of behaviours, perhaps with the exception of the behaviour "Define a healthy activity goal for yourself' where the mean for the empathic group was 3.3 compared to 3.53 for the neutral group. We expected randomisation to ensure no significant differences between the two groups at baseline. For all behaviours, we saw an increase in the mean after the intervention in both groups, indicating that interacting with Alex to chat about their health was beneficial to both groups. To identify

whether neutral or empathic Alex was more effective, we conducted independent t-tests on the change in behaviour intention from before and after the interventions between the two groups. We found some significant differences between the two groups:seven behaviours for empathic Alex and six behaviours for neutral Alex. Thus, it is unclear that either version of Alex delivers better behaviour change intention.

Comparison of the impact of neutral versus empathic Alex is aided when the behaviours are grouped together into three persuasive feature categories: goal setting, showing progress and implementation intentions extracted from the work done by van Velsen et al. (2019), in which goal setting, showing progress and implementation intention were found to be the most important persuasive strategies to motivate.

The goal setting category of behaviours consists of three behaviours relevant to setting or defining a goal in which for “setting an exercise goal”, the rating before interaction was with a mean value of 3.44 for empathic Alex which became 3.61 after interaction. Although the t-tests between empathic and neutral before or after interaction were not significant, but for each group separately the t-tests conducted for before and after interaction were significantly different which means that there was a change in health behaviour intention after the interaction. The same was observed for “setting a healthy eating goal” with mean of rating before interaction being 3.3 and after interaction increased to 3.6. For the statement “Define a healthy activity goal for yourself.” there was a significant change for empathic Alex after interaction with p-value of 0.003 but for neutral the p-value was not significant. Research on motivational strategies that help patients follow advice in the long term (Pereira et al., 2021) also use empathy during goal setting so that patients can understand triggers better and reciprocate to the treatment advised. One reason could be that emphasizing on personal goal setting in the cues as in the cue which uses “for yourself” is more empowering for the users. This refers to de Vries et al. (2017) where the process of change in behaviours is highly affected by personalised texts especially in raising consciousness.

Another behaviour category is “showing progress” in which there are four quantifiable incremental goals that help in building healthier habits in a gradual manner. The first one is “Keep track of your progress by automatic

step counter". Both empathic and neutral Alex before and after interaction had a higher intention to change (p-value for both tests <0.0001). One reason could be that use of digital technology in self-tracking is considered more effective with the user being tagged as a quantified self (a person who feels empowered enough to measure his/her own progress) who shows more intention to change (Didžiokaitė et al., 2018) The second health behaviour is "Log your food choices in a food diary" both interaction groups had significant p-values when comparing before and after interaction (p-values: empathic -E=<0.0001, neutral-N=0.0007), with empathy reporting a higher significance value. Empathy through politeness, empowerment and decision-making coaching strategies (Lelorain, 2021) maintains hope and helps show continuous progress. The third health behaviour in this category is "Tweak your daily activities to get closer to the goal". For this behaviour the neutral users rated more intention to change before and after interaction (before interaction mean: E=3.09, N=3.15 and after interaction mean: E=3.39, N=3.48). One reason that has been quoted by users in improvement is that more clarity and guidance is required for certain coaching cues and this could be one of them For the last behaviour "Drink additional glasses of water everyday" which is also a quantifiable and gradual change, the empathic Alex's change in intention was significant (p-value=0.0001) but not significant for neutral (p-value=0.26). In a nutshell, two behaviours showed a higher intention to change after interaction with empathic Alex. These two behaviours are considered as popular health maintenance goals and can be easily achieved as compared to the other two of which one required an automatic health counter and the other requires more explanation and guidance as to what to change in terms of daily activities. This links to users' feedback in which having more personalised explanation and giving more alternatives can be a viable solution. Some suggestions from the users are "the options given are not for me" or "I need more explanation to my specific health status".

The last behaviour group is implementation intention which has only one health behaviour in it which is "Link your healthy activities to specific moments in time". In terms of significance, neutral Alex users showed intention to change after interaction (p-value=0.03) whereas empathic users did not show much intention to change (p-value=0.21). Both groups had no significant variation in rating when compared before interaction or

after interaction (p-value: before=1.0, after=0.44). This group needs more health behaviours to analyse it further. One behaviour was not found sufficient enough to conclude. This behaviour also has a different interpretation for different types of users and is tightly bound to self-determination and intrinsic motivation (Ryan & Deci, 2000). The more users' psychological needs of being competent, autonomous and related are satisfied, the more the user feels enhanced self-motivation and mental health and hence can make better decisions.

In a nutshell, after interaction with the empathic health coach Alex 7 behaviours showed significant intention to change and for neutral Alex 6 behaviours showed significant intention to change. This provides marginally positive, but inconclusive, support, for RQ1: "Do ECA's empathic dialogues motivate the player to change their health behaviours more than the neutral dialogues?" where the impact of empathic cues in terms of intention to change eight health behaviours needs to be analysed. It can be seen that 87.5% of the health behaviours were rated higher after interaction with empathic Alex. The interaction with neutral Alex also resulted in higher intention to change in 62% of the behaviours. In empathic Alex, the most impactful persuasive strategies were found to be goal setting and showing progress (100% behaviours showed higher change in intention) in which the users were given quantitative goals or monitoring techniques based on their current health status. The neutral Alex had the same motivational strategies but without relational cues and 60% behaviours showed a higher intention to change after interaction. The intention to change was also found higher for neutral Alex users especially in implementation intention strategy which show that relational cues have more impact in goal setting and showing progress than in implementation intention strategies. This also relates to the research work of Beinema et al. (2022), where implementation intentions relevancy is greater for the dialogues associated with outlining the concrete steps to achieve a task than to the non-task based relational cues but this needs to be explored further since there was only one behaviour in implementation intention feature group.

The second research question RQ2: "Do ECA's empathic dialogues build a stronger working alliance with the player than the neutral dialogues?'

analyses the efficacy of the relational cues in building better working alliance which is determined by the working alliance questionnaire (Brooke, 1986). It consists of four questions whose individual contribution to the analysis determines multiple aspects of the impact of relational cues. The first SRSS question is "I felt heard, understood and respected" that caters to dialogues that according to Cameron (2015), builds mutual understanding and shared goal's planning through politeness, inclusivity and affirmation (Cameron,et al., 2015). Empathic Alex has a higher mean rating for this question (6.50) than neutral Alex (6.47) and in both groups 70% users rated Alex above 5.

For the second SRSS question: "We worked on and talked about what I wanted to work on and talk about" is about consideration of keeping the content of coaching to be as helpful as possible for all users. Empathic Alex's average rating was higher (6.19) as compared to neutral Alex (5.98). The content was designed to accommodate the motivational and persuasion features required for all users whereby the original dialogues were extracts of initial implementation of health coaching applications using virtual coaches (Beinema et al., 2021).

The third SRSS question "Alex's approach is a good fit for me" is about how Alex personalises and caters to individual users' more progressive needs in the session. Although 70% users rated high for this question in both groups but mean of neutral Alex was found to be on a higher end (5.97) as compared to empathic Alex (5.62). The feedback received from the users on this question was thematically analysed to identify enhancements and future directions for the coaching approach. The main limitations were found in the overall application's need to be more personalised (12 out of 35 users who rated it less than 5 also mentioned Alex being not personalised). One reason could be that a working alliance usually needs more personalisation that, in future implementations, needs to be structured in multiple sessions with history and response choices of the user creating more personalised and engaging scenarios (Busseri & Tyler, 2003).

The fourth question "Overall, today's session was right for me" which measures the satisfaction level of the user with the session itself was also rated higher by 70% of the users in both groups with neutral being rated

at a higher end (N=5.76, E=5.65). Overall, the working alliance rating was on a higher end for both groups and the first two questions that depict more direct association with relational cues to build working alliance have a higher alliance score for empathic Alex.

Some suggestions that have been given by users to make Alex a better fit include certain feature enhancements like having a navigational menu to re-route to other topics, having more options to embed the personalised context of the user's current health status and make recommendations accordingly, have more check and balance on whether the user wants to know advanced content or is happy knowing the basics and having the voice feature added to Alex.

The third research question (RQ3): "What is the player's experience of the empathic ECA compared to the neutral ECA?" is analysed by the user experience questionnaire that consists of three questions. The first question "I liked Alex" was rated slightly higher by the neutral Alex users although both groups rated it highly in terms of likability. One reason could be that neutral Alex was not impolite or rude ad since users of neutral Alex did not experience empathic Alex, the rating is for their own limited experience with neutral Alex. The second question is "I felt Alex was empathic". This had a higher average rating for empathic users although both groups were not significantly different. The third question was "I would recommend Alex to a friend or family member" was rated slightly higher by the neutral users. The reason could be that both groups were unaware of the dialogues variation in each other. In summary the overall experience of both user groups is rated high irrespective of empathic versus neutral.

Lastly, the SUS score also contributes towards answering RQ3 as it allows us to compare the user experience for empathic Alex and neutral Alex groups. In the SUS analysis, three usability experiences were found significantly different for both groups which are "I found the system unnecessarily complex", "I thought the system was easy to use" and "I felt very confident using the system". The empathic Alex average rating for these three was inclined towards a more negative experience which means that empathic Alex was found to be more complex and raised more concerns for users. One reason could be that empathic Alex's dialogue

paths involved longer conversations and involved Alex referring to his own life and background. This attempt to make the discussion more humanlike, rather than a set of survey questions may have added to the perceived complexity and possible frustration. Users may have just wanted to get to the point and may have found the conversations deviated too much from the goal of the conversation. There were two SUS questions which favoured empathic Alex, although for two groups they were not significantly different. These were "I found the system very cumbersome to use" and "I needed to learn a lot of things before I could get going with this system". Empathic Alex users found the system less cumbersome and also the learning curve was considered shorter by the empathic Alex users. One reason could be that, although the journey was longer for empathic coaching, that extended duration of usage also made users comfortable with the system.

5.1 LIMITATIONS

Although the goal of this study was to analyse the impact of health coaching gaming technology with a flavour of empathy and relational cues utilization in comparison to the neutral one with no relational cues, our results did not confirm better outcomes in terms of behaviour change, working alliance or experience. We note that motivating an individual to change their behaviour is likely to require a long term working alliance (Bickmore et al., 2010). Thus, to see changes may require more sessions with the same users and every session needs to adapt to the user history and personalised goal plan.

Secondly, the gaming applications are built on a plethora of modes of interaction that range from providing multiple response options through to a variety of channels. Currently, in our application the user can only interact using fixed text responses that are provided and the user selects one of them. This can be enriched with more interactive options including user menus and re-routing options to find more personalised journeys within the app.

Thirdly, the coaching application can be made more generalisable by testing on a wider range of individuals including more age variations and

users with more specific health issues so that the value addition of the virtual application can be enriched. Currently it has been tested only on students who are mostly health aware and active.

5.2 FUTURE WORK

This study is a baseline for empathic health coaches' development and can be extended further to bring in multiple coaches to provide coaching expertise that covers more than one domain area (e.g. diet, physiotherapy, diabetes, etc) in the application. This will increase the breadth of learning when the game is used by coaches who are in training and also provides also more tailored support to patients.

In the future, adding personalisation could be achieved through automatic generation of relational cues according to the preferences of the user to contribute towards building a context aware bot. Natural language processing techniques for context categorisation and generation of bags of words that are most suitable to health domains can be explored. The third idea revolves around bringing in more personality aspects into the dialogues involving showing empathy and adapting social dialogues based on individual user factors. For example, there can be a strong liking towards an assertive coach or vice versa. Hence personality based diversity can bring in more likability.

6. CONCLUSION

The main motivation behind this study was to analyse the impact of an empathic virtual coach when it comes to health coaching. The use of the right motivational techniques as well as the choice of words has been shown to be vital in many domains whereby human interaction has been explored, analysed and studied. The human embodiment of a conversational agent is a growing area of research and this study has sought to understand how empathy and relational cues could impact on bringing a change in current behaviour.

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CHAPTER 2

Fit to Game

The experience of exercising indoors using games during the COVID pandemic

KATHLEEN YIN; MATTHEW D. LEE; CHARBEL KISRWANI; KIRAN IJAZ; JAMES SMITH; AND LOUISE A. ELLIS

ABSTRACT:

We report data from an online survey that queried the player experience of using video games to exercise indoors during the year 2020, when many countries imposed strict social isolation rules and outdoor movement became limited for millions of people. Indoor exercise games such as the *Nintendo Wii Suite* are known prior to the pandemic to be effective exercise replacements in clinical settings, however little is known about people's experience using these games to maintain exercise during COVID-19 isolation. We also report on contextual enablers and barriers that influence this indoor exercise experience, offering inside to the practical considerations involved in deploying indoor exercise games to users in real life.

KEYWORDS:

Serious game, exergame, COVID-19, implementation

1. INTRODUCTION

During the initial days of the pandemic, physicians warned of the possibility of adverse effects caused by the social distancing measures used to combat the spread of COVID-19 (Ashikkali et al., 2020; Hall et al., 2021), noting that the radical modifications to daily routines risked many falling prey to unhealthy habits. Among these, a general decline in physical activity was noted as a particular concern, given the closures of gyms, offices, schools, and the adoption of remote work across many industries. Such a decline, they argued, would constitute an "inactivity pandemic" (Ferrante et al., 2021; Hall et al., 2021), with dire consequences for the population's general well-being, given the important role that regular physical activity has been found to play in preventing chronic disease (Zhu, 2019), managing weight (Chou et al., 2012), promoting immune response (Simpson et al., 2015), and mood and sleep pattern regulation (Byrne & Byrne, 1993).

Given the importance that physical activity plays in maintaining well-being, with public health guidelines (Bull et al., 2020) recommending that all adults undertake at least 150 minutes of moderate-to-vigorous activity a week, private organizations and public bodies devoted a great deal of attention and funding to strategies to encourage people be more active (Bauman & Chau, 2009; Haskell et al., 2007; Kahn et al., 2002). These strategies included financial incentives (i.e. offering reduced cost access to fitness programs) (King et al., 2019), community campaigns to help people choose more active options (i.e. walking instead of driving short distances) (Kahn et al., 2002; Nocon et al., 2010), crafting well-designed physical education programs at school (Lonsdale et al., 2013), or designing environments so that being active is either seen as convenient or is simply unavoidable. Examples include designing corporate campuses to require individuals to get up and walk to reach bathroom facilities, meetings rooms, and the like. Such strategies that utilize group dynamics and alter patterns of movement and behavior through environmental design have proven to be effective (King et al., 2019) at increasing physical activity and relatively cost effective, providing a disproportionate impact for the investment they require (Müller-Riemenschneider et al., 2009) – at least, prior to the pandemic.

Many of the fundamental assumptions of social and behavioural strategies

were invalidated in the context of the COVID-19 pandemic and the social restrictions implemented. These assumptions include individuals having prior interest in exercise, individuals having an emotional investment to a group, and individuals having access to physical spaces that allows intensive physical activity. The closure of physical spaces such as workplaces and gyms, and the consequent loss of emotional connection to that social community, had weakened the implementation of the social theories of behaviour change (Fancourt et al., 2020). While organizations have switched to chat programs, phone conversations, and videoconferencing (Watson et al., 2020) to try and retain a sense of community, these alternatives could not replace face-to-face connections. To many, these alternate channels seem less "human" (Watson et al., 2020), with detrimental effects on relationship-building, which has had negative consequences for existing community-based strategies to promote physical activity.

Alternative strategies are thus required, preferably those which do not involve tapping into a pre-existing interest in exercise, which do not rely on individuals being part of a pre-existing community, and which can be done at home, without requiring an individual to travel. Video games which require players to engage in moderate-to-vigorous physical activity in order to progress, often called active video games (AVGs) or exergames (Oh & Yang, 2010), have been suggested as one such alternative (Ferrante et al., 2021; Gonzalez et al., 2016). Exergames can be played at home alone and are an attempt to reframe exercise as entertainment, and prior research (Primack et al., 2012; Rozental-Iluz et al., 2016; Satava et al., 1995; Warburton et al., 2007) showed that the use of exergames both mediates physical exercise and is associated with cognitive, physical, and psychological benefits.

With the public health emergency posed by COVID-19 presenting great challenges to maintaining physical exercise, and with consumption of video games reaching an all-time high at 82% of global consumers playing video games during the lockdowns (The Nielson Company (US), 2020), perhaps it is time to examine the viability of exergaming as an alternative to traditional approaches. With the World Health Organization partnering with the game industry to encourage people to stay at home, play video

games, and practice physical distancing, games have been shown to be a viable part of a highly successful public health strategy (Interactive Software Federation of Europe, 2021). With so many people turning using games as entertainment, might they also turn to exergames when their usual venues for exercise are inaccessible?

1.1 RELATED WORKS ON THE IMPACT OF GAMES ON EXERCISE DURING COVID

To date, there have been few studies that examine the impact of games on exercise during COVID. While it is known that overall physical activity did decline during COVID-19 (Ferrante et al., 2021; Hall et al., 2021), giving rise to the very "inactivity pandemic" that some warned of, it is unclear what role games played in this, as opposed to the wide-scale disruptions of people's daily routines.

What little literature exists regarding the impact of games on exercise during the pandemic is mostly either speculative (dos Santos et al., 2021) or look at the effects of screen time and exercise on perceptions of mental and general health (Colley et al., 2020). To the authors' knowledge, only one study (Ellis et al., 2020) examined the impact of gameplay on exercise, finding that there was a significant positive relationship between total hours of participation in gaming and total hours of exercise per week during the pandemic among players of *Pokémon GO,* and that while there was a decrease in physical activity during the pandemic, the average *Pokémon GO* player was still physically active for an average of 6.5 hours a week – or 390 minutes – well above the minimum of 150 minutes (2.5 hours) of moderately-intense activity recommended per week (Bull et al., 2020). This finding was supported by qualitative results, with players consistently mentioning that the structure that *Pokémon GO* provided and the sense of accomplishment they received from accomplishing goals in the game provided them with motivation to exercise during the pandemic.

1.2 RELATED WORKS ON INDOOR EXERGAMES

The earliest versions of video games intended for the public were indoor exergames. They were non-sedentary and very social activities. In the

earliest instances of gaming in the arcades in the 1970s, playing a game requires players to stand in an upright position in front of an arcade cabinet for extended amounts of time while engaging in vigorous jostling of the controls – often with a great deal of body English, body movement in excess of what was needed to manipulate the controls, involved. It was only when video games shifted to being primarily played on home computers and home consoles in the 1980s that gaming became more sedentary.

There is a considerable body of literature on the physiological benefits of indoor exergames such as *Dance Dance Revolution* (DDR) or *Nintendo Wii Suite* (Bonetti et al., 2010; Maddison et al., 2007; Penko & Barkley, 2010; Primack et al., 2012; Warburton et al., 2007), with many finding that they can be effective exercise replacements in the short term. These indoor exergames are comparable to standard exercise on parameters such as heart rate (Bonetti et al., 2010), oxygen consumption (Penko & Barkley, 2010), electrocardiogram activity (Maddison et al., 2007) and self-motivated duration of exercise (Warburton et al., 2007). However, such studies have also shown that when players feel forced to use a game, efficacy suffers. Studies (Heeter et al., 2011; Madsen et al., 2007) found game engagement driven by enforced or prescribed play is often short-lived, with players losing their sense of enjoyment within weeks, and often discontinuing play altogether.

Further, few studies touched on the various real-life constraints which might impact adoption of indoor exergames. In studies involving indoor exergames, users are provided with the game and relevant hardware for the duration of the study period, or are provided with a dedicated space and time where they can use the intervention. However, not everyone has the correct hardware at home and most home environments are not designed to facilitate vigorous exercise for only one person. This presents many practical challenges to implementation that no study has adequately addressed.

To address the existing gaps in the literature, this study examines the experience of individuals who used video games to exercise indoors during the COVID-19 pandemic, with a focus on whether these games functioned as viable exercise alternatives. If they did not, we aim to identify what factors need to be addressed to make them viable in the future, given the

continuing impact of pandemic-driven behaviour and policies on outdoor exercise.

2. METHODS

2.1 RECRUITMENT

The recruitment methodology has been described in detail elsewhere (Ellis et al., 2020). Briefly, a mixed-methods survey was conducted online via convenience sampling over 2 weeks in May 2020 on subreddit Pokémon GO and Harry Potter: Wizards Unite forums. The study's ethics approval was obtained from the Macquarie University Human Research Ethics Committee for Medical Sciences (Reference No: 52019601512435. Project ID: 6015).

2.2 SURVEY

This paper is a part of a larger survey regarding exercise via games during the pandemic. Players were eligible to participate if they were over 18 years of age and played either Pokémon GO or HPWU for at least a week in English in 2020. We present demographic data regarding gender, play style (ranging from "casual", "midcore", "hardcore", and "not sure"), and age.

Quantitative data in this paper involves two questions. The first question is "Prior to the covid-19 shutdown, how many hours a day were you exercising during the days that you did physical exercises?". The second question is "How many hours a day do you exercise during the shutdown, during the days that you do physical exercises?" These two questions are chosen to examine whether there was a difference in exercise during the pandemic for those participants who exercised indoors versus those who did not.

The qualitative question analysed here is "What has your experience been regarding using video games (e.g. Wii/Xbox/VR) to exercise indoors?". This question reveals how people have used video games to exercise indoors in a holistic manner.

2.3 DATA ANALYSIS

Self-reported quantitative data was extracted from Qualtrics and directly imported into Excel, where the Real Statistics software was used to calculate inferential statistics (Zaiontz, 2021). This work was carried out by KY.

Qualitative responses were analysed through thematic analysis using NVivo v12 Plus (QSR International). The participants' answers for the qualitative question were extracted and entered into NVivo. The data was coded inductively by the researchers KY and CK. Codes were developed according to the Braun and Clarke model of thematic analysis (Braun & Clarke, 2008). The entire research team was consulted throughout the qualitative analysis process to resolve disagreements until consensus was reached.

3. RESULTS

3.1 DEMOGRAPHICS

The survey received valid answers from 1052 participants, with 284 (27%) having used video games to exercise indoors in 2020. Demographics data for the indoor exergaming population are presented in Table 1.

Table 1. Demographics data of those who played indoor exergames

Characteristic	Number of participants (Out of participants who played indoor exergames)
Gender	
Male	152 (54%)
Female	120 (42%)
Other/unindicated	12 (4%)
Age	
18-25 years old	80 (28%)
26-35 years old	124 (44%)
36-45 years old	46 (16%)
46-55 years old	15 (5%)
> 55 years old	3 (1%)
Unindicated	1 (0.4%)
Playstyle	
Casual	112 (39%)
Midcore	88 (31%)
Hardcore	79 (28%)
Unsure/No answer	4 (1.4%)

Table 1. Demographics data of those who played indoor exergames

The players who exercised indoors with video games during the COVID-19 pandemic were roughly equally distributed between female and male (42% vs 54%). They were mostly between 26 and 35 years old, and were equally spread across Casual, Something in-between, and Hardcore playstyles.

The percentage of players who exercised indoors based on total survey participants are shown in Table 2. Between 10 to 15% of all participant segments have exercised indoors using video games. The groups with the largest percentage of indoor exergame participation are those who identify as neither male or female, between the ages of 36 to 45 years old, and have a hardcore playstyle.

Table 2. Percentage against total participants

Characteristic	Percentage (Out of total survey participants)
Gender	
Male	12.90
Female	14.67
Other/unindicated	25.53
Age	
18-25 years old	12.97
26-35 years old	13.19
36-45 years old	16.03
46-55 years old	14.71
> 55 years old	6.82
Unindicated	1.00
Playstyle	
Casual	12.13
Midcore	13.35
Hardcore	20.05
Unsure/No answer	2.55

Table 2. Percentage against total participants

3.2 INDOOR EXERGAME PLAYERS DID NOT EXPERIENCE A REDUCTION IN EXERCISE HOURS

The group that did not use indoor exergames experienced a statistically significant decrease in exercise hours during COVID-19 social isolation compared to before the pandemic (p-value = 0.02), while the group that used indoor exergames did not do so (p-value = 0.25). This indicates that the group using indoor exergames maintained their level of daily exercise hours during the pandemic, while the group that did not use indoor exergames suffered a decrease in daily exercise.

Differences in exercise before and during COVID social distancing was not found to be significant between participants who played indoor exergames and those who did not (P-value = 0.63 for exercise hours before COVID. P-value = 0.56 for exercise hours during COVID).

Table 3 presents the mean and median values for the two participant groups regarding exercise per day (in hours) before and during COVID social distancing measures.

Table 3. Exercise during COVID isolation

Exercise before COVID social distancing (hours per day)	
With indoor exercise	Without indoor exercise
Mean = 1.69 (SD = 1.56)	Mean = 1.63 (SD = 1.76)
Median = 1.10	Median = 1.20
Exercise during COVID social distancing (hours per day)	
With indoor exercise	Without indoor exercise
Mean = 1.55 (SD = 1.24)	Mean = 1.49 (SD = 1.41)
Median = 1.0	Median = 1.0

* SD = standard deviation

Table 3. Exercise during COVID isolation.
** SD = standard deviation*

3.3 THEME 1 – EXERGAMES WERE FUN AND A GOOD EXPERIENCE

Many participants indicated that exergames were in general fun, good, and a positive experience during COVID-19 social distancing. Overall, participants found it to be a fun alternative to outdoor exercise, bringing in some entertainment as well as working up a sweat. Those living with family also indicated that the indoor exergames were conducted with other family members and helped with family bonding. This positive experience was reported by many segments of the participant population. Various participants highlighted that using these games to exercise was "*enjoyable*" (22 years old, male, United Kingdom, hardcore gamer), "*fun and provides a good way to exercise*" (27 years old, female, Portugal, midcore gamer), and "*a nice family activity*" (18 years old, female, Hungary, casual gamer).

The two major contributors to participants feeling the exergame was fun were stated as 1) having a purpose to physical movement and 2) having a feeling of social connection and solidarity. Games where exercise has in-game and is not merely making the player move made participants feel more motivated to come back to the game. At the same time, games that provided a social exercise and made players feel connected to other people (real people or game characters) also motivated players to keep coming

back to play, since such games provided the bonus benefit of emotional and social interaction during COVID-19 social isolation. One participant put this effect very succinctly in her answer.

"*Currently I use the app Zombies Run for their Home Front missions. These missions have a story to go with the workouts, involving game characters having to be isolated too. This metafictional solidarity is really encouraging for me, it's motivating while being a step removed from Covid19*" (28 years old, female, United States, casual gamer).

Interestingly, many participants stated that the exergames "*gets boring quickly*" (36 years old, male, United States, casual gamer) and "*Seems more fun and interesting when first starting. Sometimes it gets old and stale*" (44 years old, female, United States, casual gamer). Such findings indicate that the engagement of these exergames did not always last for a long time, especially in the absence of other factors – such as social connections – that encouraged maintained engagement.

3.4 THEME 2 – EXERGAMES WERE BORING AND NOT AS ENGAGING AS REAL EXERCISE

As stated above, participants often find the indoor exergames quickly lose their lustre. The main factor attributed to this loss of interest is that some games are not engaging and are even less fun as standard exercise or outdoor exercise. Participants ascribe their negative attitudes towards indoor exergames to reasons such as "*not as fun as the outdoors*" (33 years old, male, United States, hardcore gamer) and "*not really the same feel [as outdoor exercise]* (21 years old, male, United States, hardcore gamer)", indicating these games are not able to keep the fun over a long time.

Specifically, some exergames are described as being less fun than normal games and normal exercise. They have the repetitive routine of exercises and an arbitrary gamification on top of the exercise, and thus unable to provide continuous engagement. Participants stated "*It's hard to stick with it. The exercise video games are good, but they feel too much like exercise!*" (38 years old, female, Canada, midcore gamer). Moreover, participants indicated they would cease playing with the exergame based on

engagement, rather than perceived physical benefit, with participants indicating "*if I am not engaged in the experience I likely won't follow through*" (21 years old, male, Canada, hardcore gamer).

3.5 THEME 3 – EXERGAMES WERE SPECIFICALLY DESIGNED FOR CARDIO EXERCISES

Participants also pointed out that exergames were only good for specific types of exercise, namely cardio exercises aimed at increasing heart rate and maintaining it. This could either be a positive or negative influence, depending on what kind of exercise the participants desired. Some participants were simply trying to look for a way to get their body moving, and thus found the brief burst of cardio as a welcome addition to their day.

One type of indoor exergames that is highlighted as very good cardio is the dancing game genre. These games, which involved whole body movement, were favoured for cardio compared to other games. "*I love Dance Dance Revolution. It's a great cardio routine."* (36 years old, male, United States, casual gamer) "*DDR (PS2) is fun and I'm counting it as cardio."* (24 years old, non-binary gender, United States, midcore gamer) Dancing games have the added benefit of being a very social game that involved the entire family, which increases the amount of fun and engagement felt by the participants. "*Good, dancing with family is fun*" (36 years old, male, United States, midcore gamer). "*Use Just Dance routines (with child and partner)"* (36 years old, female, Australia, casual gamer).

On the contrary, participants who were looking for more comprehensive fitness activities were disappointed in exergames for their lack of variety. Participants who were used to more diverse or comprehensive exercise regimes that focused on more than simply burning energy want something more than cardio and were unable to get it from existing exergames. "*It's a little fun, but I think just working out following an exercise routine is more efficient. I would probably use a game like that just to add some variety or to add some cardio into my week, but I would not use it for my other goals of strength and flexibility."* (35 years old, female, United States, casual)

3.6 THEME 4 – EXERGAMES WERE LIMITED BY REAL-LIFE

CONTEXTS

The experience of indoor exercise was also hindered by its implementation in a home setting and the myriad of contexts in daily life. Participants reported the hardware of the exergames can cause physical discomfort, which leads to terminating the experience. Consoles that required specialised handheld equipment were highlighted as the main culprit, with pain at the hand or wrist noted as the major concern. "*The wii fit hurts my joints."* (26 years old, non-binary gender, United States, midcore gamer) "*I've been using the Nintendo Switch. It's a fun side diversion, but also hurts my wrists if I use it for too long."* (33 years old, female, United States, midcore gamer)

The physical confines of a house and apartment also limits the extent of indoor exergaming. As the games are not the same as specialised exercise equipment and does not provide noise control, soft contact surfaces, or limit the range of movement or force, participants cited these issues as reasons why they don't conduct indoor exergaming. Hitting physical barriers in the house, getting hurt due to not having soft contact surfaces, having to share their exercise space with other people, and creating excess noise for other people living in the same dwelling were all cited as reasons that limited participation in indoor exergames. *"Jumping Hardwood floors bookcases are not a good exercise space."* (35 years old, male, United States, casual gamer) "*Broke a wall."* (40 years old, male, Australia, gamer type unsure)

4. DISCUSSION

4.1 DEMOGRAPHIC DIFFERENCES IN USING INDOOR EXERCISES DURING COVID-19 ISOLATION

An equal percentage of males and females indicate they have played indoor exercise games during the COVID-19 social isolation. Approximately 12-14% of the wider male and female participants played indoor exercise games in our cohort, a ratio that is maintained in all other demographic segments of our participant pool. The groups that differ from this number are those who identify as other than male or female in gender (25.53%) and hardcore gamers (20.05%), and may reflect how these groups are

emotionally invested gaming and virtual worlds to satisfy their psychological needs and as a lifestyle choice (Manero et al., 2016; Morgan et al., 2020).

The participants who did not use indoor exergames suffered a statistically significant decrease in their daily exercise hours during COVID-19 social isolation compared to before the pandemic, as expected in light of widespread decline in exercise hours on a global level (Colley et al., 2020). However, the group that *did* use indoor exercise retained the same level of exercise as per before the pandemic, indicating that indoor exercise may have had a positive effect in maintaining physical activity in this population. This is comparable to our prior work on *outdoor exergames* during the pandemic, where users of such outdoor games such as *Pokémon GO* and *Harry Potter: Wizards Unite* also report using such games to maintain physical exercise levels (Ellis et al., 2020). Indeed, there is precedent to show adults not engaged by traditional exercise can use indoor exergames as effective alternatives to increase physical activity (Street et al., 2017). It is thus likely that indoor games can also be a positive alternative to standard exercise during social isolation.

4.2 Differences between "real exercise" and exergame

The biggest issue with indoor exergames, highlighted in our data and in literature, is how engagement is often short-lived and participants profess to lose interest in such games very quickly. Engagement to these games can start to drop off as soon as a few weeks into studies (Madsen et al., 2007), ultimately resulting in reducing play and exercise hours and discontinuing the game completely (Heeter et al., 2011). This is observed in our participants where many reported indoor exergames became boring very quickly and play was ceased within weeks or months, and indicated a lack of engagement with the game resulted in this reduction in interest. Such data had been highlighted before regarding how exergames have issues in being used as a long-term health promotion strategy (Cacciata et al., 2019; Street et al., 2017). As such, exergames may need to re-evaluate its design principles and include more long-term engagement into its game design, moving from a model where scores and badges are providing superficial external motivation to where the physical activity has intrinsic

meaning in the game. Immersion both in real-life and within the software should be valued by designers of these exergames to promote movement, adding value and purpose to these movements, and thus achieving intrinsic motivation for exergames. The games that our participants reported to have the best engagement with, such as *Zombie Run!*, provided in-game value to the exercise conducted in real life, as well as giving a sort of companionship and support to isolated players during the pandemic. These factors add to immersion, contributing to the desire to exercise, together with external factors such as social interactions.

Social companionship and support are indeed some of the biggest components of exergames that modern indoor games lack. *Dance Dance Revolution* (DDR), one of the most popular exergames in our participants, is a franchise that goes back to the 1990s and has always been a social game in arcades. Even before the age of rapid digital communication, DDR players created websites and message boards such as DDRFreak.com to continue socializing with one another online (Ko, 2005; Liu, 2004). These online spaces provided a place where DDR enthusiasts could interact outside of the arcades. Online, people would trade gameplay tips, discuss how to best add their own improvisations to their DDR performances, share where the newest machines were located, or make plans to gather offline. Indeed, even individual play was often done with the community in mind, with many buying the game so they could improve their performance at home and show off their skills during the next meetup (Webster, 2009). In more modern times, while exergames can be played individually, Wii *Sports* is considered a social game as much as it is an exercise game (Espineli, 2019). In the case of mobile exergames, most players are connected either with a larger community invested in the franchise the game is part of (in the case of *Pokémon GO*), or with a larger cultural moment that the game happened to be part of (like *Zombies, Run!*). The importance of this sense of relatedness to engagement is congruent with findings in other gaming genres (Przybylski et al., 2010; Ryan et al., 2006), yet has not been formally examined for exergames, aside from what little work has been done on the factors determining engagement with and benefit from *Pokémon GO* and *Harry Potter: Wizards Unite* (Smith et al., 2021; Yin & Lee, 2019)

4.3 EXERGAMES BEYOND SIMPLY CARDIO EXERCISES

Our players raised a concern that most exergames on the market are only concerned with cardio exercises, and very few addressed other types of exercise that would be present in a professional fitness regimen. Indeed, in the exergame literature, the major standard via which exergames were measured for their efficiency had been cardio parameters such as heart rate and oxygen consumption (Bonetti et al., 2010; Penko & Barkley, 2010). While there are games that function as a fitness coach and offers a larger repertoire of exercise types (Consumer Reports, 2013), the most popular exergames in our cohort – such as dance games (DDR), the Wii Suite, and virtual reality (VR) exergames – remain focused on providing an intensive burst of cardio. As these off-the-shelf exergames are limited to utilizing the corresponding console's in-built motion sensors, perhaps exploring different hardware and design philosophies would help to include other aspects of fitness into these games.

Work has already been done to combine treadmills, cycling, and other fitness equipment with games. Blue Goji Infinity, a patented home treadmill that combines walking on a treadmill with a screen where games can be displayed or a VR headset that allows for VR experiences, seeks to gamify the prolonged running regimens conducted over the treadmill (BlueGoji, 2021). There is also a large variety of commercial makers of indoor bicycles that combine VR to facilitate VR cycling, where users can conduct cardio and body toning workouts on the indoor bicycle while wearing a VR headset or watching a monitor that shows them cycling through a virtual track (Holodia, 2022; Zwift, 2022). Lastly, the versatility of VR has also given rise to a niche family of games that allows for lifting weights for strength training, yoga for flexibility, rowing for upper body strength and dodging/tennis for coordination and lower body movement (Dingman, 2022). These games offer a large variety of exercises, but struggle to become as popular as older games such DDR and Wii Suites. This is due to contextual limitations such as the high costs of VR gear, the spatial and special requirements of VR, the limitations in the modern home, and the incapacity of making VR into a family and social activity.

4.4 CONTEXTUAL LIMITATIONS TO EXERCISING IN THE HOME

It is also significant to remember that these indoor exergames are conducted inside people's homes, where there is often a lack of space, time, and proper equipment. Our participants reported spatial constrictions (especially those living in urban apartments) the prevented them from exercising to the capacity permitted by the game, potentially decreasing the effectiveness of the games. In contrast, many studies for exergames were either done in a controlled laboratory environment, facilitated by staff who checked-in with the participants, or had consoles/ other hardware provided to the participants (Bogost, 2005; Bonetti et al., 2010; Maddison et al., 2007; Penko & Barkley, 2010; Warburton et al., 2007). These studies would also have provided detailed instructions on how to use the hardware and how long to use it for, while our participants using exergames in real life reported wrist and hand pain from overuse. Given that not everyone has a console or other hardware needed to play an indoor exergame, and that the home environment is not designed to facilitate vigorous exercise, with many spaces used for gaming being shared by others and used for multiple purposes, this presents many practical challenges to implementation that no study has adequately addressed.

Considering these contextual limitations, it is no surprise that the most popular exergames remain simple console games such as Wii Sports, which require nothing more than the Nintendo Wii console to function, and mobile exergames, which can be played with nothing more than a phone. The few exceptions to the equipment issue include These have both been effective at attracting new demographics to gaming, especially mobile games, where the game itself is usually free to download (Espineli, 2019; Wijman, 2020). However, in terms of indoor exercise, neither fully address how exergames require more space than others for movement during play, or how the shared recreation spaces of a modern home may need to be reconfigured prior to and after play sessions.

5. CONCLUSION

Our study indicates that indoor exergames exerted a positive influence to

maintaining physical exercise during the pandemic, but their effects were limited by low engagement in design, monotonous exercise types, and contextual limitations regarding space and time involved. More engaging software design that incorporates purpose and social connection, and more innovative hardware that incorporates a holistic regimen of fitness activities, could be the key to further improve the efficiency of these games for populations in isolation.

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CHAPTER 3

A Fine Balance

Cultivating Compassion and Leadership through Games

ANURATI SRIVASTVA; SAI SIDDARTHA MARAM; AND MAGY SEIF EL-NASR

ABSTRACT:

> *"Gifted leadership occurs where the head and the heart-feeling and thought meet"[Goleman et al., 2013]*

Leadership plays an essential role in systems, organizations, and classrooms. Good leadership strikes a delicate balance between employee well-being and team members' productivity, further improving trust and loyalty. There has been a paradigm shift in what constitutes "good leadership," from one based on exerting control and power to one rooted in self-compassion, empathy, and emotional management. Within management systems, compassion helps foster stronger connections between people, reduces burnout rates, and improves staff retention and collaboration. In a mindful leadership approach, self-compassion, empathy, and emotional awareness are first cultivated within the leader and then utilized within situations at the workplace. This evolved definition of leadership is a more expansive and inclusive term that takes a comprehensive and personal view of leadership. Alongside this view of leadership, there are small, daily actions one might take to develop as a leader, which adds value to ourselves and, by extension, to others.

Serious games have effectively cultivated qualities critical to leadership,

such as self-compassion, empathy, and emotional management. This work investigates attempts, approaches, and design principles in serious games that aim to build the above-mentioned competencies essential for leadership. We present game elements, themes, and mechanics that could be further empirically studied and used by serious game designers to produce digital games that cultivate the competencies (self-compassion, empathy, and emotional management) for leadership training.

KEYWORDS:

self-compassion, empathy, emotional management, serious games, digital leadership training

1 INTRODUCTION

Literature has established the relationship between leadership and organizational culture, growth, and firm success (Ciulla, 2020; Sfantou et al., 2017). There is evidence that literature can be fostered and developed with the appropriate training and guidance (Crosby, 2017). Serious games have been critical in developing skills and training across various domains, and the same goes for leadership (Buzady, 2017). Previous studies have shown increased prosocial behavior amongst participants after playing a digital game with embedded compassion training. With the multiple facets essential for good leadership, and the demand for innovative experiences to deliver leadership training implicitly, it becomes imperative for serious game designers to design and develop new games addressing various competencies of serious games to cater to leadership training.

Lanaj et al. (2021) discuss the role of self-compassion in leadership. Their study explores the interconnectedness of qualities of self-kindness, self-care, self-love, self-esteem, self-compassion, and effective leadership. We benchmark our definition of self-compassion from Kristin Neff (2003) as "being open to and moved by one's suffering, experiencing feelings of caring and kindness toward oneself, taking an understanding, non-judgmental attitude toward one's inadequacies and failures, and recognizing that one's experience is part of the common human experience". Shuck et al. (2019) and Bakar et al. (2014) mention the

importance of empathy and self-compassion in delivering quality leadership. Empathy is an affective response that acknowledges and attempts to understand an individual's suffering through emotional resonance (Sinclair et al., 2017). Gardner and Stough (2002) investigate the role of emotional management on leadership and establish a strong positive correlation. Emotional Management is the ability to realize, readily accept, and successfully control feelings in oneself (and sometimes others), which is known as emotional management (Carminati, 2021).

Given the importance of self-compassion, empathy, and emotional management qualities, this paper aims to investigate the game-based techniques that have been used to foster these qualities. Specifically, we will search and identify several games that are publicly available aiming to target these constructs. We acknowledge that multiple other competencies are associated with being labeled a successful leader. For the scope of this paper, we limit ourselves to exploring the role of using serious games to cultivate competencies of self-compassion, empathy, and emotional management for purposes of leadership. We then identify game elements from the selected games and discuss key features of these games that could be used to strengthen leadership skills.

The paper first discusses the definition of selected competencies essential for leadership. Next, we discuss how digital games foster these competencies through the use of affordances, elements, mechanics, and narratives. This is followed by a methodology section discussing a sequential process to arrive at a selected list of games most suited for the exploratory study. The games used for the study are described in the following section. Lastly, the authors discuss the various themes, elements, and mechanics that emerge from the study of the games.

2 SELF-COMPASSION, EMPATHY, AND EMOTIONAL MANAGEMENT IN DIGITAL GAMES

Studies have shown that curated mobile applications and digital games can improve self-compassion amongst late adolescents and emerging adults, which results in an enhanced sense of well-being (Rodgers et al., 2018). Most conventional tools of self-compassion interventions include the

following three parts: (1) psychoeducation, providing the reason and science behind self-compassion, (2) mindfulness and acceptance exercises; and (3) practicing compassion towards others (Kirby, 2017). The third one is remarkable: practicing compassion towards others enhances self-compassion. Self-compassionate tasks of gratitude journaling, emotional recognition, and reflective writing have been shown to promote emotional regulation, acceptance, and openness towards both positive and negative affect (Odou & Brinker, 2015). A previous study has demonstrated that self-compassionate exercises using visualization techniques increase positive emotions, mindfulness, and feelings of purpose in life (Fredrickson et al., 2008).

Digital interventions for mental health provide another layer of safety due to their anonymity, accessibility, and flexibility (Chew-Graham et al., 2003). Digital games inherently promote autonomy and the mastery of goals and skills (Erhel & Jamet, 2016). These skills, when practiced regularly with the help of games, can help individuals broaden their attention, cognition, and action, enabling them to thrive and flourish through all life experiences, whether they be positive or negative.

Serious games (Flanagan & Nissenbaum, 2014) can promote empathy as a value in a variety of ways, such as their premise, characters, player choices, and context of play. In a comparative study of the game, *Darfur is Dying*—a serious game about the Haitian earthquake crisis—players were more willing to help in the crisis than those who read an informational text and those who observed the game as an animation. In narrative-driven role-playing games, the player experiences embodied cognition, which simulates empathy for the characters in the game (Shin, 2018). In another study, in-game empathy emerged as a strong predictor of commitment toward learning skills and adopting prosocial actions and attitudes (Bachen et al., 2016). In some games, empathy in the player may be evoked when players take agency over choices and then experience the consequences of their actions (Isbister, 2016). However, sometimes, games might employ subversive game design techniques to convey the limitation of options available to a particular character due to systemic challenges such as racism, sexism, classism, etc. In such situations, players

may experience feelings of hopelessness and frustration due to the lack of control over their life decisions and outcomes (Schrier & Farber, 2021).

Cooperative gameplay, role-play, collaborative games, small group activities, and discussions have been conventionally used in classrooms to cultivate emotional management skills (Hromek & Roffey, 2009). In-game interventions to further strengthen these skills include active listening, emotional identification, rational analysis, problem-solving, anticipating, evaluating, and accepting responses. There is limited research on the use of such games within workplaces and their impact on leadership skills and the organizational climate. The interactional nature of games makes them most suited to social-emotional learning skills such as emotional management using dialogue and problem-solving in the context of a dilemma (Hromek & Roffey, 2009). Players manage feelings of frustration and delayed gratification to play with others and move towards their goals. Games provide a playground to try out various actions and evaluate responses multiple times with a lower fear of failure as opposed to the urgency of real-life situations.

Filtration Step	**Self-Compassion Games**	**Empathy Games**	**Emotional Management Games**
Initially, a set of 32 games were identified. There were 4 duplicates. Removing 4 duplicates (marked with *) N = 28	1. Kinder World 2. #SelfCare 3. Everybody's Sad (VR only) 4. A Show of Kindness (VR only)	1. Dot's Home 2. Kind Words* 3. Please Knock on My Door 4. SweetxHeart 5. Unpacking 6. Stanley Parable 7. Spiritfarer 8. Gris 9. A Normal Lost Phone 10. Elude 11. The Cat in the Hijab 12. What Remains of Edith Finch 13. Bury Me, My Love* 14. Florence 15. Change	1. This War of Mine 2. SuperBetter* 3. Zoo U* 4. The Guardians 5. Amaru: The Self-Care Virtual Pet 6. WorryDolls 7. Potential Project App (private) 8. MY CHILD LEBENSBORN 9. Don't Starve

Removing 2 VR-based games. N = 26	1. Kinder World 2. #SelfCare	1. Dot's Home 2. Kind Words* 3. Please Knock on My Door 4. SweetxHeart 5. Unpacking 6. Stanley Parable 7. Spiritfarer 8. Gris 9. A Normal Lost Phone 10. Elude 11. The Cat in the Hijab 12. What Remains of Edith Finch 13. Bury Me, My Love* 14. Florence 15 .Change	1. This War of Mine 2. SuperBetter* 3. Zoo U* 4. The Guardians 5. Amaru: The Self-Care Virtual Pet 6. WorryDolls, 7. Potential Project App (private) 8. MY CHILD LEBENSBORN 9. Don't Starve
Removing games with private access N = 25	1. Kinder World 2. #SelfCare	1. Dot's Home 2. Kind Words* 3. Please Knock on My Door 4. SweetxHeart 5. Unpacking 6. Stanley Parable 7. Spiritfarer 8. Gris 9. A Normal Lost Phone 10. Elude 11. The Cat in the Hijab 12. What Remains of Edith Finch 13. Bury Me, My Love* 14. Florence 15 .Change	1. This War of Mine 2. SuperBetter* 3. Zoo U* 4. The Guardians 5. Amaru: The Self-Care Virtual Pet 6. WorryDolls 7. Potential Project App (private) 8. MY CHILD LEBENSBORN

Removing games with similar mechanics. Identified after playing/ watching N = 8	1. Kinder World 2. #SelfCare	1. Dot's Home 2. Kind Words*	1. This War of Mine 2. SuperBetter* 3. Zoo U* 4. The Guardians

Table 1. Step-wise filtering to arrive at the final set of games for studying.

3 METHODS

We use the PRISMA framework to establish a set of games to study and understand game mechanics associated with SEL competencies and leadership. The PRISMA framework is a four-step process used to develop an archive of literature to review and synthesize findings (Shamseer et al., 2015). Among many competencies essential for leadership, we investigate three core competencies of self-compassion (Lanaj et al., 2021), empathy (Shuck et al., 2019), and emotional management (Gardner & Stough, 2002). With these keywords established we have selected several distribution and publishing outlets for identifying games. Specifically, STEAM–a popular game hosting service, the Games for Change catalog, and Academic digital libraries, which include Springer and ACM databases. We limit our search to games published in the last 10 years, that is, between 2012-2022.

Given these search terms and publishing outlets, we found a set of 32 games (n=32). In the screening process, we identified and removed four duplicates (n=28). From the set of 28 games, the authors further identified two games that were only available in VR (n=26). Further, the authors identified one game with restricted access intended for industrial training (n=25). From the 25 games, the authors went ahead to play the games (17 games) they had access to (free, already purchased). For those they did not have access to they went ahead to watch comprehensive YouTube playthroughs of the gameplay. The authors identified 15 games with common mechanics of branching narrative-driven role-playing characters. Similarly, three games were gamification-based behavior change/ habit formation mobile games. Another three games were time-constrained resource management games. The authors chose one representative game

from each of these three categories. The elimination of these 17 games resulted in a list of eight games the authors planned to investigate in detail. The process of arriving at a final set of game titles to explore is also illustrated in Table 1.

This study is not meant to be exhaustive and uses the case study methodology to arrive at common elements and themes that could be further empirically studied. We acknowledge bias in our sampling and curation, as most of the games studied were produced in the United States by English-speaking design teams. For the scope of this study, the researchers limited the case studies to digital games that could be played on either mobile phones or desktops. Physical games, augmented reality games and virtual reality games were excluded from the scope of this study. The two researchers split the games amongst themselves and evaluated each of the eight games together. Most of the games took about two to six hours of gameplay except for three games aimed at behavior change through procedural learning (*SuperBetter, #SelfCare, Kinder World*, and *The Guardians*), which were played for five consecutive days in order to unlock more features and elements on the application. The researchers separately took notes and recorded memos on each game, and analyzed each of them thematically. Additionally, data from online artifacts such as game reviews and research papers were sourced to provide a more complete picture of the games studied.

4 FINDINGS

This section shares findings, which are descriptive in nature and presented separately. Each case study of a game is descriptive and illustrative of the mechanics, narratives, and elements of the game. The thematic analysis of the games is shared in the Discussion section. In Table 2, we deconstruct the game mechanics offered by each game and the genres they address.

#SelfCare (TruLuv, 2018) is a mobile-based game that aims to develop rituals that deepen care and compassion for the player. Developed by the studio TruLuv, the game leverages minigames on well-being, reflected journaling, virtual petting, and breathing exercises to help the player find a sense of calm and comfort. Stepping away from high-pressure game

mechanics and gamification models, the game eliminates all elements of scoring, streak mechanisms, and competitiveness. The premise of the game is that the player wakes up in their virtual bedroom and stays in bed for the whole day, occupying themselves with rest, and routine tasks, such as picking up laundry, tending to a plant, drawing tarot cards, or interactive breathing exercises. Most of the objects in the room are clickable and point the player to specific mini-games: (i) The cat in the room leads you to a mini-game that allows you to stroke your virtual pet. (ii) The books lead you to a game where you have to fill in the letters of a word that completes a positive affirmation or a self-care word. (iii) A flowering plant in the room redirects the player to a few guided breathing exercises with controls for the pacing of the breath and shapes. (iv) The laundry game directs you to a tile-matching puzzle game. (v) A coloring game allows the user to color a sphere. (vi) An orb in the room directs the player to a lunar reading. There are no intrusive notifications, no levels, no inherent risks or rewards, and no win/loss state in any of the games. The game mechanics do not follow the linear progression of becoming more difficult as time passes. The more time that the user spends on the minigame, the easier it starts to get. The game designer on the project, Brie Code, defines the mechanics as being based on the "tend and befriend" response, which is a completely different stress response than the adrenaline/dopamine model (Takahashi, 2019).

Image 1: Screenshots from the game #SelfCare

Instead of being driven by fear, the players are motivated by care and connection. They find joy in solving problems so that everyone benefits.

Kinder World (Kinder World, 2021) is a simulation game where the player takes care of their plants by taking care of themselves via journaling activities, acts of kindness, gratitude practices, emotional check-ins, and compassionate practices. The game utilizes evidence-based well-being exercises such as daily gratitude and emotional recognition, which are designed to improve the mental health of players. The visuals of the game are calming and atmospheric, with soft ambient music and a focus on creating one's own cozy space with pets and plants. The game mechanics are slow, non-intrusive, and non-competitive. Lauren Clinnick, Co-Founder of the studio, says in an interview (SIFTER, 2021) that the game is designed for players who are motivated by connection, care, and emotional expression and not by mastery or competition. She continues to say that their design is directed towards people who look for a "utilitarian value," that of mindfulness, educational benefits, or a feel-good experience in games over hyper-casual games.

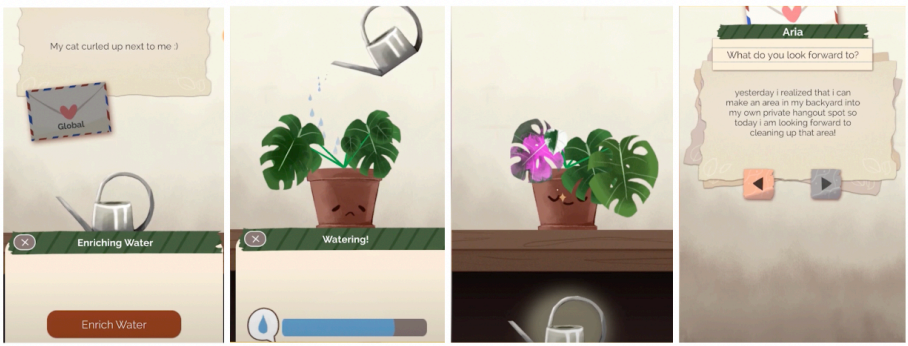

Image 2: Screenshots from Kinder World.

There are no risks or punishments in the game. For instance, unlike in real life, plants do not die in the game if they're not tended to. Lauren talks about minimizing the anxiety inherent within the game design. Apart from self-compassion activities, there are also activities to be compassionate towards others, such as sending notes of appreciation and positive affirmations to other players. In the upcoming updates of the game, there are also plans to integrate a feature that allows players to build a community garden with other players.

Dot's Home (Rise-Home Stories Project, 2022) is a single-player, 2D, choice-based visual novel whose protagonist, Dot, is a young black woman who lives in her grandmother's home. She travels through time to relive moments in her family's history and learns about race, home, migration, and discrimination while helping her family make choices. Her decisions make her understand how the past affects the future. As the role-playing character, the game aims to cultivate empathy towards the experience of housing inequality amongst BIPOC who have migrated from their home countries. Although the game consists of branching narratives, the storyline hinges on the illusion of choice (Morris, 2022), which means that there is no right choice that would lead to the most successful outcome, reflecting the lived experience of many marginalized communities. The game is rigged against the player's favor, since the system does not account for the needs of specific communities, leaving Dot with very less control of the outcomes of her decisions, which may impact generations to come.

Kind Words (Popcannibal, 2019) is a game that allows the player to write letters of appreciation and encouragement to strangers who might be struggling. The player can also, in turn, request a letter of comfort and inspiration. The gameplay relies on building a positive community on the internet. The experience is also gamified since each letter that is sent comes with a sticker, and upon receiving a letter, the stickers can be redeemed to decorate your bedroom. The music is calming, and a new song is added each time the player sends a letter. The mascot of the game, a female mail delivery deer, prompts players to ask for help or write a letter, such as, "What are you worried about? Maybe someone else is too." If a user writes about a particularly distressing time, the deer prompts the user with hotline services as well as mental health resources.

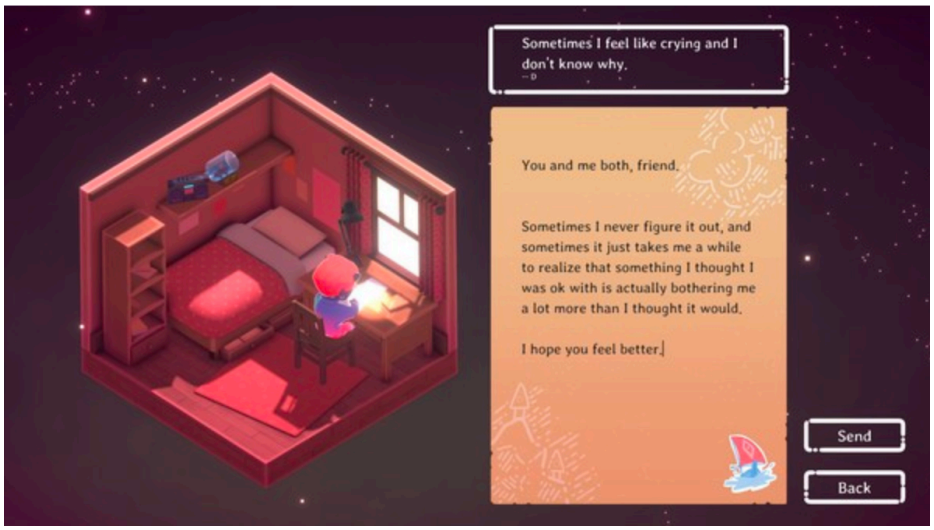

Image 3: Screenshot from Kind Words

SuperBetter (SuperBetter LLC, 2012) is a mobile-based game that aims to enhance the resilience of people by cultivating skills of social-emotional learning. Players have to choose a particular goal for themselves, such as overcoming depression, improving self-esteem, procrastination, etc. Then, they have to take recommended steps toward this goal, which are known as 'quests'. Each quest has associated mood-boosting activities in the form of power-ups. They also have to directly address specific obstacles which are known as "battle bad guys," and enlist social support if desired signified as 'invite allies.' In a randomized control trial with 283 players, the game has shown to improve symptoms of depression (Roepke et al., 2015). One of the game's objectives was that the actions play out through real-life activities and interactions, with allies in the form of support systems such as friends, family, counselors, therapists, and doctors, who help the players achieve their wellness goals. A key feature of SuperBetter is the inclusion of customized resources and practical tips that are created in partnership with different organizations on particular themes, such as Full Diet, Stanford's Center for Compassion and Altruism Research and Education (CCARE), University of California, Berkeley's The Greater Good Science Center and more.

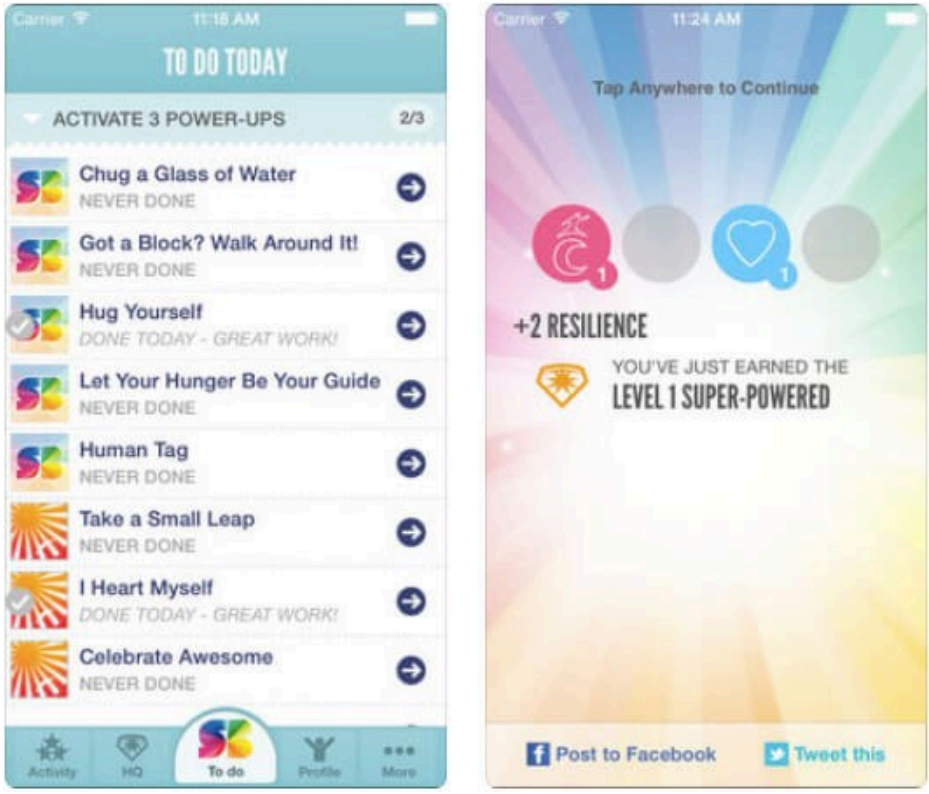

Image 4: Screenshots from SuperBetter

Zoo U (ZooU, 2017) is an evidence-backed game-based SEL performance assessment game for students in grades 2-4. Funded by the US Department of Education, the game was created to fill the need for a reliable, affordable, efficient, and effective alternative to traditional self-reported SEL assessments. Through choice-based storytelling as well as informational pop-ups, the game aims to positively reinforce social-emotional learning skills. The game targets six core areas of emotional management, mainly, (i) impulse control (ii) emotional regulation (iii) communication (iv) cooperation (v) empathy and (vi) initiation. The players create their avatars and make decisions in each of these six game-based scenarios. Embedded audio ensures that not only the stimulus in the conversation with intonation is received but also that before responding,

players can hear the tone of the verbal response and make an appropriate choice.

Image 5: Choosing responses in the game ZooU

The game encourages the player to master the skill of social-emotional learning since the player can replay each situation and test the consequences of their actions. Once a scene is completed, Professor Wild delivers constructive feedback on their choices. The game is equipped with lesson plans and an SEL curriculum with educators' access to student data for assessments. In a sample size of 50 children, it was shown that children who had played the game showed enhanced social skills in the areas of impulse control, emotion regulation, and initiation (DeRosier & Thomas, 2018).

This War of Mine (This War of Mine, 2014**)** is a unique war survival simulation game set in the fictional city of Pogoren, Graznavia. The player is the leader of a group of war-stricken civilian survivors in this single-player strategy game. The player must ensure that the characters maintain their health, food resources, and mood levels until the declaration of a ceasefire. Through empathic storytelling, the game puts the player's risk-taking, decision-making, and conflict management abilities to test. Each game session is randomized and is of indefinite length depending on the

choices made by the player as well as the civilians. The player can control the actions of a few civilians at a time. During the daytime, the objective is to maintain your hideout. At night, the player venture outside with the civilians to scavenge for resources that are needed for survival. By making the player accountable for the survival of other civilians and exposing the player to the discomfort of grief, loneliness, poverty, depression, and fear of death, the game indulges in transgressive realism (Karlsen & Jørgensen, 2018), wherein instead of graphic violence, the game experiences create disturbing and transgressive scenarios. Through dialogue and events, the game makes emotions like guilt, grief, trauma, loss, and hope tangible. In-game prompts and character responses compel the player to reflect upon their actions in the face of ethical dilemmas. No matter what the consequences are, the player is complicit in the war through their actions.

The Guardians (MIT Media Lab, 2022) is a free-to-play mobile game developed by MIT Media Lab that aims to motivate players digitally when they successfully achieve healthy real-world tasks. The framework for the game is informed by behavioral activation (Ferguson et al., 2021) which encourages individuals to engage in pleasant, adaptive, and engaging behaviors. Each successful real-world task is rewarded with pets–characters that complete in-game adventures–and experience points that are gained from adventures. Players can progress in the game using the points and unlock more of its features. Each time players level up, the pets are sent on a mission to free each realm's Guardian from evil characters called *Scorians*. Simultaneously, players can go on their selected adventures, which range from categorized options under "Art," "Basic," "Fitness," "Fun," "Social," or other custom options.

Each activity ranges from three to 60 minutes. The aim is to form a habit of carrying out these self-care tasks to foster competencies of self-efficacy (Gardner et al., 2012), which is positively related to self-compassion (Iskender, 2009). Upon completing each task, players are to reflect on how the activity made them feel on a 5-point scale ranging from "Worse" to "Much Better". Then, players immediately receive the awards, which are redeemed within the game. The game aims at evoking eudaimonic feelings of productivity, motivation, and inspiration. The game is divided into three realms, each of which unlocks after 21 days, regardless of

player progress, to bring back lapsed players. Each realm contains unique gameplay mechanics and missions that their pets must go on so that the players progress.

5 DISCUSSION

In this section, we explore six of the themes that emerged from our analysis of the eight games, including (1) Eudaimonic Game Design, (2) In-Game Reflection, (3) Non-competitive Gameplay, (4) Limited Agency and Forced Failure, (5) Digital Companion, and (6) Dialogue-based Responses. We also consider how, with these elements, the skills of empathy, self-compassion, and emotional management might be cultivated, and how these may be utilized to foster compassionate leadership skills, leading to improved well-being at work.

Game Name	Genre	Associated Tag	Player-Mode	Gameplay and Mechanics
#SelfCare	Simulation; Idle; Digital Companion	self-compassion	Single-player	• Non-competitive • Endless game • Positive Reinforcements
Kinder World	Simulation; Idle; Digital Companion	self-compassion	Single-player	• Non-competitive • Endless game • Positive Reinforcements
Dot's Home	Narrative; Role-Play; Simulation; Adventure; Visual Novel	empathy	Single-player	• Choice-based decision-making • Alternate endings based on previous actions with "*good*," "*bad*," and *neutral* endings • Limited Agency • Forced Failure
Kind Words	Casual	empathy	Single-player and Online Multi-player mode	• Non-competitive • Endless game • Positive Reinforcements
SuperBetter	Self-Help; Mental Health	emotional management	Single-player	• Non-competitive • Endless game • Positive Reinforcements • Prosocial habit formation • Goal orientation
Zoo U	Simulation; Educational; Narrative; Role-play; Visual Novel	emotional management	Single-player	• Non-competitive • Choice-based decision-making and responses to NPCs • Voice-based dialogue with NPCs to perceive intonation

This War of Mine	Narrative, Role-Play, Simulation; Survival and Strategy	emotional management	Single-player	• Choice-based decision-making • Alternate endings based on previous actions • Limited Agency • Forced Failure
The Guardians	Simulation; Digital Companion	emotional management	Single-player	• Non-competitive • Endless game • Positive Reinforcements • Prosocial habit formation • Goal orientation

Table 2: Breakdown of Selected Games with their themes and offered Mechanics

5.1 EUDAIMONIC GAME DESIGN

Several studies have explored the connection between eudaimonia and the concept of flow within game design. Eudaimonia is a feeling that enables players to constructively cope with negative events and find enjoyment in overcoming them in the pursuit of a goal (Torsi et al., 2020). The state of eudaimonia promotes overall well-being, adaptation, self-acceptance, and positivity toward others and toward life in general (Deci & Ryan, 2008). Both eudaimonia and flow are positive emotions that enable the player to persist through the challenges by providing appropriate positive and negative reinforcements (Torsi et al., 2020). The integration of these elements into game design ensures an emphasis on control, feedback, fun, incremental goals, and progressive difficulties. Six of the eight games studied by the two researchers exhibit eudaimonic game design elements. The goals in each of them may be perceived as too difficult, whether it be getting out of bed in *#SelfCare*, or it could be maintaining a streak on a new habit in SuperBetter, or taking a self-compassion break in *Kinder World*. Each goal is rewarded within the game with extrinsic (power-ups, progression, currency) or intrinsic rewards (receiving a letter of appreciation from a stranger on *Kind Words*).

5.2 IN-GAME REFLECTION

Previous studies have shown that providing a moment of reflection to players gives them a chance to experience empathy (Kors et al., 2016). The mundaneness of certain slow activities that may seem meaningless (Kors et al., 2016; Marsh, 2016), such as doing the laundry in the *#SelfCare* game or waiting for your virtual pet to return from their mission in *The Guardian*, or waiting for your plant to grow in a day allows for mindful moments of downtime. It is reported in literature too that slower moments in the game contribute to mental rest as well as opportunities for reflection (Chittaro & Sioni, 2018). For instance, in *The Guardian*, the player engagement in a personal adventure is limited to one per hour. The gameplay is designed to favor delayed gratification over fast-paced engagement to facilitate meaningful play (Crookall, 2010). These moments may provide for introspection and may also hold an appreciation for the slowness of growth. These pause points allow for a "positive serious experience," helping in balancing out attention-demanding storylines on social issues. Such a pause point can also be found in the game *Dot's Home* when the protagonist shuttles between the past and the present, while physically walking through a portal for a minute. None of the eight discussed games are timed in nature, lending them to the use of reflective gameplay, which could be used for the purposes of capacity-building.

5.3 NON-COMPETITIVE AND INFINITE GAMEPLAY

Digital learning effectiveness is significantly higher in non-competitive individualistic contexts than in competitive contexts (Zaphiris et al., 2007). All of the selected games fall under the category of non-competitive, single-player games. There is a huge advantage of using such a game for psychoeducation. Educator guides, discussion, and reflection prompts could be provided in hybrid contexts to test the games in future empirical studies. This allows for the game to be used for skill-building purposes, where learning could be largely self-paced. An infinite game is one wherein there is no win or lose state. Such a game reinforces the progression of activities to reach mastery over skills, goals, and growth. Five of the eight games are infinite. The remaining three are untimed narrative games with

a plot structure and a subsequent ending. Games such as *Kind Words* and *#SelfCare* provide an atmospheric space to practice self-compassion, and a player can return to them at any point in time.

5.4 LIMITED AGENCY AND FORCED FAILURE

Two of the games, *This War of Mine* and *Dot's Home*, provided limited agency to the player to control the outcome of the game. For instance, *This War of Mine* provides the illusion of choice through dialogue actions. The game's motive may be to evoke empathy for a civilian surviving in war, which forces the player to come to terms with surprising actions and captures the complexity of difficult choices. Providing limited agency shakes the assumptions and belief systems of players. By being forced to deal with failure, the player has to navigate contradictory emotions to succeed in such a game. Both the games share themes about life situations spiraling out of one's control under overwhelming

life circumstances. *Dot's Home* presents limited choices because the goal is for players to use different strategies, see a different point of view, and try out a sequence of events that may not have been apparent to the player. The loss of agency helps focus on self-acceptance rather than the exertion of control over a certain situation, which is a core tenet of self-compassion (Dryden, 2013).

5.5 DIGITAL COMPANION

Digital companions come in various forms within the eight games, whether it be the pet dog in *Kinder World*, the reindeer in *Kind Words*, the cat in *#SelfCare*, or multiple pets in *The Guardian*. The presence of digital companions has been known to boost learning and retention of knowledge (Rehm & Jensen, 2015). The game mechanics related to the digital companion are often related to caretaking qualities such as feeding the companion, petting it, and providing it with clothing and shelter. The act of being compassionate toward a virtual being might help evoke feelings of compassion toward one's self, as discussed previously (Kirby, 2017).

5.6 DIALOGUE-BASED RESPONSES

In conventional in-person teaching methods, dialogic reading has been known to promote social-emotional learning amongst children (Rehm & Jensen, 2015). *Zoo U, Dot's Home*, and *This War of Mine* use dialogues to further decision-making. *Zoo U* in particular provides voice-based feedback with intonation to let the player know in advance what a response may sound like. The three games focus on problem-solving certain situations by taking actions and conversing with various non-playing characters (NPCs). Such dialogue-based responses assess the skills of communication, cooperation, and social initiation (Kirby, 2017).

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CHAPTER 4

Tabletop Games for Training

Teaching Soft Skills to Game Development Students

MATTHEW JOHN DYET

ABSTRACT

Among the key competencies for game development that tertiary education provides, soft skills are among the most challenging to coach students on. In an active learning environment the expectation is that soft skills such as communication, estimation, and prioritisation are gained through experience when students undertake group project work. While appropriately scaled projects may provide an opportunity to engage with soft skills in a meaningful way, this learning is often a lower priority to the student presented with more tangible project outcomes that they expect to be graded upon. Engaged and enthusiastic students may reflect upon how their experiences have helped them to hone their existing soft skills as they have a basic understanding of their value, but most students are reliant upon direct involvement with a subject to recognise its benefits in any meaningful way. To facilitate this learning an activity was designed to encourage reflection upon soft skills and their value to games development. Trial By Fire is a tabletop card game that was developed through action research across the course of three years of iteration and qualitative testing with students. Students consistently expressed a clearer understanding of how soft skills are applicable in their projects and careers after just a few minutes of gameplay. Today this activity can be incorporated into university level lesson plans alongside a class discussion

after just a few minutes of gameplay and presents an opportunity for expansion into other disciplines or soft skills.

KEYWORDS:

Serious Game, Card Game, Soft Skills, Games Development, Leadership

THE SOFT SKILL PROBLEM

Game development is a highly technical industry that requires a great deal of collaboration between drastically different roles. Being highly technical, there is an expectation that new staff – even experienced staff – will require some degree of training and support to become familiar with a development studio's unique set of processes and techniques. However, the heavily collaborative nature of the industry means that studios will often prioritise soft skills over hard skills when considering potential staff for employment, due to the challenges of training soft skills to inexperienced staff (Zuniga, 2016). Despite the similarities between the industries, software engineering businesses fail to identify the requirements of soft skills in their job listings (Ahmed et al., 2012; Capretz & Ahmed, 2018). Each developer in a studio is expected to have the capacity to communicate and collaborate with their team; and to estimate and prioritise tasks individually or as a collective. The development of a game will go through a series of iterations with a particular focus on a specific outcome; pre-production to ideate and conceptualise, production to develop and test, and post-production to patch and support

Preparing students for entering the workplace throughout the course of their degree is a process that requires that facilitators identify and train skills that the industry desires. Usually such training is focused particularly on hard skills, which the SAE Institute delivers through active learning in simulated workplace units called studios (SAE Australia, 2021a). In addition to the essential hard skills, SAE also reinforces to students the value of transferable skills (SAE Australia, 2021b), which students are encouraged to engage with throughout their studies by way of reflection upon their experiences in the classroom. Transferable skills make up a mixture of hard and soft skills: the modern office will value a hard skill such as an

employee's word processing, in addition to valuing a soft skill such as their leadership qualities. Soft skills are widely recognised and desired among the creative industries, often more so than the hard skills that students come expecting to learn from a university (Brown et al., 2009; González-Morales et al., 2011; Kenwright, 2022). It's this high value attributed to soft skills that has led SAE to doing holistic grading that looks at what it calls the three P's (SAE Australia, 2020):

- Person, relating to interpersonal skills and quality of character;
- Process, particularly time and project management; and
- Proficiency, the hard skills students come to study.

Soft skills pose a particular challenge for facilitators to teach, however. Their successful delivery is reliant upon two key factors: that the student understands the value of soft skills, and that they can exercise the necessary self-awareness to internalise and reflect upon their behaviour and the behaviour of others. While facilitators can deliver content in such a way that a student may understand the value of these skills, self-reflection is itself a soft skill that is a base requirement for this learning to take place. A great deal of time and effort is spent teaching students Rolfe's reflective model (Rolfe et al., 2001) and reinforcing the value of self-reflection early on in a student's studies at SAE to encourage the behaviour. However, a substantial number of students reject the concept of self-reflexivity and will only engage as much as necessary in order to pass units. These same students as a result do not engage with soft skills, and often require a direct experience with them – either through a simulated studio workplace in their studies or professional experience after graduating – in order to begin to understand and respect the value of them as skills. This is a fact that many creative industry workplaces presently experience and are prepared for, as their expectation is that students have the essential hard skills to begin work but are yet to fully develop their soft skills that are the difference between working and working effectively (González-Morales et al., 2011; Kenwright, 2022; Zuniga, 2016).

The challenges of teaching soft skills, along with their importance in industry practice, created a problem in the delivery of one unit taught in the games program at SAE. Games Studio 1 is a unit particularly focused upon

production and project management processes, with learning outcomes around project management, time management, estimation, and communication (SAE Australia, 2021c). These learning outcomes were expected to be achieved as a result of a student collaborating and building a project within a team through an active learning framework (Bonwell, 1991), and tutoring from the facilitator about project management and communication techniques. However, getting students to a stage that they could execute upon the technical aspects of the unit requires a great deal of class time and training. This meant that content inadvertently reinforced the wrong skills as the major priority of the unit. The less time that is spent on delivery and discussion of the soft skills, the less clear to the student what the desired outcome of their learning should be. Without clear prompting to help students understand the value of soft skills, they would spend all their time focused on building up their technical skills on the project.

ITERATIVE ACTIVITY DESIGN

A method needed to be developed that could prime the students with an understanding of the soft skills expected as graduate outcomes of their work, while not detracting from the time necessary to teach the hard skills required to undertake a technically complex project. As SAE is ostensibly an active learning-oriented educator, creating an interactive learning activity that could deliver soft skills to prepare students for a better understanding of the unit's outcomes was a must. There was also potential for the activity to tie into or reflect actual games production practices in a way that was relevant and familiar to the students; while also providing additional learning opportunities in the realm of industry practice and process. These key points would become the goals for the activity design:

- The activity must be interactive, to fit within the active learning environment.
- The activity must be short, to not detract from the necessary time for technical skill building.
- The activity must reflect real games industry practice, in order to

feel relevant to learners.

Based on these goals, a game was designed that could be played in the classroom in just a few minutes. The game is broken up into three phases: pre-production, production, and post-production. In pre-production, students are separated into teams where they must choose from a variety of game development roles with different responsibilities and actions. They then prioritise a list of development tasks into a desired completion order. When production begins, students attempt to resolve all the development tasks within a given time limit. Students must discuss and decide the most appropriate actions to take in order to complete their given tasks before time runs out. In the post-production phase, students discuss and compare the results of the activity with other teams. Specifics of the game's design would change over every iteration based on observations and feedback from students; however, these core structural elements of gameplay remain largely the same.

THE RISKS OF PARODY

Design of the game began in earnest in 2019 to the backdrop of widely known game development news. Bioware's Anthem (Bioware, 2019) had been released in February in a clearly incomplete state, and a subsequent article by investigative journalist Jason Schrier (Schreier, 2019) made clear the extent of the problems in the studio that led to the game's failure. Anthem would be used as the initial inspiration for the game now named Trial By Fire, placing students in the role of developers working on Anthem to try and develop the whole game and change its fate in just 5 minutes. Students would get into teams of two to three and fill one of two roles: Producer or Developer. Producers would be provided with a list of features from Anthem that they would need to write onto sticky notes and organise into what they felt were the priorities. Developers would be provided with dice that they would have to roll every thirty seconds to attempt to complete the top priority task set by the Producer. Failure to roll high enough would result in the creation of a bug, which the Producer would have to write onto a new sticky note and choose where it fell in terms of the list of other priorities. Part-way through the game, students would get

an opportunity to add another task to the game – Microtransactions – in exchange for more time to try and finish the full product.

As simple a concept as this iteration of the game was, it proved to be a hit with students. It got the classroom thinking about and discussing the whole process of game development, they understood the importance of communication in their process, and they were keen to return to the activity again to see what they could potentially change. This was already an improvement over the previous iterations of the unit without the game, as now students were entering into their projects early with a greater understanding for how their work could go wrong and what they needed to look for in order to improve their outcomes. There were also detriments to the game, however, as noted in figure 1; the framing of the activity resulted in conversations primarily around the studio and game that inspired the activity, and bugs were largely ignored on repeat engagement. The game showed great potential, but the initial feedback and analysis made it clear that there was room to improve.

Trial By Fire Iteration 1	
Noted Behaviour / Comment	Analysis / Design Impact
Students required at least two plays of the game to understand how to play	Create print-out rule sheets to provide to students to guide them. Create playing cards to simplify the preparation step of the game.
Students could identify the importance of communication and discussion around priorities	The activity is effective at rapidly highlighting the importance of communication during development.
Students got competitive about which group had gotten closest to making the game with the most complete features and least bugs	Add point scoring mechanics to future iterations of the activity for students to discuss and compare strategies.
No teams managed to complete every task while also getting rid of every bug	Students stopped trying to squash bugs and focused less on the simulated process in subsequent plays of the game.
"We are EA, we will just hire some unpaid interns to finish the game."	Remove any reference to Anthem or Bioware as it derails conversation about the process. Encourage students to empathise with the developers they are roleplaying as.
"At least we got everything in, we can patch out the bugs later."	Students do not seem to care about bugs as they do not have any real impact on the outcome of the activity

Figure 1. Student feedback and analysis of iteration 1 of the activity.

BUGS IN THE MESSAGING

The second iteration of the game built upon this feedback and the solid foundation that had been established with the first iteration. Taking the observations of how students interacted with the activity and the feedback they provided, the next iteration would be developed with five tweaks and additions to the formula:

- Simplify the gameplay and get into the activity faster by creating Feature and Bug cards rather than having students write out

sticky notes.

- Add point scoring to the game by giving feature cards positive and negative points dependent upon their being completed, and bug cards only negative points for being left incomplete at the games end.
- Get students invested in the outcome of the activity by allowing them to choose from a variety of the provided feature cards to define a game concept.
- Focus the conversation more upon the process and outcomes by adding a product owner role, and removing references to EA, Bioware or Anthem.
- Create conversation about developer wellbeing by giving the producer the ability to tell the developers to crunch.

The product owner's role in this iteration of the game is to choose the features that the game would include from the provided feature cards. The game would then play out much the same way as in the first iteration, with the producer tasked with collaborating with the product owner to define priorities after every attempt at resolving the current top priority task. The crunch ability added to the producer role would allow developers to roll the dice twice, enabling them to potentially complete two tasks in rapid succession; at a cost of permanently reduced dice rolls on all future tasks.

While this iteration of the game was more rapidly deployed to students and succeeded in introducing more concepts of game project management, it came with a new set of challenges. As noted in figure 2, bugs became rapidly insurmountable based on the luck of a dice roll in this iteration of the game due to a small tweak on the table of dice roll outcomes. A roll of five or less would result in the addition of a bug to the game, and students still needed to roll the dice in order to attempt to resolve a bug task – meaning that attempting to resolve a bug would have an 83.3% chance of generating an additional bug. This was by design, as the intent was to highlight the necessity to balance the benefits of completing features with the detriment of ignoring rapidly growing bugs; however, it had the opposite of the intended effect, as students ended out just ignoring the insurmountable number of bugs their project would inevitably gain to

instead prioritise completing as many features as possible to offset the score loss.

Trial By Fire Iteration 2	
Noted Behaviour / Comment	Analysis / Design Impact
Students require multiple playthroughs to understand the basic game rules.	Investigate simplification of the game rules, inclusion of symbols in rules to help students identify cards.
Randomness is too much of a factor in students' ability to succeed at the activity.	Provide students with more tools through the game to control the outcome.
Students felt that bug generation and management was outside of their control and could too easily proliferate.	Dice rolls to resolve bugs can generate bugs too, which isn't necessarily unrealistic but can proliferate out of control. Need some means of bug management.
Students would focus on completing all of their features and then pick off the remaining bugs until the game ended.	This behaviour seems to be a result of the sheer number of bugs being generated and students attempting to maximise their scores.
"Are bugs really this constant and this all-encompassing of development?"	Currently bug management is vastly more important than anything else.

Figure 2. Student feedback and analysis of iteration 2 of the activity.

KNOWN UNKNOWNS

Key among the objectives of the development of iteration 3 was bringing some balance to the game. It was clear from observations of student behaviour and feedback that the number of bugs they faced each game were a detriment to their learning experience. Removal of bugs as a concept from the game was not an option, as the underlying learning surrounding them was good: that a team needs to attempt to account for unknowns in their development processes. The objective then became to

change how students managed both bug and feature cards in the game. Rather than allowing students to see and handle all the cards to define their order, they would now only be able to see the current top priority task. The remaining feature cards would be placed face down in a stack called the backlog deck, in reference to the task backlog used in kanban boards and their digital equivalents. The design of the backlog deck and how it was handled by students was heavily influenced by Pandemic (Leacock, 2008), and how it ensures a fair and even gameplay experience by artificially spacing out detrimental cards through the card deck. While this iteration of the game would not artificially control the location of bug cards, it would allow students to estimate just how likely they would be to draw a bug card from the deck.

The game would play out with a few key differences that obscured the current state of play, while also providing students with more control over that state. At the start of the game, the product owner would decide the current top priority task and place the remaining features into the backlog game. Dice rolls by developers would generate bugs (although with a slightly reduced chance from previous iterations). The generated bugs are added to the backlog deck, and the backlog deck would then be shuffled. This encouraged students to try and keep track internally of how many bugs they had versus features, in order to estimate their odds of pulling a bug or task card the next time it was necessary to define the top priority task. This doubled as a great example of known unknowns (Chua Chow & Sarin, 2002; Knight, n.d.); the bugs in the backlog deck are a risk that students are aware of. However, additional actions added to the producer and product owner would allow them to circumvent this need to blind draw in exchange for using up precious development time to go through the deck and hand pick the next top priority card rather than leave it to chance. The final necessary addition was in the form of a new role: quality assurance, who could continuously draw bug cards from the backlog until they came to a feature card. These removed bugs would be eliminated from the game, allowing students to wipe out large amounts of bugs in a single action – if they organised themselves well enough.

As hoped from a major change to the gameplay such as this, the improvements to the game were clear and feedback from students was

strikingly specific as noted in figure 3. Where iteration 1's discussions focused on the studio and game, and iteration 2's discussions focused on the unfair balance of the game, conversation around iteration 3 now looked deeper at how teams achieved their results and made use of their time. The producer of one team noted the challenge of keeping track of time along with the state of the project. All teams agreed that the limitation of acting every 30 seconds resulted in either moments of boredom with nothing to do, or frantic rushes to get themselves organised and decide upon a course of action. However, the activity was notably vastly more balanced, with all teams reporting that they had either squashed all or most of the bugs generated throughout their gameplay within the five-minute deadline of play.

Trial By Fire Iteration 3	
Noted Behaviour / Comment	Analysis / Design Impact
Point scoring is needlessly complicated and time consuming. Students are only interested in the game score and not the project score.	Reduce the complexity of point scoring and the maths involved.
Crunching became a joke to one team.	Need to consider how to better communicate the cost of crunch upon an individual, rather than just the score at the end of a project.
"It became really hard to keep track of time with everything going on, and I'm not sure if that's the point."	Time management should absolutely be a lesson taken away from the gameplay.
"We ended up just sitting there chatting, waiting for the timer to run down every 30 seconds."	The timer is clearly a problem for students, but there's a potential for the game to become a race to finish without some sort of gating that encourages students to communicate.
Students require multiple playthroughs to understand the basic game rules.	Further refinement on the rules and scoring, creation of cards with instructions for individual roles, changes to time keeping.

Figure 3. Student feedback and analysis of iteration 3 of the activity.

THE PRODUCTION GAME

With the core mechanics stable and balanced, this placed the game in an excellent state for the fourth and most recent iteration of play. This version of the activity looked at building upon the balanced mechanics of the previous iteration to reduce the overhead and explanation time, while also capturing a greater feeling of what it is like to manage a games development project. Planning, collaboration, and communication were the key goals of this version. Budget tokens were added to the game, with each player action costing a single budget token. At the start of the game

in the pre-production phase, students estimate their necessary budget tokens. Roles now come with a card that describes their job and the actions they can take, with each role action flowing well into the actions of other roles. The rules were simplified and opened up, enabling students to decide what to do next within the provided framework. The dice were replaced with card draws that students can control through actions on their role cards, reducing the random factor. Each member of the team must choose the next team member to act after them, encouraging collaboration and strategising during turns. The enforced thirty second timer is gone and replaced by an overall 5 minute limit that can be increased just once through a player action, adding to a sense of urgency as it's not entirely clear how many turns are remaining. A game board has also been added, themed as a Kanban board with columns for the backlog deck, in progress tasks, and completed tasks. Each task starts in the Backlog and makes its way through each column to Completed.

Results from this version of the gameplay testing were immediately apparent and positive. Students were provided with sheets that explained the rules, the deck of cards to play, and the kanban board. After reviewing the rules and understanding how the game was intended to play, students spent a substantial amount of time planning out their actions and strategy ahead of time. Other than questions about the phrasing of certain cards or edge case circumstances that the rules had not covered, students were self-sufficient in playing the game. Interactions in the groups were much more active, as it was clear to the students that the abilities on their role cards could allow them to manipulate and control the outcome of the gameplay through collaboration. Minor tweaks were made to the game balance ahead of a second playtest as it was discovered that certain abilities were powerful enough to reduce the challenge and communication required. The second playtest showed much less of these problems, with students requesting additional time to play after two rounds that enabled them to explore their strategies.

Trial By Fire Iteration4	
Noted Behaviour / Comment	Analysis / Design Impact
Individuals rarely chose who to act next without the input of other players during their turns.	Collaboration between players extended well beyond the planning phrase, which is a greater than expected outcome.
"It was very easy to lose track of time, I'm glad we had somebody responsible for doing that."	Validates the decision to make the "Producer" role a time management one with ongoing responsibilities.
"Time and budget felt rather meaningless".	This feedback resulted in a change before the second set of playtests to reduce the ability to add more time and budget.
"It was easy to feel frustrated with others taking so long until I was the one trying to quickly shuffle cards."	Quite exciting to hear students talking about empathy as a result of gameplay, as it was not the expected outcome."
"We lost but it feels like there's a way to win, and I really want to find it."	While it may be in reference to the game itself, getting students interested in time and project management skills are the key objectives of this game.

Figure 4. Student feedback and analysis of iteration 4 of the activity.

WHERE NEXT

Over the three years of development and iteration on this game, students have shown a great deal of enthusiasm for learning that simulates and engages with relevant real-world concepts. Trial by Fire has presented more than just a chance to play a game in the classroom with their peers, but also an opportunity to learn more about the medium they are studying in a way that is interactive and engaging. Involving students in the process of development of this project has also encouraged them to engage with other concepts that the university aims to teach, such as concepts of game balancing, testing, and research. Students rewarded transparency about the nature of the activity as an object of research and development with a higher level of engagement, excitement, and enthusiasm to be involved in

the active development of a game. Any educator that is interested in the creation of similar activities for the classroom would benefit from treating students as a collaborator in the development of the activity.

Probably the most important and interesting discovery of this game and its research is the finding that students engaged more with the desired behaviours the less rules that were presented. Typically, a serious game requires codifying the specific learning outcomes into the project design in some way (Catalano et al., 2014; Suttie et al., 2012; Westera et al., 2008). However, when approaching soft skill development in students, this research has found the opposite to be true; that students are more likely to engage with these concepts if placed in a simulated environment where they can explore with other people; and that the reduction of cognitive load is especially important (Catalano et al., 2014). It is the belief of this author that the experiences gained from students in this game would be challenging to replicate in a single player experience with dialogue options, due to the complexity of getting a student to empathise with a digital character and explore their interactions in a way that didn't lead them to the desired outcome. This should be a key consideration for the design for any game that seeks to teach or reinforce soft skills in its players.

Despite going into the design of this activity with a clear plan to capture the essence of project management for games students, it has the potential to become so much more. Facilitators from other disciplines outside of games have expressed an interest in the activity and its capacity to be easily transformed into a learning game about topics such as film or animation production. The desire from students for more opportunities to play what was designed specifically as a learning activity shows a clear potential for the game to expand into audiences outside of tertiary education. There is a possibility to develop the game into a full product for print that can be used in classrooms as a learning activity or for the broader public interested in games development. Until such a time as that happens however, the game will continue to be iterated on with feedback from the students that play it every year.

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CHAPTER 5

Towards Understanding the Cognitive Aspects of Transparency in Human-Autonomy Teaming

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MATT CABANAG AND CHRISTOPHER J STANTON

ABSTRACT

This study explores transparency in a command and control (C2) context, using a low-fidelity air traffic control game, which is real-time, dynamic, and time constrained. Autonomous agent performance, anthropomorphism, and other factors have been a major focus in studying trust in human-autonomy teaming (HAT). We propose that agent predictability may be an important area of investigation. Where autonomy is imperfect, increasing its predictability may reduce the incidence of mistrust and dis- use. Indeed, we suggest that predictability is a quintessential indicator of agent transparency, which we propose to encapsulate in a model of trust that is based on predictability. We speculate that cognitive fit and cognitive fit theory may have a large role to play in enabling predictability. This has implications for transparency design in self driving cars, domestic household robots, as well as other industrial applications where autonomous systems and agents are used.

KEYWORDS:

serious games; command and control; human autonomy teaming; trust in au- tonomous agents; cognitive load; cognitive fit

1 BACKGROUND

Anthropomorphism has long been a focal point in human-autonomy teaming (HAT), with researchers investigating etiquette (Parasuraman & Miller, 2004), apologies (M. C. Cohen, Demir, Chiou, & Cooke, 2021; Galdon & Wang, 2019), and compensation behaviours (De Visser, Pak, & Shaw, 2018; Rebensky et al., 2021). While these studies attempt to investigate if humans attribute human moral qualities to their autonomous team-mates, there may be another key factor which could be interesting. Embedded in these studies is the implicit notion of predictability being beneficial for trust.

For example, Parasuraman's etiquette paper concludes that expected interruptions from autonomy (i.e. polite error messages) are beneficial for trust (Parasuraman & Miller, 2004). De Visser's transactional model for trust violation and repair suggests that trust violations can come from unexpected behaviours of autonomy, even if the unexpected behaviour had some benefit for the human team-mate (De Visser et al., 2018). This accords with the well established notion that transparency can mitigate the effects of imperfect autonomy (Hoff & Bashir, 2015; O'Neill, McNeese, Barron, & Schelble, 2022)

2 EXTENDED BACKGROUND

2.1 TRUST IN AUTONOMY

Parasuaraman et. al. set out the broad issues surrounding humans and autonomy (Para- suraman & Riley, 1997). Although they were describing tool-like automation, these issues are still relevant for teammate-like autonomy. Trust in autonomy is a key factor in determining how a human will utilise autonomous technologies, so it is a very important focus in the field of HAT. The most obvious, and the primary moderator of trust is the reliability and performance of the autonomy itself (Baker, Phillips, Ullman,

& Keebler, 2018; Chen, Barnes, Selkowitz, & Stowers, 2016; M. S. Cohen, Parasuraman, & Freeman, 1998; Endsley, 2017; Hancock et al., 2011; Hoff & Bashir, 2015; Ososky, Schuster, Phillips, & Jentsch, 2013; Parasuraman & Riley, 1997; Schaefer, Chen, Szalma, & Hancock, 2016). However, the very nature of technology means that we will often be dealing with imperfect autonomy.

There are also many other factors that influence trust, including anthropomorphism, group membership and organisational factors (Baker et al., 2018; Hoff & Bashir, 2015). These are important and should be mentioned, however they are not the focus of our study.

2.2 TRUST CALIBRATION

When dealing with imperfect autonomy, it is important to be able to know how much it can be trusted or it will be used improperly (Parasuraman, 1997; Cohen, 1998; Dzindolet, 2003; Lee, 2004; McBride, 2010). Broadly, this kind of managed trust in automation is termed as "trust calibration". If the autonomy is visibly unreliable, the user may simply disuse it and do the entire task manually themselves (Freedy, DeVisser, Weltman, & Coeyman, 2007; Parasuraman & Riley, 1997). This is undesirable as it may lead to lower overall task performance because the user discards all advantages provided by the automation (Dzindolet, Peterson, Pomranky, Pierce, & Beck, 2003; Lee & See, 2004; Wright, Chen, Barnes, & Boyce, 2015). Lee & See succinctly describe trust calibration as being the correct assignment of trust levels given the capabilities of the automation (Lee & See, 2004).

For clarity, 'misuse' is defined as over-reliance on automation or overtrust. 'Disuse' is defined as an underutilisation of automation and an under-reliance on automation or undertrust. Disuse and misuse had specifically been identified by Parasuraman (Parasuraman & Riley, 1997) and these definitions have been broadly adopted by the HAT community. Both 'disuse' and 'misuse' are undesirable outcomes, and transparency has been shown to mitigate them by enabling trust calibration. A clear example of this was demonstrated by Furukawa and Parasuraman in their experiments with aviation automation (Furukawa & Parasuraman, 2003). When they deliberately introduced delays or errors in the automation's

notification capabilities, pilots were able to predict or identify imminent engine failures simply by using the provided transparency information. Seong & Bisantz (2008) also found similar results in their aircraft identification decision aid study; showing performance benefits for unreliable automation that have transparency information available. Similarly, Wang et. al (2016) found that users were able to correctly reject an automated teammate's recommendation based on the teammate's observation explanations alone.

There are many more experimentally demonstrated examples of transparency being successfully used for trust calibration, as cited by previous survey works (Hancock et al., 2011; Lee & See, 2004; McBride & Morgan, 2010; Seong & Bisantz, 2008; Westin, Borst, & Hilburn, 2016). The overarching paradigm here is not to increase trust in automation overall, but to give the user enough context to be able to assign the correct level of trust given the dynamic circumstances (Cohen et al., 1998; Lee & See, 2004). Imperfect autonomy is assumed.

2.3 TRANSPARENCY

Transparency is a critical component in forming trust in human autonomy teaming (HAT) (Baker et al., 2018; Endsley, 2017; Freedy et al., 2007; Hancock et al., 2011; Hoff & Bashir, 2015; Lyons, 2013; Ososky et al., 2013; Parasuraman & Miller, 2004; Parasuraman & Riley, 1997; Schaefer et al., 2016). By allowing the user some insight into the autonomy's reasoning and "state of mind", transparency holds the key to mitigating or correcting errors caused by the imperfect autonomy (Baker et al., 2018; Chen et al., 2014; Lyons, 2013; Ososky et al., 2013; Schaefer et al., 2016; Selkowitz, Lakhmani, & Chen, 2017; Wright et al., 2015). Even when there are no errors, but the behaviour is unexpected or unintuitive to the user, transparency has an important role in forming a user's trust in the machine (De Visser et al., 2018; Endsley, 2017; McBride & Morgan, 2010; Parasuraman & Riley, 1997).

A quick and simple example of transparency would be displaying the intended pathway of a self-navigating vehicle. Another would be a symbolic representation of what a computer vision (CV) agent is seeing, where

detected objects are clearly annotated. In either example, a user will be able to see the agent's intentions and any flaws in its reasoning. If the agent plots a course through a dangerous obstacle, or if the agent wrongly classifies a critical object, the user will have the opportunity to enact appropriate countermeasures to avoid failures. In the case where failures do occur, the user will have some level of explainability as to why it occurred and avoid such occurrences in the future.

It must be noted that transparency is not limited to graphical formats, as in the previous examples. Verbal and written natural language and audio are also common channels of communication (Hoff & Bashir, 2015; Lee & See, 2004). Haptic feedback is not as prominent but exists in some specialised contexts such as telerobotics (Brown & Farkhatdinov, 2021; Preusche & Hirzinger, 2007).

Generally, transparency is the mechanism by which we understand the actions of the autonomous agent. However, the term should not be misconstrued as simply the mass of information given to the human. Too much information will actually result in less transparency, as the human reaches their cognitive load limits, impeding their performance.

2.4 COGNITIVE CONSIDERATIONS IN HAT

Whenever the machine needs to send information to the user, they will inevitably incur a cognitive cost for receiving it. Be it reading a dial, or interpreting a graph, or even listening to voice output, the user will need to spend some of their cognitive capacity to absorb this information. This has been the motivating factor in Ecological Interface Design (EID) theory (Furukawa & Parasuraman, 2003; Westin et al., 2016) but has not been the focus of HAT research. However, there are some relevant studies.

Cummings et. al. were interested in this area and demonstrated the upper bounds of human cognitive capacity in monitoring tasks (Cummings & Guerlain, 2007; Cummings & Mitchell, 2008). Interestingly, when using a "utilization" metric (percentage of busy time), they found that task performance stopped improving at around 50-60%, as shown in Figure 1. This suggests that at lower utilisation rates, the user simply was not

sufficiently engaged in the task to achieve their best results. Interestingly, it also clearly demonstrates that user performance is significantly affected as the user approaches their cognitive load limit.

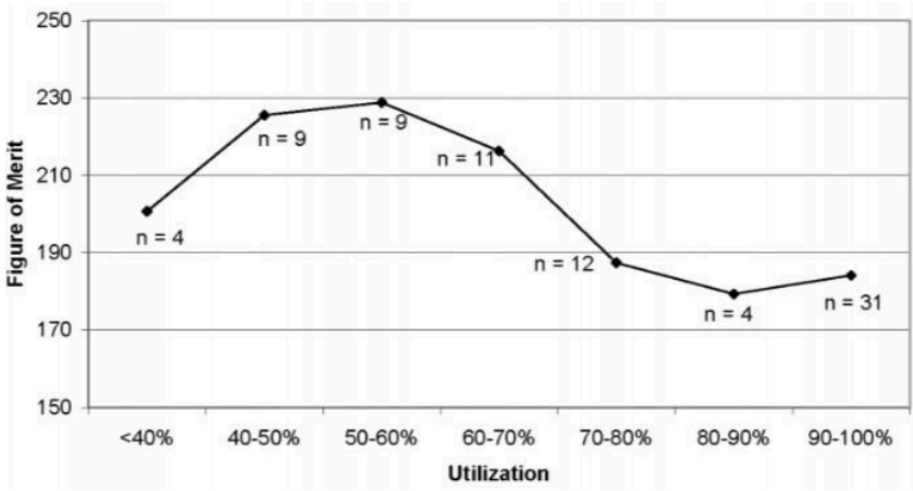

Figure 1: Cummings and Guerlain demonstrate a "cognitive hump", where performance peaks at 60% utilisation (Cummings & Guerlain, 2007). Human performance degrades after reaching a cognitive limit.

Chen et. al. have also found a similar "hump" for situational awareness (SA) and trust. In their experiments, each additional transparency layer resulted in improved trust and SA, until they reached SA1 2 3 U (Chen et al., 2016; 2014). Once the uncertainty information was added to the mix, SA and trust was comparable to when transparency was at SA1 2 only. It is reasonable to attribute this to the user reaching their cognitive limit, given the results of Cummings et. al. (Cummings & Guerlain, 2007; Cummings & Mitchell, 2008) and the general motivations of Ecological Interface Design (EID) theory.

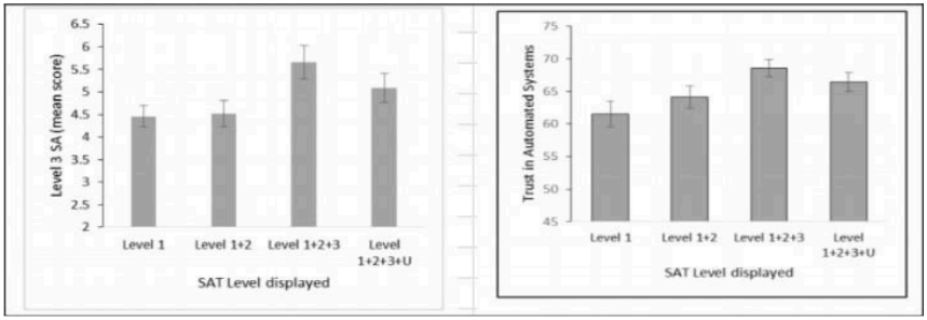

Figure 2: Situational Awareness and trust fall after SAT 1 + 2 + 3 is presented to the user (Chen et al., 2016, 2014). Human performance degrades after reaching a cognitive limit

Westin, et. al. (2016, p.202) support this explanation stating: "Increasing transparency by providing more information, can be a potential issue if the amount of information exceeds what the operator is capable to process within a certain amount of time". Seong, & Bizantz (2008) have a further insight, suggesting that the type of transparency may have an effect on performance. They state: "It is feasible that a configural display of critical information can be better understood compared to an alphanumeric based display, which eventually may lead to better calibration of human trust"(Seong, & Bizantz, 2008, p. 624). Taken together, this suggests that different types of transparency will have varying cognitive costs, and there may be optimal types of transparency for certain types of information.

2.4.1 POSSIBLE ROLE FOR COGNITIVE FIT THEORY (CFT)

"Cognitive Fit Theory" (Vessey, 1991; Vessey & Galletta, 1991; Moody, 2009) offers a possible mitigation for the issue of cognitive overload. It is indeed possible to optimise data presentation for humans to better suit given tasks. More recently, Nuamah et. al. (2020) tested the user's accuracy and speed in performing a judgment task with graphical and text/tabular information and found that the graphical mode of presentation performed best. Cognitive Fit Theory has so far only been investigated in static, non-dynamic, and time-insensitive contexts. That is, it has only been tested "in the office". We speculate that it may have applications in dynamic and time sensitive contexts as well. That is, CFT may have applications in the command and control (C2) domain.

2.5 TRUST VIOLATION AND REPAIR (TVR)

It is possible to degrade or violate a user's trust in the automation during the course of their interaction. In the context of HAT, the violation of trust centres around unexpected behaviour from the autonomous system (Baker et al., 2018; Cohen et al., 1998; De Visser et al., 2018; Dzindolet et al., 2003; Lee & See, 2004; Yang, Unhelkar, Li, & Shah, 2017). This encompasses blatant errors, total system failures, and more subtle, counter-intuitive behaviour, where there may not necessarily have been any errors. Over and above good trust calibration, it is also important to consider trust repair strategies when trust in au- tonomy is violated. Trust violation and repair (TVR) is a well researched topic in human to human (HH) relationships (Galdon & Wang, 2019), however there is fertile ground for exploration in human to machine (HM) relationships.

DeVisser et. al. proposes a transactional model of trust repair (De Visser et al., 2018). Human trust levels are increased or decreased when the autonomy engages in "relation- ship acts" and "relationship regulation acts". Cost acts can be roughly equated to trust violations and reduces trust. Beneficial acts are the opposite. Repair acts lessen the impact of cost acts, whereas dampening acts lessen the impact of beneficial acts. The combined impacts of these can result in a "net victim effect", which results in the degradation of trust.

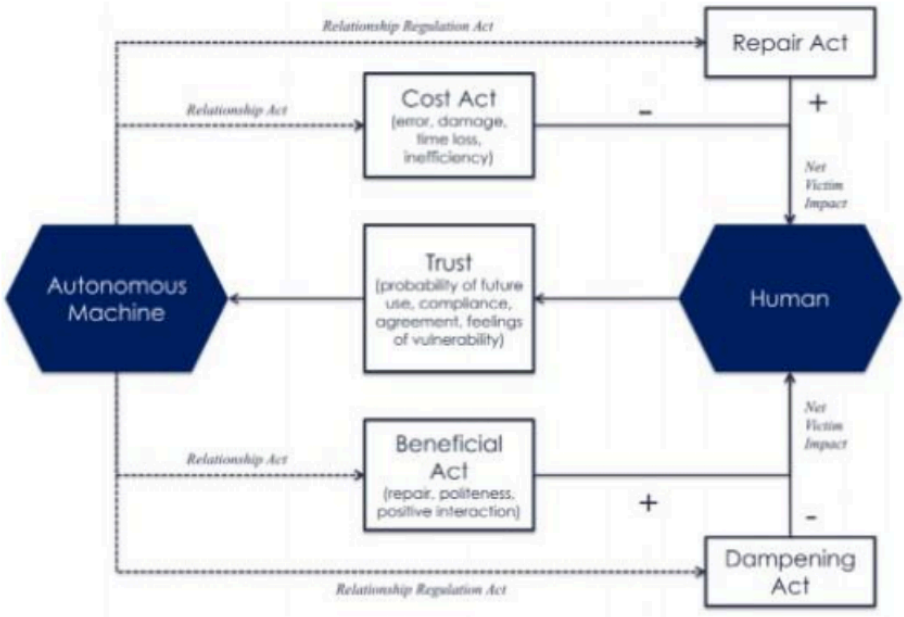

Figure 3: DeVisser's transactional model of trust violation and repair (De Visser et al., 2018)

In one illustrative example, the "net victim effect" is demonstrated in a situation where an automated personal assistant purchases a movie for the user without their explicit permission. In this instance, trust was violated because the user incurred an unexpected expense. However, this personal assistant was set to monitor the user's stress levels and act to alleviate their stress in various ways. The agent chose to purchase the movie because it was a type that the user liked and reasoned that having it available to watch when the user returned home would reduce their stress levels.

The trust repair behaviour in this example was for 1) the agent to explain its own reasoning and 2) offer a remedial action, which in this case was to initiate a refund. Once the user heard the agent's explanation of its behaviour and knew they had a remedial option, trust in the autonomy was repaired. This is of course only an illustrative example, and actual experimental data was not obtained. However, this is a guide for future research.

Although DeVisser's arguments are theoretical, Dzindolet et al. (2003) have experimentally demonstrated that providing explanations for the automation's errors improves trust. Indeed, a key finding that they have made is that knowing why an automation may make a mistake increases trust and reliance, even if the automation is ac- tually unreliable; another manifestation of automation bias. However, these studies were done in the context of trust calibration and not necessarily about active TVR behaviours. The results were also presented as overall summaries of trials in different conditions and do not show variability of trust over time.

To better understand TVR in HAT, we need to be able to see how trust is affected by trust repair behaviours, and this requires visibility of trust levels over time. DeVisser's paper provides for this by their example graphs (De Visser et al., 2018) but actual data from experimental studies is still difficult to find. Yang et. al (2017) have identified this gap and have run a study providing temporal data, however, once again, this study was focused on trust calibration, not TVR.

Trust repair and trust calibration are closely related in the sense that they both require transparency. The defining difference between them lies in the responsibility of the user in the interaction. For trust calibration, the user is actively assessing how much they can trust the automation and then acting accordingly. However, in TVR, it is the automation that is actively trying to regain the trust of the user. We advocate bypassing the TVR process in favour of promoting agent predictability.

3 PROPOSING A PREDICTABILITY BASED MODEL

The motivation behind this is to simplify more complex existing models such as the ones described by Hoff & Bashir (2015), and De Visser et al. (2018). The model described in Figure 4 shows the flow of possible interactions between the autonomous team-mate and the human in one interaction cycle. It also indicates the proportions of these interactions in a desirable scenario. The biggest arrow shows the most desired, and the smallest arrow shows the least desired.

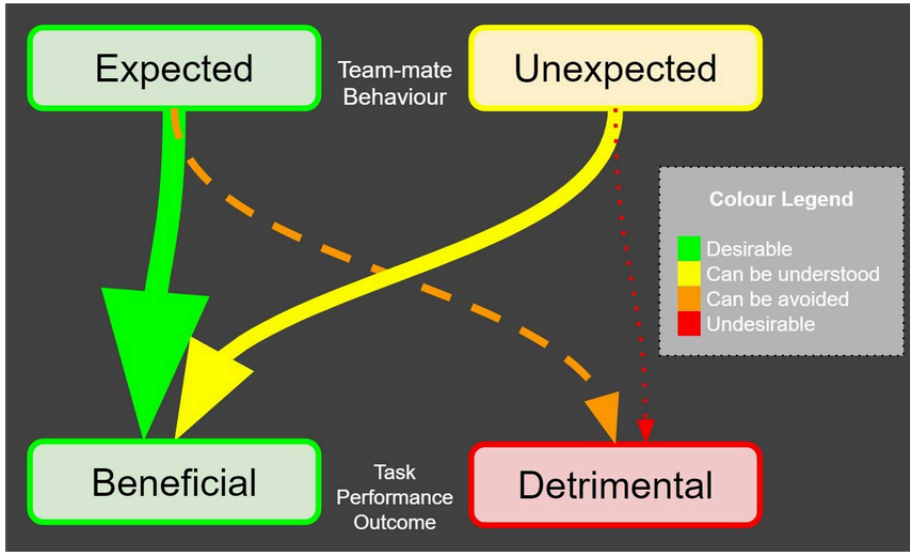

Figure 4: Human-autonomy teaming trust model based on predictability

While of course, the optimal scenario is to have all agent interactions be expected and beneficial, this is not always possible. When this model is viewed as part of a continuous interaction cycle, we can see that it is desirable to change all other agent interaction flows to one that is expected and beneficial. Where it is possible, all effort must be made to make this transition.

All possible interventions to make this happen are not explicitly shown in the model, however it does attempt to encapsulate them. These interventions can of course include, but are not limited to:

1. Reallocation of team-mate tasks

- e.g. the human will take over tasks that the agent performs badly

2. Adjustment of team-mate performance parameters

- e.g. the human will only allow the agent to perform automation to a level that the human is confident that the autonomy can perform well

3. Adjustment in transparency schemes to be more suitable for the current context

3.1 BEHAVIOURAL CONTRACTS

Recall that in Section 2.5, De Visser et al. (2018) described an illustrative example where an autonomous agent wrongly anticipated the desire of its human counterpart to purchase a DVD. This resulted in what they referred to as a "Net Victim Effect". We note that one cause of the net victim effect could have been avoided if the agent had only asked permission in the first place. There was a point where the user had a complete lack of transparency of the process; a Human out-of-the-loop (OOTL) situation as Endsley (2017) would describe it. However, in time-critical settings, asking for permission may not always be a practical interruption, as the user might be concentrating on higher priority tasks. It would be interesting to see if violation of consent is involved here, and if a mechanism for pre-consent can mitigate or even eliminate the net victim effect.

We suggest that a mechanism for pre-consent could come in the form of behavioural contracts. That is, the human teammate and the autonomy negotiates pre-agreed parameters of behaviour to avoid a human out-of-the-loop situation as shown in the illustrative example. The artificial agent would not need to ask permission at the point of decision making because pre-authorisation has already been given. This avoids the need for a prompt that might potentially be intrusive, and also avoids unexpected behaviour from the agent. The idea of behavioural contracts is embedded in the proposed model, however it is not tested in this study. We will study this directly in future work.

4 RESEARCH QUESTIONS

Considering the exposition that was given in the background sections, and our proposed predictability model, we aimed to answer the following questions:

- What is the relationship between trust and agent predictability?

- What is the relationship between trust and user workload?

- Can cognitive fit theory be applied to the command and control (C2) context?

5 METHODOLOGY

An air traffic control task was given to 70 undergraduate psychology students in exchange for course credit. This was conducted in multiple Zoom sessions where participants did the task on a web browser. Participants were exposed to several trials in which they were paired with an autonomous team mate which they could intervene with if they thought appropriate. Each session was strictly timed to 30 minutes, and the number of trials participants were exposed to varied depending on how fast they completed the surveys, and/or if they required extra time in the training phase.

This paradigm was chosen because of its ability to quickly increase a user's cognitive workload (Cummings & Guerlain, 2007), forcing them to rely on their autonomous team- mate. Users were also discouraged from intervening unless they deemed it necessary as an extra incentive to rely on their autonomous team-mate.

The online context was deliberately chosen to avoid the logistical challenges and the recruitment difficulties involved in face-to-face studies. For example, Cabanag et al. (2012) only had eight participants due to these challenges. Finally, given the continuing pandemic situation, it is preferable to minimise face- to-face contacts where possible and practical.

5.1 TASK (GAME)

The goal of the game was to safely land as many aeroplanes as possible. Each aeroplane carried a cargo value, which would be added to the participant's score when it had safely landed. If an aeroplane crashed for any reason, the value of their cargo would be deducted from the player's score.

To discourage users from simply micromanaging the aeroplanes, all interventions would deduct one point from their score. This prevented them from indiscriminately making interventions, and interventions would only be advantageous if it resulted in saving aeroplanes from crashing.

5.1.1 Collisions

It was possible for aeroplanes to collide with each other, and this is obviously an undesirable outcome. The participant would be able to detect this by observing the direction of aeroplanes and their indicated heights. The player's display is a typical, two dimensional, top-down view, akin to a real air-traffic controller's display.

A subtle situation that must be noted is what we refer to as a ”feigned collision course”. This is where aeroplanes appear to be on a collision course on the 2D, top-down display, but in fact indicate different heights. In this case, no collision will occur as the aeroplanes will safely overfly each other.

Players are informed that they should intervene if they detect a collision course, but not intervene otherwise. A key error that we observe in this study is when participants unnecessarily divert the aforementioned ”feigned collision course.”

5.1.2 Danger Zones

Aeroplanes could also be endangered by simply flying over designated areas, which would be indicated by a translucent red box. When aeroplanes made incursions into these danger zones, they would slowly take damage until they finally crashed when their health reached zero. In the obvious case, participants are encouraged to avoid the danger zones.

Again, there was a subtle situation that must be noted, which we refer to as a ”safe danger zone incursion”. Danger zones have a minimum safe speed. If aeroplanes travel at a speed above this level, they will not take damage while they are in the danger zone. Traveling safely through danger zones has an advantage in shortening flight distance to the goal. Players

were informed of this fact and were encouraged to allow safe danger zone incursions.

5.2 VARYING VISUALISATIONS

Participants were exposed to three different types of data visualisations. They were:

- Text: Shown in Figure: 9
- Graphical: Shown in Figure: 10
- Text Graphical: Shown in Figure: 11

Please see Figures 9, 10 and 11 at the end of this document

5.3 TEAM ROLES, AUTONOMY AND HUMAN

Both the human and the autonomous team-mate could instruct the aeroplanes to make diversions at any time. The autonomous team-mate was ostensibly actively ensuring the safe passage of all aeroplanes, while the role of the human was to oversee the autonomous team-mate's decisions.

Errors and other specific behaviours were deliberately executed by the autonomous team-mate in some trials. The participant's reaction to these errors and specific behaviours were observed and measured.

5.4 BEHAVIOURAL MEASURES

We considered a higher number of interventions to be an indication of mistrust of the agent. Conversely, we considered a lower number of interventions to be an indication of trust.

We also monitored specific successful and erroneous behaviours. There were two distinct tasks which were presented to the participant, and they were:

- Managing Collisions
- Managing Danger Zones

As the human player and the autonomous-agent interacted, we counted the occurrences of these successful and erroneous behaviours. While there were numerous sub-behaviours involved in here, these were amalgamated into the following key measures:

- Collision Management:
  - Successes
  - Errors
- Danger Zone Management:
  - Successes
  - Errors

Please refer to the Appendix for a full listing of all behavioural measures, including the behaviour codes that were used for data gathering. Behaviour codes are relevant for reading the data summary in Figure 8.

5.5 SELF REPORT SURVEYS

After each trial, participants were given two surveys to measure perceived workload and agent predictability:

- The NASA Task Load Index (TLX) (Hart, 2006) to measure the perceived workload after each trial.
- A ”Competence and Predictability” survey to measure the perceived performance of the autonomous agent. The 1-5 Likert scale questions are:
  - This autonomous team-mate contributed to successfully performing the overall task
  - The autonomous team-mate made a lot of mistakes

– I knew what the autonomous team-mate was going to do

Please note that this survey was abbreviated in the interests of experimental time, and we acknowledge that the lack of co-verification questions is a limitation.

6 ANALYSIS OF RESULTS

6.1 PREDICTABILITY & TRUST

Results show that the most predictable agents were also the ones that were given the least amount of interventions, as shown in Figures 5 and 6.

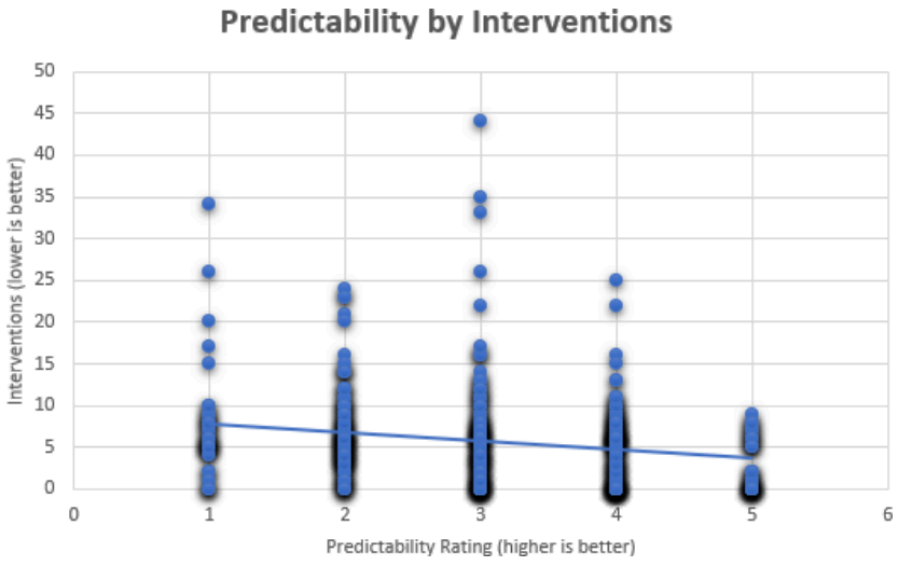

Figure 5: Scatter graph of intervention count grouped by predictability rating. Note the downward trend-line of interventions as predictability rating increases.

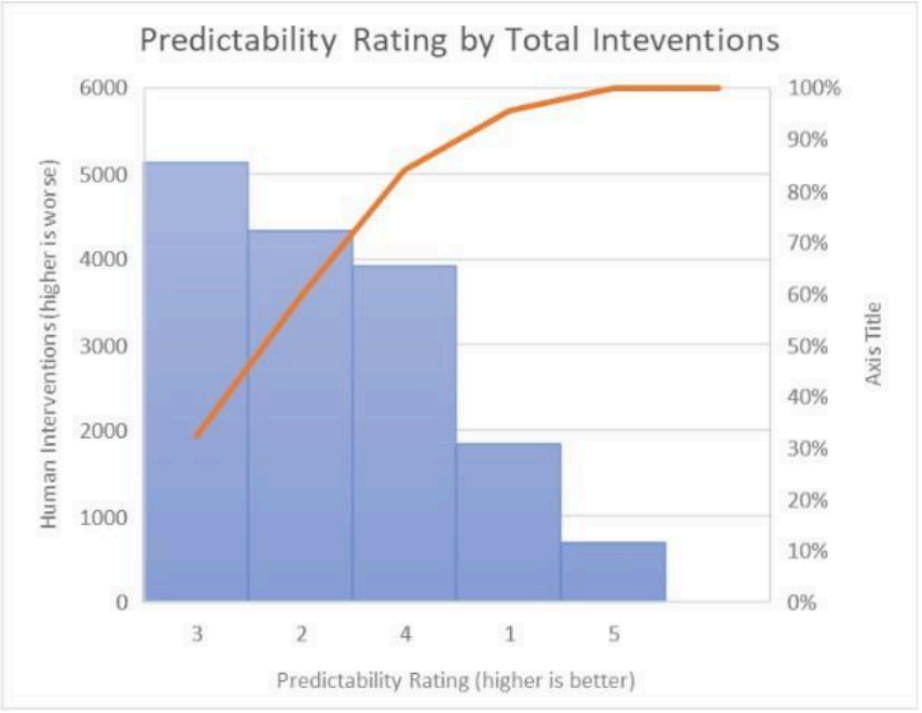

Figure 6: Pareto line chart showing that the highest predictability rating has the lowest number of human interventions.

Although we have not yet determined the key factors that affected the number of interventions, the Pareto line chart in Figure 6 indicates that a high level of predictability in the agent may be conducive to a high level of trust. It is strange that the lowest predictability rating resulted in the second lowest number of interventions, as we would have expected it to have the highest number of interventions. However, it is interesting to note that the highest predictability rating had over 2.5 times the number of interventions than what was observed for the highest predictability rating. This is indicative that agent predictability is indeed a desirable trait for trust in an autonomous team-mate.

6.2 PREDICTABILITY & WORKLOAD

Our results show that the most predictable agents were also the ones that

had the least perceived workloads, as shown in Figure 7. It appears that high agent predictability is also conducive to low human workload.

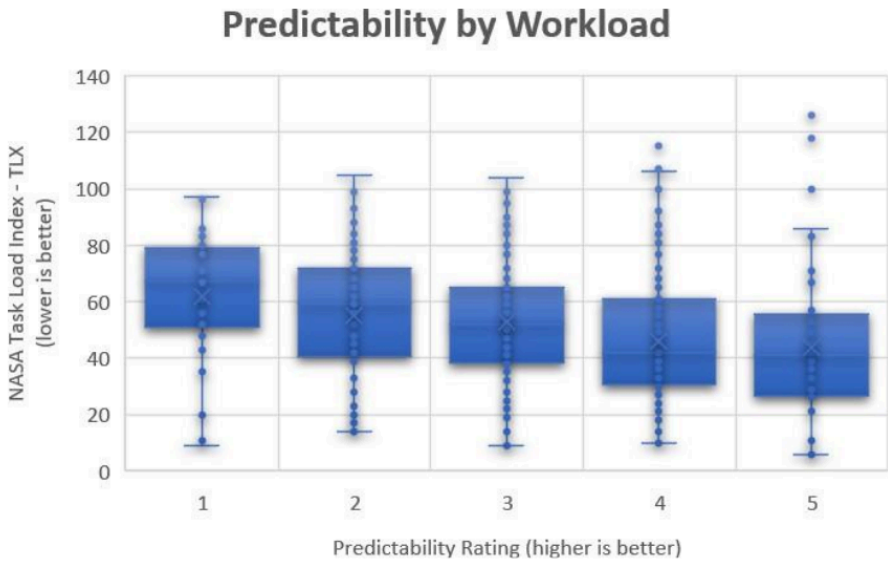

Figure 7: Boxplot of TLX rating grouped by predictability rating. Note the downward trend of workload as predictability increases

6.3 COGNITIVE FIT

Looking at Figure 8, we see that there is some clustering effect around some visualisa- tion types and task types. Specifically, it is interesting to note that errors for the Collision Course Management task dramatically fall in the Text visualisation condition. Similarly, graphical information seems to be a noticeable advantage for successful behaviours in the Collision Course Management task.

Still looking at Figure 8, we see that the Graphical Text visualisation does not au- tomatically result in the worst task performance, which suggests that the user is still able to use relevant available information (whilst filtering out the less relevant information) to perform their task. This is not necessarily surprising, but it would be interesting to see the effects of participants being close to their cognitive load limits.

Best Performing Visualisation per Measured Behaviour (Means)					
(higher is better for **successes**, lower is better for **errors**)			Best	Runner Up	
Behaviour Codes	**Best Performer**		**G Condition**	**T Condition**	**G+T Condition**
divertCC	Graphical	0.748344371	0.748344371	0.43125	0.730538922
safeOverfly	Graphical + Text	13.73652695	12.66887417	10.80625	13.73652695
CC_success	Graphical + Text	15.92715232	13.41721854	11.90728477	15.92715232
collisions	Text	2.2375	3.337748344	2.2375	3.473053892
divertFCC	Text	0.43125	0.748344371	0.43125	0.730538922
CC_error	Text	2.562913907	3.701986755	2.562913907	4.132450331
dzSafeIncursions	Graphical	0.331125828	0.331125828	0.18125	0.275449102
divertDZDI	Graphical + Text	0.928143713	0.741721854	0.6	0.928143713
divertCancelDZSI	Text	1.13125	1.046357616	1.13125	0.946107784
DZ_success	Graphical + Text	5.092715232	4.225165563	4.814569536	5.092715232
dzCrashes	Text	0.08125	0.105960265	0.08125	0.089820359
dzDangerousIncursions	Graphical	1.185430464	1.185430464	1.39375	1.281437126
divertDZSI	Text	0.18125	0.331125828	0.18125	0.275449102
DZ_error	Graphical	2.337748344	2.337748344	2.761589404	2.549668874

Figure 8: Some clustering effect is apparent when it comes to task and visualisation type. Note the CC error block resulting in notably lower error rates under the Text visualisation condition. Please see the appendix for descriptions of the behaviour codes.

7 LIMITATIONS

The results discussed here are preliminary and require deeper analysis. The simple anal- ysis of means needs to undergo significance testing to determine that there are indeed statistically significant effects. However, the clustering behaviour observed in Figure 8 seems to suggest that it might be statistically significant.

The survey based measurement of predictability is also a limitation. It would be more convincing to measure predictability behaviourally, i.e. we should try to see if the participant is successfully predicting their autonomous team-mate's behaviour, rather than just suggesting that they did.

Similarly, workload was also only measured using a self-report survey. Although the NASA Task Load Index or TLX (Hart, 2006) is often cited and used in our field, it may be of some benefit to measure workload behaviourally as well.

Additionally, the data sampled has unequal instances for each visualisation condition due to the strict requirement of ending the experiment after 30 minutes, even if the participant was not able to complete all trials. However, it is in the order of single digits across 478 trials. The exact numbers are: Graphical: 151, Text: 160, Graphical Text: 167. This small variation should not have a significant skewing effect, nonetheless we are noting it for the sake of reader transparency.

The strict ending time also affected the survey results, as participants were instructed to stop the experiment midway through. 14 trials did not have any TLX survey data, and were excluded from any analysis involving TLX.

8 IMPLICATIONS & FUTURE WORK

Our results support key notions that:

A : High agent predictability is tied with high levels of trust.

B : Reduced human workload is tied with increased agent predictability.

This accords well with the predictability based model that we proposed earlier in Section 3. Therefore, it can be said that strategies that increase agent predictability, and reduce human workload will indeed result in improved trust in autonomy. We believe further in- vestigation is warranted to study the validity of the proposed predictability based model. TVR behaviours, as described by De Visser et al. (2018) could be encapsulated into this scheme. However, we advocate explicitly investigating the concept of behavioural contracts, and the notion of pre-consent between the human and autonomous team-mates. This would bypass the need for TVR behaviours all together.

Our results are also suggestive of the phenomenon described by ”Cognitive Fit The- ory” (Moody, 2009; Vessey, 1991; Vessey & Galletta, 1991), whereby specific tasks are ob- served to have optimal visualisations. This study seems to demonstrate a counterexample to the findings by Nuamah et. al. (2020), which showed that the graphical condition was the best performing visualisation. As shown in Figure 8, the Text Condition for minimising errors

in the Collision Management task was the highest performing visualisation type in this study.

This is not to say that Nuamah et. al. claimed that the graphical condition would be best generally. However, it does reinforce the idea that data visualisations are closely coupled to the specific task that they are aimed at.

This is a more nuanced approach that is taken by contemporary schemes such as Situational Awareness Transparency (SAT), which puts visualisations on different levels along the same axis. Generally, there is a prevalent practice of equating the term transparency with information given to the user (Westin et al., 2016). Adopting cognitive fit as a guiding principle allows us to specify that transparency refers to the understandability of a system, not simply the amount of visualisations presented to the user. In fact, taking this approach is prone to exceeding the human cognitive load limit and can inadvertently reduce transparency instead of increasing it (Westin et al., 2016).

Instead of pursuing a grand theory for cognitively efficient information displays, more pragmatic approaches may be required to meet the current needs of C2 operators. It may be more practical to use heuristic based approaches which will be able to readily accept and apply domain expert knowledge within the immediate context in which they operate. As these approaches proliferate, a clearer picture will emerge and would help inform a grand theory for cognitively efficient information displays.
Future studies will address some of the previously discussed limitations. The tutorial phase and other administrative parts of the trial will be shortened so as to allow enough time for participants to complete all exposures. A behavioural measure of predictability will be used, in conjunction with a survey based one. It would also be interesting to see how cognitive fit interacts with a wide range of workload conditions. This study did not manipulate workload, but only measured it using TLX. We would be specially interested in looking at workload conditions at users' upper cognitive capacity.

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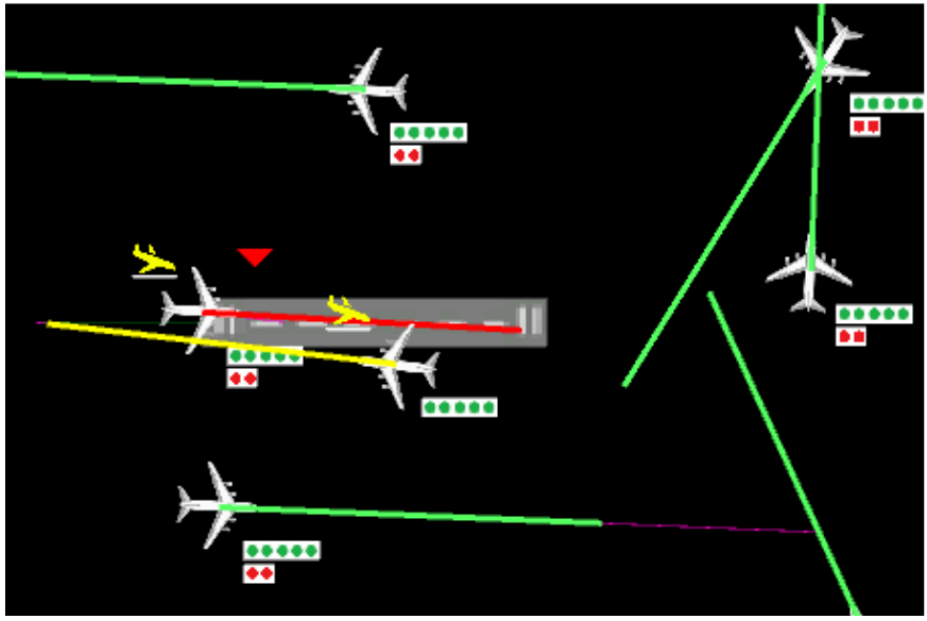

Figure 9: Text condition

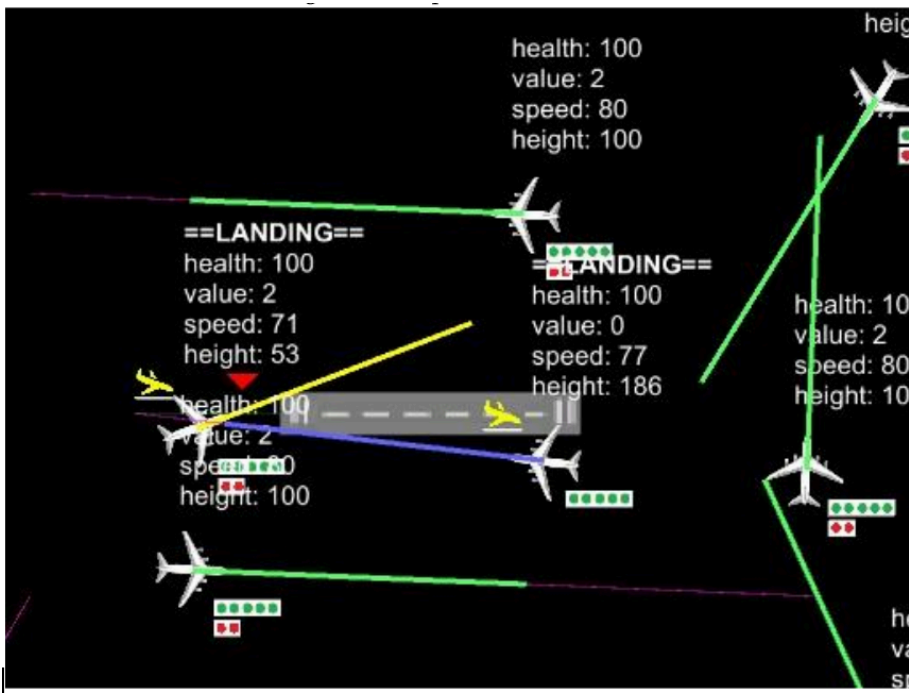

Figure 10: Graphical condition

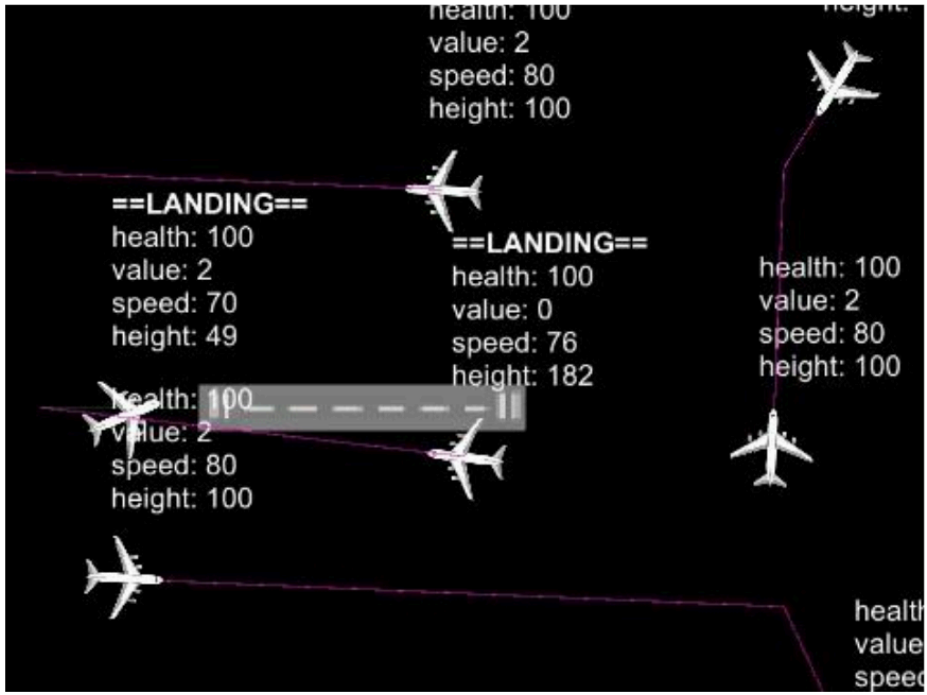

Figure 11: Text Graphical condition

A APPENDIX

A.1 FULL ENUMARATION OF BEHAVIOURAL MEASURES

For transparency to the reader, the conceptual tasks are further broken down into the following specific measures:

- Collision Management:
  - Successes (CC success)
    * Diverting aeroplane on collision course [divertCC]
    * Allowing safe overfly [safeOverfly]
  - Errors (CC error):
    * Aeroplanes collided with each other [collisions]
    * Safe overfly diverted incorrectly [divertFCC]

- Danger Zone Management:
  - Successes (DZ success):

* Safe incursions allowed [dzSafeIncursions]
* Diverting dangerous incursions [divertDZDI]
* Cancelling unnecessary diversions (of what was going to be a safe incur- sion) [divertCancelDZSI]
– Errors (DZ error):
* Crashes in the danger zone [dzCrashes]
* Dangerous incursions [dzDangerousIncursion]
* Diverting safe incursions [divertDZSI]
* Cancelling necessary diversions (inadvertently causing a dangerous incur- sion) [divertCancelDZDI]

CHAPTER 6

An Oscillatory Model for Developing Narratives for Serious Games

VEDANT SANSARE; MALCOLM RYAN; AND MITCHELL MCEWAN

ABSTRACT:

Designers often use a scripted approach to developing branching narratives for serious games. In this approach, the designer hand-crafts each dilemma at a low level, presenting these scenarios to the player with fixed branching pathways. However, this can create disconnect and disengagement within the player as the presented choices reflect the designer's intent rather than the player's interpretation of the scenario. On the other hand, a systems-based approach will allow the designer to develop a set of gameplay systems that integrate the game's learning goals as interactive processes. However, this approach is not as sought after due to the difficulties designers face while implementing it into practice due to the requirements of a robust, cohesive gameplay system capable of organically producing dilemmas and scenarios. In this paper, we propose an oscillatory model for systems-based narrative design, which relies on the current understanding of the scripted approach. The oscillatory model goes back and forth between the scripted and systemic approaches to simultaneously build both versions of the game narratives.

KEYWORDS:

Serious game, Systems-based Gameplay, Scripted Play, Systemic Narrative

1 INTRODUCTION

Designing for scripted play is a popular approach for developers of serious games. It commonly uses a branching narrative design, where the designer hand-crafts each individual path to provide a cohesive and more directed experience for the player. However, this approach leads to limited individual branches due to the effort required to develop each path to a similar level of fidelity while confining the player to these limited choices (Formosa et al., 2016; Ryan et al., 2012; Sweetser & Wiles, 2005). Finally, this approach can also create conflict between designer and player intentions, as they may have differing views on how a scenario should be resolved. Therefore, while providing the potential for an immersive narrative (and educational) experience, the scripted design method limits the developer and the player with the number of choices they can offer and interact with. On a fundamental level, this approach misses the value of games as procedural rhetoric, whereby concepts are conveyed through an interactive process (Bogost, 2007; Ryan et al., 2012).

An alternative is to use a systems-based approach for serious games design. In this case, rather than hand-crafting each path, the developer designs a system that is robust enough to accommodate the organic formation of scenarios and decisions. This allows the player to experience more agency and less frequent conflict with the designer while reducing the effort required to develop cutscenes or pre-rendered animations (Formosa et al., 2016; Staines et al., 2019). The systems-based approach, from a pedagogical perspective, enables the designer to embed not only the narrative but also the abstract learning goals associated with the narrative into the interactive processes of the system by inviting the player to play with the system as they gradually discover new patterns and gain proficiency over it (Ryan et al., 2012; Staines et al., 2019). However, due to its inherently abstract nature, it can promote disengagement for the player as they focus more on the outcome of the system rather than the concepts and lessons the serious game is trying to convey (Krcmar & Eden,

2019; Melzer & Holl, 2019). Moreover, designing a robust systems-based game requires the designer to identify a fine-grained model of the real-world system and mould it into a playful toy with which the player can interact. This can further dissuade designers from preferring the systems-based design approach over the scripted one (Sweetser & Wiles, 2005).

As such, in this paper, we propose an iterative, oscillatory model for systemic narrative development that relies on our current understanding of scripted game design to develop the systemic components of the game. This paper will initially provide a breakdown of the two approaches to developing serious game design. They will be further broken down into finer components which affect decision-making not only on a procedural level but also at a semiotic level. Based on this decision-making framework, the paper will present the oscillatory model with an example for each stage.

2 SCRIPTED AND SYSTEMIC PLAY

First, we discuss the scripted and systems-based approaches to designing serious games, which rely on two different approaches to learning.

2.1 SCRIPTED APPROACH

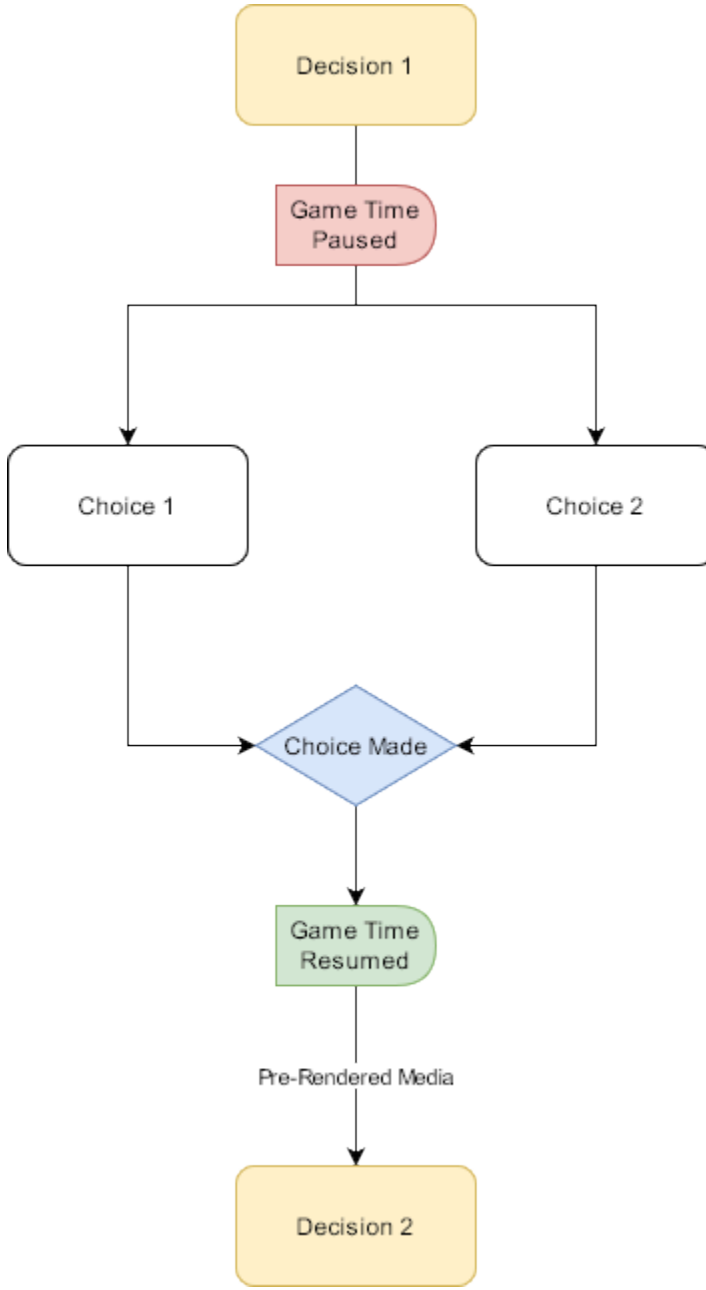

Figure 1: Scripted Approach to Narrative Design

The scripted approach to game design allows the designer to possess complete creative control over the narrative as well as the structure of the play. In the scripted approach, the designer's primary role is to intricately develop every aspect of the game's model to facilitate a consistent experience for the player, although this still will not guarantee that every player will experience the game the same way (Formosa et al., 2016).

As illustrated in Figure 1, branching narrative design techniques are a commonly observed design choice that facilities this approach to game design. In a branching narrative, at each narrative beat, the player is presented with a certain number of hand-crafted choices, which further lead towards the subsequent narrative and so on (Riedl & Young, 2006). As a result, in the scripted version, the designer hand-crafts the narrative structure and critical narrative beats where the player is required to make decisions to progress in the game. The player's role here is to choose an option they broadly agree with and experience the corresponding outcome, which they may or may not agree with. The outcomes of these choices are often in the form of pre-authored or pre-rendered animation as per the designer's desire.

Furthermore, from a pedagogical perspective, previous research associates scripted approaches (or approaches like scripted design) with the behaviourist model. Specifically, the more scripted approaches to game design discourage games to go beyond rote-learning (Ryan et al., 2012; Stieler-Hunt et al., 2014). In the scripted model, when the player is faced with choices, not only does the player experience the narrative through pre-authored media but also passively gains knowledge or concepts the designer was trying to convey.

2.2 SYSTEMS-BASED APPROACH

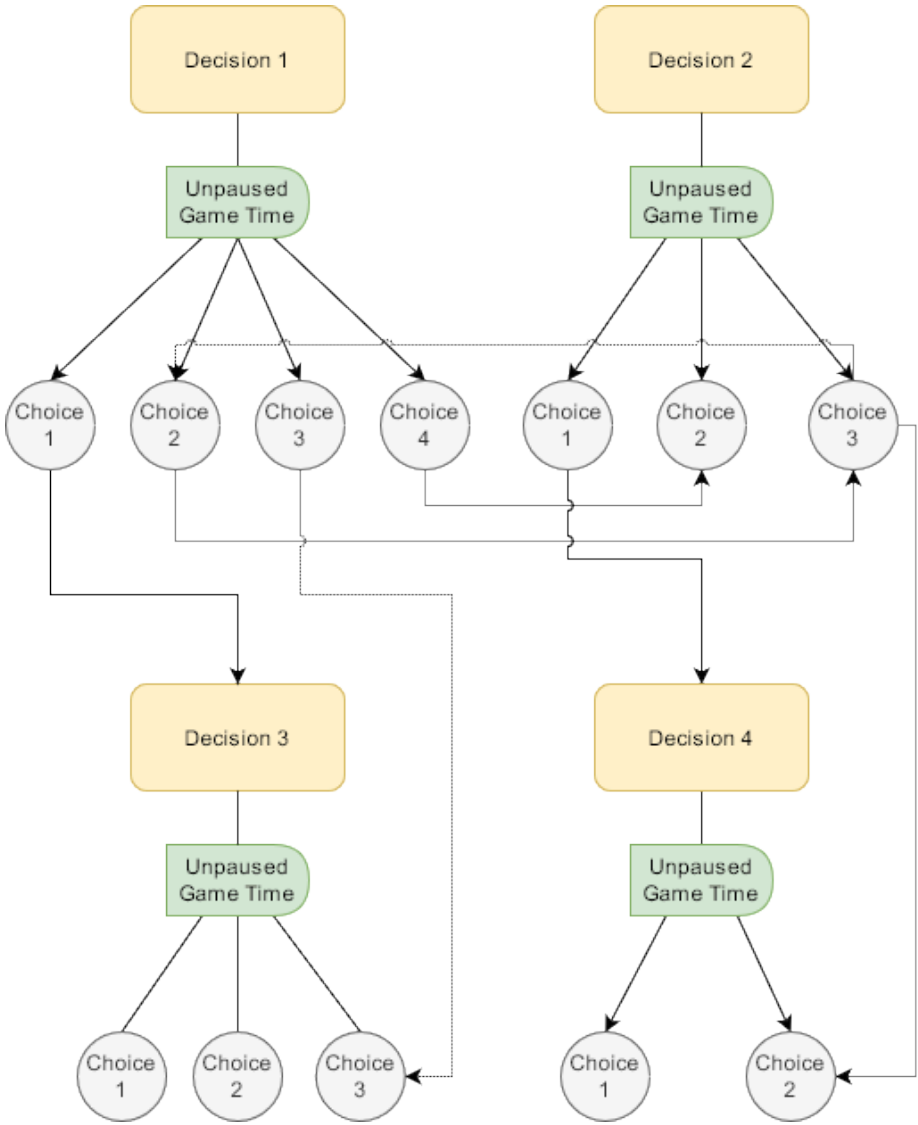

Figure 2: Systems-based Approach

On the other hand, in systemic play, the designer's role is vastly more implicit. Rather than micro-managing the game experience, they are tasked

with developing a robust enough system to facilitate a varied, personalised experience for the player. In this approach, the developer delegates the authorial control to the player by presenting them with a set of systems that interact with both the procedural and semiotic layers of the game.

As seen in Figure 2, in systemic play, the narrative beats are generated because of multiple systems interacting with each other. Following Bogost's procedural rhetoric, this weaves not only the learning goals but also the narrative conflicts within the interactive processes of the game's system (Bogost, 2007). It further allows the player to associate the abstract concepts the developer wants to convey more easily with the rules of the system.

From a learning perspective, prior studies have highlighted the significance of a systems-based approach supporting the player to go beyond rote learning by allowing them to interact with the "play space" composed of different gameplay systems (Klopfer et al., 2009; Ryan et al., 2012; Stieler-Hunt et al., 2014). This active, experiential type of learning allows the player to be involved at a very low level as they interact with the different processes and experience a learning cycle of discovery, generalisation, and experimentation (Ryan et al., 2012; Stieler-Hunt et al., 2014).

To understand both these systems on a more fundamental level, we will further explore how they present choices to the player and how they impact each other on both a procedural and a semiotic level.

2.3 COMPONENTS OF SYSTEMIC AND SCRIPTED METHODS

So far, this paper has covered both discussed design approaches at a relatively abstract conceptual level, defining the scripted approach as limiting agency and the systemic approach supporting it. However, to understand how they affect agency at a lower level, the following section will explore each approach from both a game design and narrative perspective and the distinct factors that determine the degree of scripted and systemic play in a game.

2.3.1 Atomicity of Choices

The atomicity of choices in games relates to the level to which a big decision is granulated into more minor decisions. As such, a game with high or fine-grained atomicity will have decisions granularised into numerous choices that might appear to relate to more negligible outcomes. On the other hand, a game with low or coarse-grained atomicity will have a decision granularised into bigger chunks.

In a narrative game where most of the gameplay is scripted, the branching-narrative decision tree represents the coarse-grained atomicity of choices available to the player. On the other hand, a game designed using systemic methods will possess a much more fine-grained and moment-to-moment decision structure as the player's choices are directly connected to the game systems, which often require multiple low-level micro-decisions.

2.3.2 Aggregation of Choices

The second factor which affects decisions in games is the aggregation of choices, which is the extent to which the outcome of a decision is a result of many smaller, previous micro-decisions (Sicart, 2013). Games with decision trees can fall within a range of high or low aggression, i.e., a game with high aggregation will contain decisions with multiple dependencies relying on each other; on the other hand, zero aggregation will have all the in-game decisions independent and contained from each other.

Game narratives designed using a systemic method allow for higher aggregation of choices as the associating dependencies emerge organically from the defined values contained within the interacting system. However, in the case of scripted narratives, the presented aggregation is lower as the designer needs to manually hand-craft these internal dependencies, locally defining the relationship between each decision (Stang, 2019; Sweetser & Wiles, 2005).

2.3.3 Narratives Beats

A narrative "beat" represents the beads from the "beads-on-a-string"

approach, representing a branch in a narrative where the player is required to perform a choice to navigate the flow of the game (Costikyan, 2007).

In games using scripted play, this narrative beat is typically sign-posted as the game-time comes to a halt while the player is presented with a user-interface containing a set of two to four enumerated choices (Formosa et al., 2016). Upon deciding, the game moves towards the next beat, where the process repeats.

On the other hand, in systemic play, the narrative beat is much more implicit and is the product of different systems interacting with each other. The narrative aspect of the beat is a result of the semiotic layer associated with the system's rules. As a result, the game-time, in this case, keeps moving forward, and it is up to the player to identify the beat and interact with it. In a scenario where the beat goes unidentified (and hence unattended), its consequences are reflected in the future as the player progresses in the game.

2.3.4 Conflict Between Procedural and Semiotic Layer

According to Sicart, games have two dominant layers of abstraction: a) Procedural Layer and b) Semiotic Layer.

The procedural layer constitutes the interaction between the mechanical agents (player and NPC) and the state machine through game mechanics in the form of input-output I/O operations. These operations or actions are conducted on the system's parameters, which in turn modify the state of the game. Some examples of the elements of the procedural layer are experience points, combat systems or resource management systems (Sicart, 2013).

On the other hand, the semiotic layer provides cultural and narrative context to the various procedural elements of the system. This context allows the player to apply their internal values to operations of the state machine, to consider not just the procedural perspective while making decisions (Sicart, 2013).

3 SYSTEMS-BASED NARRATIVE DEVELOPMENT

Based on this theoretical framework and concepts from scripted design, this paper proposes an oscillatory approach to narrative development using a system-based method. In this approach, the narrative is initially designed using a branching paths method to map out the critical decision structure and narrative beats involved in the game.

In this proposed method, the designer will simultaneously develop the scripted and systemic version of the game by going back and forth between the two versions. The core idea is that the game's scripted version follows a coarse-grained, low aggregation decision structure. As a result, multiple micro-decisions are grouped in a larger chunk. Following this, we break this sizeable chunk into smaller micro-decisions and translate them into interactive processes as part of a more extensive gameplay system.

For example, Figure 3 presents an example of a serious game currently undergoing the oscillatory design approach in the context of a larger research programme exploring systemic and scripted design in serious games. In this figure, the flowchart represents the narrative structure of a game where the player plays the role of a system administrator of a small-scale hospital.

As part of the player's day job, they must process emails, log files, and address other activities as part of their daily duties. The yellow entities indicate the narrative beats, while the orange boxes show a scenario followed by choices in red and the subsequent impact of these choices in blue. This structure is more akin to a scripted design method where the atomicity of choices is very coarse-grained, and the outcome of each choice is not necessarily relevant to how future scenarios develop and how the outcomes of these scenarios are determined

In this scenario, there are two junctions where the player can affect the narrative, firstly by choosing how to proceed with the received email and secondly, how to process the ransomware scenario.

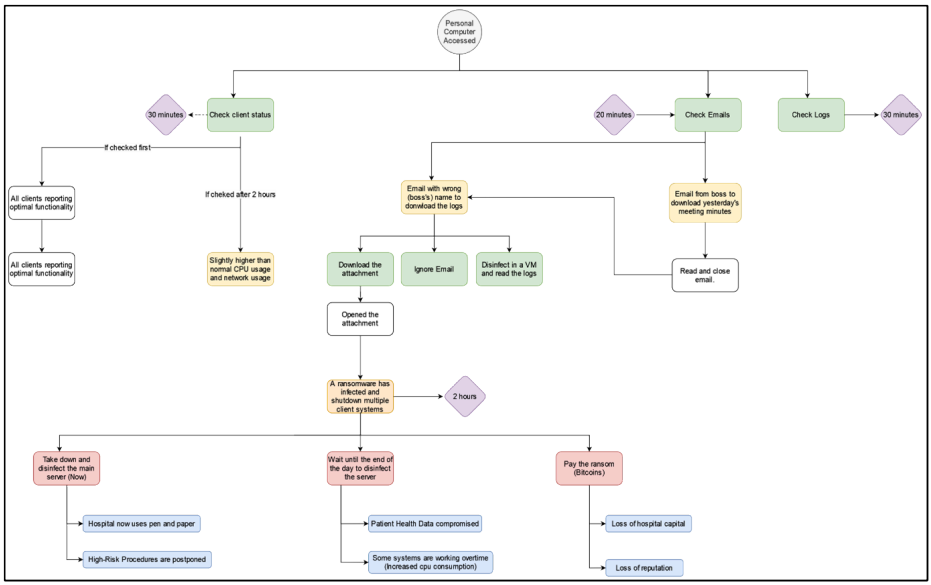

Figure 3: Key Decision Structure and Narrative Beats

There are specific noticeable actions chunked together here, such as automatically downloading and opening the attachment after reading the email or preventing the player from spreading the ransomware after opening the attachment. Furthermore, in the second junction, there are limited choices available to the player.

Another essential aspect presented in the scripted version is the passage of time, as indicated in purple. In this scripted version, the player-character and the player experience time differently. When the player is presented with the choice of checking client machines' status, emails, and logs, each task consumes a pre-determine chunk of in-game time regardless of how much time passes for the player. Similarly, the player can take as much time as needed to deliberate on the choices during the "ransomware" scenario.

To convert this scripted design into a version of the proposed game that supports systemic play, each narrative beat needs to be broken down into a series of actions and events. This translation should be conducted so that a combination of player actions will produce another narrative beat as a product of the system rather than being hand-crafted by the designer.

As such, in the systemic version of the game, the first junction will be broken into smaller actions that the player will carry out as part of a more extensive system. One approach would be integrating these micro-decisions as a resource-management simulation framework. In this design, entities such as “Emails”, “Logs”, and “Meetings”are tasks in the form of cards. The player acts upon these cards, reading, ignoring, or destroying them. In this case, we are taking a more substantial chunk and breaking it down into smaller actions, allowing the player greater agency as now they can choose how and if they want to interact with the tasks. Figure 4 shows a bare-metal representation of the systemic version developed in machinations (Machinations.Io, 2016) using a resource-management systemic design, with the labels for each entity undertext providing a contextual meaning to each entity (or game objects).

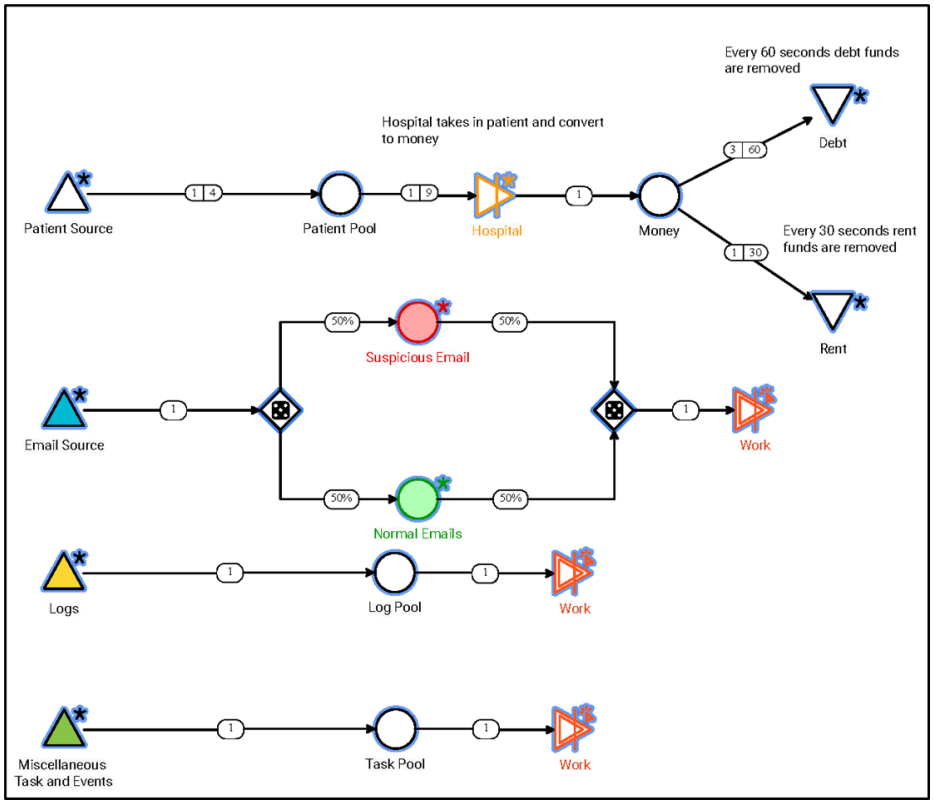

Figure 4: Systemic translation of the scripted version

Naturally, the next step in the process would be to go back to the scripted version and flesh out the next chunk of narrative. Following this, we will go back to the systems-based version to replicate the changes we saw in the example above.

4 DISCUSSION

In this paper, we propose an iterative, oscillatory model of narrative design using a systems-based approach. This model builds upon the work of Bogost's *procedural rhetoric* and Sicart's argument of "friction between the procedural and semiotic layers". By including elements observed in scripted game design narratives, specifically scaffolded narrative beats, this approach integrates these elements as part of a cohesive gameplay

system rather than stopping game time to allow the player to perform a decision. As such, the oscillatory model relies on initially designing a scripted narrative chunk, following which this chunk is broken down into interactive processes of a systems-based model. After integrating the narrative chunk within the system's process, we return to the scripted model and flesh out the next chunk.

As we previously saw, a rough sketch or a flowchart of the scripted version acts as a skeleton to enable the development of the systems-based version. However, at this stage, there still exists the issue of developing a front-end for the systemic model of how the player will interact with the game in real life, i.e., artwork, music, audio-visual effects etc. The primary advantage of this model is that the designer does not have to rely on developing pre-rendered media or flesh out each branching path to maximum fidelity. This ongoing research aims at bridging the gap between scripted and systemic approaches by utilising elements from both methods. To emphasise the advantage of games as an interactive medium, it stresses the systemic component of games by highlighting how the conflict between procedural and semiotic layers could be used in conjunction with the pros of the scripted approach to developing a systems-based narrative.

At the current stage, we aim to apply the model and iterate upon it to develop the serious game presented in the example above. The next step is to develop both the scripted and systemic versions to measure the level of engagement players experience in each case.

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CHAPTER 7

Providing Alternative Ethical Perspectives Through Intelligent Agents in A Serious Game for Cybersecurity Ethical Training

MUHAMMAD HASSAN ALI BAJWA; DEBORAH RICHARDS; AND PAUL FORMOSA

ABSTRACT:

This article contributes to the development of virtual agents that act as non-player characters (NPCs) that offer different ethical viewpoints to assist the player to learn about ethical decision-making. To explore this, we developed a serious game designed to train users to consider five relevant ethical principles (Autonomy, Justice, Beneficence, Non-maleficence, and Explicability) when making cybersecurity decisions. After receiving interactive training in the game about these five ethical principles, the player participates in two cybersecurity scenarios involving three intelligent agents who play the role of virtual office employees. Each virtual agent has been allocated a different combination of personality and ethical principle priorities to present different viewpoints through their dialogues with the player. These dialogues are designed to represent each agent's personality (using the Big-5 personality model of Openness, Extraversion, Emotional

Stability, Conscientiousness, and Agreeableness) and the ethical principles that they consider to be of high or low importance. The scenarios conclude with the player making a choice, followed by a reflection statement to help them review their choice. Through comparison of pre- and post-game responses to other cyber-ethical scenarios, our initial analysis with first-year cybersecurity students shows that players' understanding of ethical principles in cybersecurity improved after playing our game.

KEYWORDS:

Cybersecurity ethics, Agents, ethical principles, serious game, ethical training, Agent personality

1. INTRODUCTION:

The key concept of cybersecurity technologies is to provide a range of tools, resources, and processes to protect the data, integrity, and confidentiality of online systems and end-users (Brey, 2007; Craigen et al., 2014). As the number of cloud-based services has rapidly increased in the last decade, the need for more secure services is required to protect these systems from the malicious attacks that may occur to steal important personal and financial data. Breaches due to the human element are also increasing (Ayyagari, 2012). As reported by Dunn (2014), 93% of cybersecurity breaches were caused by human error rather than any technical issue. System designers and users pose a key vulnerability if they are not aware of the human aspects that can impact computer systems. The designers and users of cyberspace need to understand the impact of their actions and decisions.

Despite the utmost importance of ethical decision-making in the domain of cybersecurity, this vulnerability gap has received comparatively less attention from users and researchers. This gap can be alleviated by training cybersecurity professionals to consider alternative ethical perspectives while making a decision in cyberspace. These decisions can range from implementing a new control protocol to setting the organization's policies or norms. Serious games provide pedagogical effectiveness (Kianpour et

al., 2019) in training by giving hands-on practical experience in an artificial, virtual but still familiar environment.

There are many serious games available in the literature that focus on cybersecurity training (e.g. (Ferro et al., 2022; Hale et al., 2015; Jordan et al., 2011). Nevertheless, there is a gap in the development of serious games whose primary focus is to consider the ethical aspects of cybersecurity decision-making. To cover this gap, we have designed a serious game populated with non-player characters (NPCs) who are agents with ethical priorities. Agent interactions with the player provides us with the chance to provide the player with *social learning* opportunities. In social learning, the player gets a chance to observe other agents and these observations create new behaviors in the observers. As argued by Reed et al. (2010) social learning occurs through an interaction between individuals and it changes the understanding of individuals involved in the interaction. Some of the time, observers might try to imitate others. In this case, providing multiple virtual agent perspectives aims to promote player reflection which may potentially lead to a change in ethical principles.

Experiential learning requires all the participants to play a specific role, participate, interact and apply the skills to create a replica of a real-time environment (Gentry, 1990). Serious role-play games are an effective tool to provide experiential learning. Designing intelligent agents for a serious role-playing game is vital as human players may not be available all the time and they may not be well trained to perform a specific role. Thus, agents acting as non-player characters in the game mimic the role of different humans. An artificial agent in place of a human in an artificial environment provides the opportunity for trainees to see the effects of their decision before implementing them in the real world.

We have developed a serious role-playing game that aims to provide a training medium for cybersecurity professionals in which they encounter different ethical perspectives through the design of intelligent virtual agents. The agents (non-player characters) have different personality behaviors and inclinations toward different ethical principles. Those agents will present different ethical perspectives during the game. The game provides a real-time working environment to the user in which they interact with other agents. The interaction helps an individual to apply and practice

ethical and social skills. At the start of the game, the player receives training on the five ethical principles in cybersecurity. These are from the principlist approach developed by Formosa et al. (2021) and comprise: beneficence, non-maleficence, autonomy, justice, and explicability.

To provide non-player characters (NPCs) in the game that model different ethical perspectives, we assign different combinations of ethical principles that are of high or low importance to each of our three NPCs. It is widely discussed in the literature that an individual's personality influences their ethical decision-making (Craft, 2013). For this reason, we also assign different combinations of personality traits to our NPCs using the Big Five personality model (Conscientiousness, Agreeableness, Extraversion, Neuroticism, and Openness) (Roccas et al., 2002). Due to their different personalities, agents provide different ethical perspectives, and these perspectives are used to improve the ethical awareness and sensitivity of the player during the game. This study aims to evaluate whether the player's awareness of ethical principles increased after playing the game. The following research question is addressed in this article.

Research question 1: What is the influence of a serious game on the awareness of ethical principles when making decisions in a cybersecurity context?

In the following section, we provide background literature. Section 3 describes our methodology, including a description of the implemented game. Section 4 provides the results which are discussed in Section 5. The paper ends in Section 6 with conclusions, limitations, and future work.

2. BACKGROUND LITERATURE

2.1 Decision-Making in Cybersecurity

Cybersecurity breaches can be minimized by using the latest cybersecurity technologies and understanding how these technologies are used by humans. The human aspect of implementing and using these technologies cannot be ignored as human error is a major contributing factor to cyber breaches (Streeter, 2013). One way these human errors occur is when

a cybersecurity professional is not able to make a suitable decision in cyberspace intentionally or unintentionally. Ethical decision-making provides an individual with a framework to decide between right and wrong. The ethical issues in cybersecurity arise when the ethical implications of a decision are ignored in cyberspace (Formosa et al., 2021; Vallor et al., 2018)). To minimize human error, cybersecurity professionals need to be trained to consider ethics in their decision-making in cyber ethical dilemmas (Blanken-Webb et al., 2018).

Craft (2013) presented 16 individual factors that influence decision-making. From these factors, we found "Personality" to be the most influential factor as it is discussed by most of the studies. We use the most used personality model, Big Five Factor (Costa Jr & McCrae, 2008) also known as the Big Five, to illustrate personality in our virtual agents. The model provides five factors that are used to represent personality traits (Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Emotional Stability). Openness to Experience describes a person's feeling about new changes and being open-minded. Conscientiousness describes a person's inclination towards following a plan and being self-disciplined. Extraversion describes a person's feelings about enjoying being with people, being outgoing and participating in social gathering. Agreeableness assesses a person's feeling of being generally helpful, warm, and getting along with others and is tied to a group interest. And lastly the emotional stability factor of the Big Five refers to a person's ability to be stable all or most of the time and not be easily changed emotionally.

2.2 Frameworks and Training for Ethical Decision-Making

2.2.1. Ethical Frameworks in cybersecurity

Ethical frameworks for cybersecurity provide us with the ability to analyze the ethical issues that arise in the context of cybersecurity (Loi & Christen, 2020) . For that purpose, we used a principlist framework that has been proposed for the cybersecurity domain by Formosa et al. (2021). While there are other principlist frameworks that could be applied to cybersecurity ethics (e.g. van de Poel & Christen, 2020; Loi & Christen, 2020;

Weber & Kleine, 2020; Morgan & Gordijn, 2020), we adopt this framework here because it clearly highlights the ethical issues raised by cybersecurity, builds upon previous work in this area, and avoids principle proliferation by re-using ethical principles that are widely used in cognate fields (Formosa, Wilson et al. 2021). The framework consists of five ethical principles. Those principles are beneficence (cybersecurity technologies should enhance human lives), non-maleficence (cybersecurity technologies should not be used to harm individuals' lives), justice (cybersecurity technologies should improve fairness and provide impartial access for all), autonomy (cybersecurity technologies should not limit users' choices of applications) and explicability (cybersecurity technologies should be both understandable and accountable clearly for their functioning). These principles are modeled on the five AI4People principles (Floridi et al., 2018) for ethical AI, which are in turn an extension of four well-accepted ethical principles from bio-ethics (Beauchamp & Childress, 2001). Our adopted framework provides a novel and relevant approach to understanding ethical issues in cybersecurity.

2.2.2. Serious game in cybersecurity

Serious games help to increase the effectiveness of training (De Freitas & Jarvis, 2007) by providing hands-on practical experience by replicating a real-time environment in an artificial virtual environment. According to Gino et al. (2009), reminding people about ethical behavior and/or observing others' ethical behaviour may change their own ethical behaviour, such as their honesty. Serious games can also help to achieve this goal.

There are several serious games developed to help the user to understand different aspects of cybersecurity. CounterMeasures (Jordan et al., 2011) is a text and command base game designed to teach about computer security. The game helps the user to learn and apply computer security skills through guided objectives, such as scanning a remote system given an IP address. CyberVR (Veneruso et al., 2020) is another attempt to increase user awareness of cybersecurity-related issues using virtual reality technology. CyberPhishing (Hale et al., 2015) is a serious game focused on raising awareness related to Phishing attacks. AWATO (Ferro et al., 2022) is

a role-playing serious game that teaches participants about cybersecurity vulnerabilities. They created a threat model for issues that arise due to human factors. The game focused on minimizing human error by identifying the factors influencing decision-making, including lack of knowledge, lack of resources, lack of awareness, norms, and complacency.

We see that games in cybersecurity have been created that offer a wide range of training to teach cybersecurity issues and challenges. There are also several games that have been developed for teaching ethics, such as Global Conflicts, Cooking Mama: Mama Kills Animals (Pereira et al., 2012). Global Conflicts is a series of games that focus on social awareness and ethics. Cooking Mama focuses on ethics by raising awareness about the cruelty involved in animal-based food production. Serious games are also used for corporate training (Larson, 2020) and ethics in IT design (Urquhart & Craigon, 2021). However, we did not find any game that focuses on teaching the ethical aspects of cybersecurity issues. To address this gap, we have developed a serious game designed to train users to consider the ethical aspects of decision-making in cybersecurity. The game and our evaluation of its ability to improve ethical awareness and decision-making are described in the next section.

3. METHODOLOGY

An online study called "V-Meet Cybersecurity" was conducted in week 13 of the first semester of 2022 at Macquarie University with the approval of the University's Human Research Ethics Committee. The main aim of this study was to raise participants' awareness of the ethical principles underlying common decision-making in cybersecurity contexts using a serious game. To measure the success of our game, we asked participants to respond to two cybersecurity-related scenarios: one before playing the game (pre-test) and one after playing the game (post-test). With the help of this approach, we were able to capture if the ethical knowledge of an individual increased after playing the game. The game provides a training medium where non-player characters (agents) present different ethical choices and issues through dialogue. The dialogues were created from the cues available in the literature. The player also had to respond to those agents by selecting choices that match the user's personality and ethical choice.

The study, including the game, was accessed via a survey developed in the Qualtrics research survey software.

3.1 Recruitment

The online study was conducted with undergraduate students enrolled in the course "COMP1300– Introduction to Cyber Security" at Macquarie University. Students participated during their scheduled tutorial class in the final week of the semester. Students were provided with information about the study and asked for voluntary consent to include their data for research purposes. A total of 272 students commenced the study.

3.2 Materials: V-Meet Cybersecurity ethical training Game

This is a short serious game developed to simulate a cybersecurity organization in which the player acts as Alex who is starting a new job as Lead Security Analyst at a cybersecurity firm, *Prescott and Kruger*, next week. The player (i.e. Alex) has agreed to sit in on a couple of video calls with Marielle, the CTO, and the current acting Lead Security Analyst, to meet some of the new team members and discuss some of the important decisions. The flow of the game is represented in Figure 1.

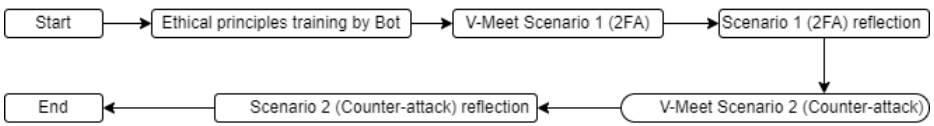

Figure 1: V-Meet Game Flow

The game starts with a conversation between Alex (the Player) and the player's assistant in a text messaging application (which can be viewed in Figure 2). The assistant guides the player through the initial training which is essential for every new employee. The ethical principles training is conducted by Ethbot (a virtual Ethical Training Bot) which guides players through learning about our five ethical principles (Beneficence, Non-Maleficence, Justice, Autonomy, Explicability) in cybersecurity. To complete

the training process, Ethbot tests the player's knowledge of the ethical principle they have learnt by providing an ethical scenario and asking the player to identify the principle that is most applicable. The player receives feedback and multiple chances to get the correct answer. After completing the ethical training, the player continues with routine official tasks in the game and takes part in the first video meeting using the V-Meet app. We discuss this in detail below.

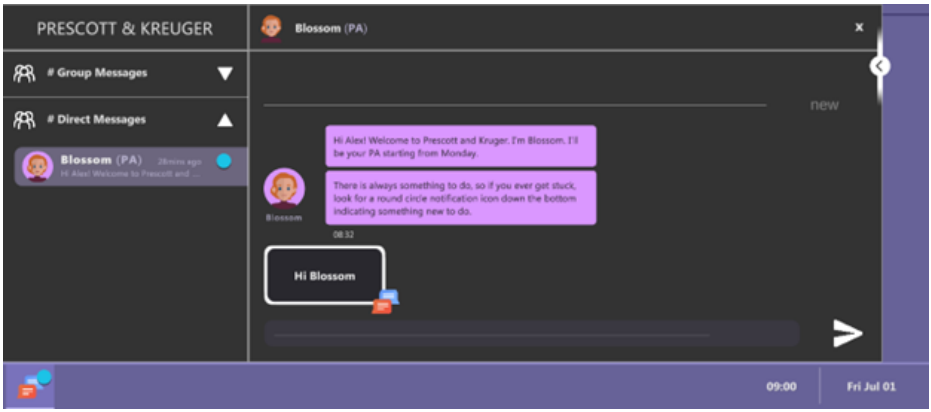

Figure 2: Text Messaging Application

3.2.1. V-Meet Scenarios and Agents

The game presents two scenarios to the player as video meetings: 2-factor authentication (2FA) and cyberattack. The 2FA scenario is presented in Figure 3. The outcome of this discussion is having to decide whether to implement the 2-factor authentication policy or not.

You are a customer of a popular cloud storage provider that provides you with an online space to save your data. The provider sends an email informing its users that in 3 weeks all users will have to nominate a mobile phone number to use with 2-factor authentication (2FA). The 2FA will use a combination of existing passwords and 1-time use codes delivered via SMS to improve the security of its authentication. The cloud storage provider updates their terms of use requiring all users to utilize 2FA or their accounts will be inaccessible for usage. Since you regularly need to access data on the cloud you face a choice. Providing a phone number will maintain access and improve the security of the service, but will also require you to share sensitive personal information (i.e., your mobile phone number) that raises privacy considerations. Not providing your Mobile phone number will avoid these privacy concerns, but result in you losing access to the shared documents from the storage provider.

Figure 3: 2FA scenario

Both the 2FA and cyberattack video meetings include three agents (non-player characters). Each agent is high or low in each of the five personality traits. Also, each agent considers each of the five ethical principles to be of low or high importance to them. One of the NPCs is Shiva who is a Coder/ Penetration Tester at Prescott & Kreuger. She is passionate about her work; her single-minded focus means she will often rush to complete tasks without planning. Though perfectly cheerful and open with her family, Shiva is a lot more distant with coworkers. Shiva's personality traits and ethical influences are provided below. Her avatar, personality scores, and ethical influences can be seen in Figure 4. Each character has a set of numerical values representing ethical principles. Ethical principle values range from -2 to +2. The characters are designed keeping in mind that each character should be strong (positive and negative) on some principles and relatively neutral on some principles. The same approach is used to define an agent's personality. Ranging from 0-100, a high and low score in any personality trait shows that the agent is high or low in that specific personality trait. For example, a high score in agreeableness means that the agent is highly agreeable and vice versa.

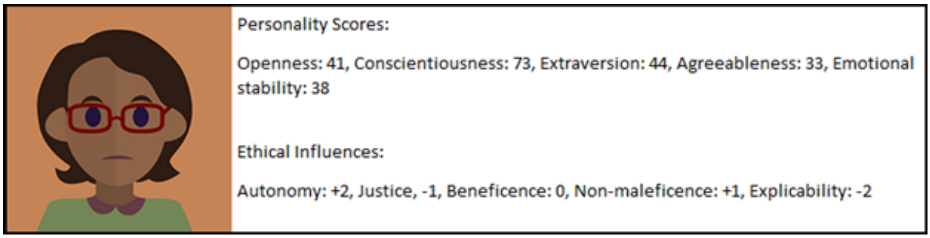

Figure 4: Shiva Avatar and Profile

To depict a human-like behavior in the agents, lip syncing of the dialogue and facial expressions were also embedded with the agent's interaction. For example, if something goes against the agent's principles, the agent makes a sad face. The game is particularly designed for a new employee in a cybersecurity organization who can then implement these principles in their subsequent decision making.

During their first video meeting in the 2FA scenario, the player and the other 3 agents (non-player characters) are discussing the implementation of a new 2-factor authentication policy in the organization. As programmed, the agents react to different situations as per their different personalities. The player participates in the dialogue by responding to questions asked by any agent in a variable period during dialogue. The player has a choice to select between two options for each question. Each option shows the opposite personality trait and/or ethical choice, so the selection of the answer depends upon the player's personality type and the player's ethical principle inclination. An example of a V-Meet application is found in Figure 5 which shows the characters talking to each other and the set of options which are provided to the player to provide their input.

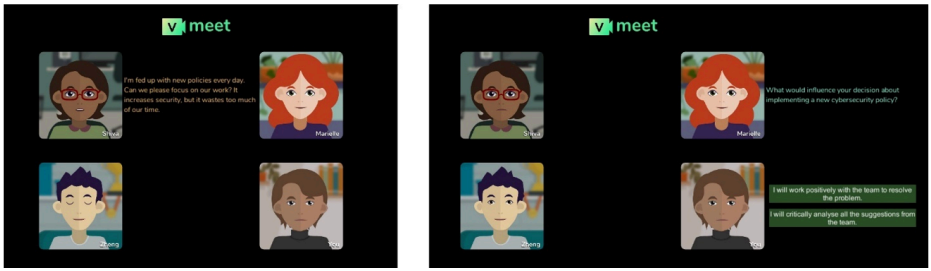

Figure 5: V-Meet Dialogue

A snippet of the agents' dialogue discussing the 2FA scenario is shown in Figure 6. In the given code snippet, it can be observed that Zheng is agreeing that 2-factor authentication is a good policy from his sentence "Seems like a good initiative", which shows that he has a high score in agreeableness. The blue highlighted area of the dialogue shows that Zheng is open to new experiences. Zheng regards the beneficence ethical principle as highly important, and this can be seen from the underline with 2 as a superscript that clearly shows that Zheng is oriented towards the principle of Beneficence.

Zheng:

The 2-factor policy seems like a good initiative. It is good idea to try implement this new policy in our company.
I hope it will benefit us and our clients[2] by increasing our security. As a Security Analyst, I believe this is a great step toward increasing the security of employees'[2] accounts.

Marielle:

Shiva, I've given careful consideration to what you are talking about. But I think, eventually we will have to strictly follow the company's policies. The email I received stated that failing to provide a personal mobile phone number will result in losing access to shared documents from our storage provider. And providing your phone number will also improve security.

Figure 6: 2FA Dialogue Snippet

3.2.2.Reflection Statements

After participating in each V-Meet meeting with other agents, the player

responds to a set of ten reflection statements. The reflection statements were used to analyze the player's ethical perspective on the decision taken by them in that dialogue. There were a total of ten reflection statements after each dialogue, two statements for each ethical principle. Five out of the ten statements were opposite to the decision the player took in the scenario and five statements were in favor of their decision. For example, the player will see two statements for the ethical principle 'Autonomy' in the 2-factor implementation scenario, with one statement in favour of implementing the policy and the other autonomy statement not in favour of implementing the policy. The player was asked to give thumbs up for a statement if the statement supports their decision and thumbs down if the statement is against their decision. The player also had to label each statement with the relevant ethical principle. A star is used to indicate the player's most important statement in support of their decision, and the bin is used if the player thinks that a statement was not relevant to their decision-making (as shown in Figure 7). The player can also click on Ethbot (bottom left) to remind them about the five ethical principles and to help them provide better reflections. The reflection statement was also used to answer our research question. From these results, we were interested to know if the player could correctly identify which ethical principle applied to each reflection statement.

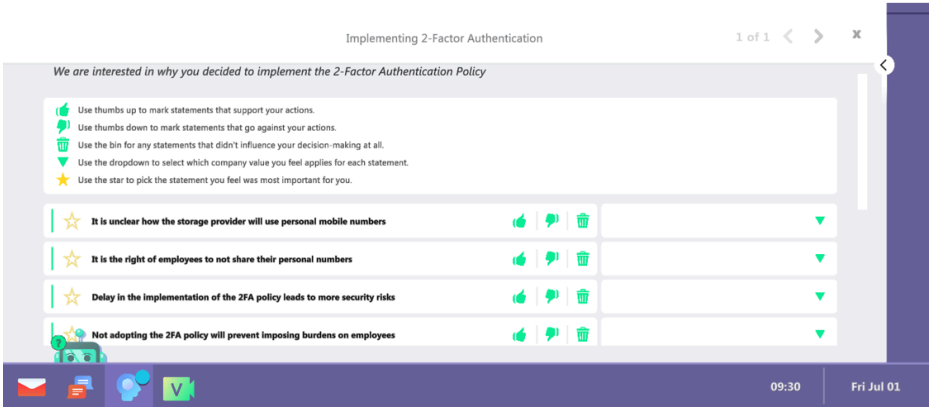

Figure 7: Reflection Statements to apply the ethical principle in different scenarios

3.2.3.Pre and Post scenarios

We designed two written cybersecurity ethical scenarios other than the two scenarios played in the game. The player had to respond to one scenario before playing the game and respond to the other scenario after playing the game. The player was provided with two options to choose from in each ethical dilemma. One scenario was about releasing an ethical worm to employees' computers to force automatic updates (Figure 8) and the second scenario was about undertaking a password hack to identify employees with poor passwords (Figure 9). The participants were divided randomly and evenly into two groups. Group 1 received scenario 2 first and group 2 received scenario 1 first for their pre-test. The reason behind randomizing the scenarios was to ensure that the participants' responses had nothing to do with which scenario was provided first. After taking the decision, the player was given the option to justify their answers. From their justifications, we aimed to answer our research question by determining if their ethical awareness increased after playing the game. This also allowed us to know whether the participant took into consideration our five ethical principles, or ethics more generally, when making their decision.

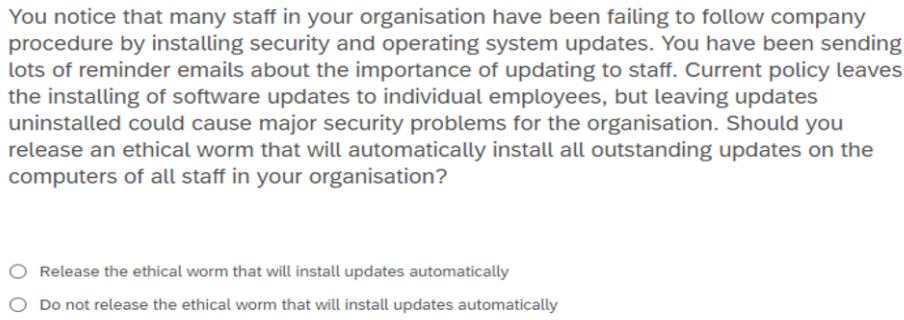

Figure 8: Scenario 1 (Pre/Post Test Scenarios)

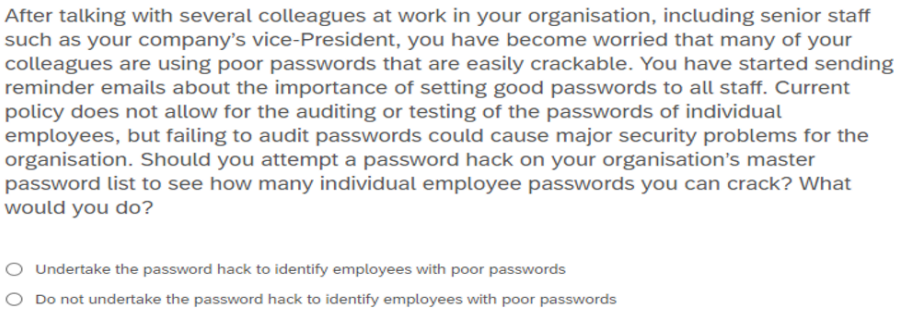

Figure 9: Scenario 1 (Pre/Post Test Scenarios)

3.3. Data Collection and Procedure

After providing consent, participants answered a set of demographic questions (age, gender, cultural background, and area of study). Then they answered questions concerning their knowledge of ethics using a 5-point Likert Scale (1=Terrible, 2=Poor, 3=Average, 4=Good, 5=Excellent), followed by completion of the Ten-Item Personality Inventory (TIPI) (Gosling et al., 2003) to capture the individual's personality traits. The scale has ten items to measure the five personality traits of Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Emotional Stability. The scale uses a 7-point Likert Scale (1=strongly disagree, 7=strongly agree).

To measure the change in ethical awareness before and after playing the game, we conducted a pre- and post-test involving the two scenarios described in Section 3.2.3. After completing the pre-test scenario, participants took a link in the survey to the game which passed an anonymous user ID to the game. After playing the game, participants completed the post-test scenario. Finally, we asked players whether their understanding of ethical principles increased by playing the game, and questions about their competency in the game and the intuitiveness of the game. The player responded to these questions using a 7-point Likert Scale (1-Strongly Disagree, 7-Strongly Agree).

3.4. Data Analysis

We calculated descriptive statistics (mean and standard deviation) and performed other statistical tests, such as the T-test to find any significant difference between pre- and post-test results. We used $p<0.05$ to determine the statistical significance.

To answer our research question, we aimed to identify whether the player was able to identify the ethical principle associated with the given ethical scenario. For that purpose, we used the reflection statements described in section 3.2.2. Correctly identifying the ethical statement shows that the player can identify the ethical principles in different scenarios and thus can apply those principles outside the training context. We excluded the statements nominated as irrelevant by the player and then found the average correctly identified from the remaining statements.

To determine a change in the ethical reasoning of participants, we coded their pre and post-test responses to two different ethical cybersecurity scenarios before and after playing the game. We capture how participants responded to those scenarios and analyzed the results using the t-test to determine any significant differences in the mean responses in their pre and post-test results.

To analyze the players' justifications used in the pre- and post-test scenarios, we encoded their justifications using the following coding scheme. Initially, six codes were created to categorize participants' responses. This coding scheme allowed us to categorize the given participants' text justifications about the decision they had taken in pre- and post-test scenarios. For example, they justified why they decided to release the ethical worm in an ethical worm scenario. We were interested to see if participants considered ethics in their decision-making or not. We grouped codes 2, 3 and 4 as ethical responses and 1, 5, 6 as others. This coding scheme was then further simplified to three codes (0,1,2). In order to calculate paired t-test we needed response to both the pre and post-test.

1. No answer or irrelevant answer was given – unrelated to the scenario or rubbish

2. They used at least one of our ethical principle terms (Autonomy, Justice, Beneficence, non-maleficence, explicability)
3. They used the word "ethics" or derivatives (e.g., ethically)
4. They discussed ethics in general, without using one of our particular words or terms
5. They chose to act in that way due to policy
6. Relevant answer was given, but did not refer to ethics

Simplified Coding Scheme:

1. No answer or no irrelevant answer – unrelated to the scenario or rubbish
2. Discussed ethics in general or used any ethical principle term [Combining 2,3 and 4]
3. Relevant answer, but did not discuss ethics at all [Combining 5 and 6].

4. RESULTS

A total of 272 participants took part in the online study conducted through Qualtrics. Out of the 272 participants, 40 participants didn't give consent to use their data. We therefore excluded their data from further analysis. After careful consideration of all the responses, we excluded all the invalid attempts. We considered responses to be invalid if the data in the survey response was too low, such as if they had only completed 10 percent of the survey, which means they had only answered the demographic questions. Moreover, a response was also invalid if we found a similar pattern in choice selection, such as the user always choosing option number 4 in all the questions. After excluding such responses, the total number of valid responses left for further analysis was 219.

Among those 219 responses, 153 (69.86%) responses were 100 percent complete and answered all the questions. 49 (22.38%) responses completed less than 50 percent of the survey, and 17 responses (7.76 %) completed the survey between 50 to 94 percent. 200 participants played

the game that was embedded inside the survey questionnaire. 19 participants did not play the game at all. Of the 200 participants who played the game, 92 (46%) participants completed the game, and 35 participants (17.5%) played the game but left the game before the start of the first V-meet scenario. Player logs reveal 102 attempts to play both scenarios in the game, which is 51% of the players who played the game. 25 players (12.5%) completed only the first scenario and left the game afterward. 19 players (9.5%) started responding to the first scenario but left before completing it, and the same number of participants completed the first scenario but did not complete the second scenario and left before completing it. We retained the data for those participants who played the first scenario and responded to the reflection statement as this data provides a full scenario cycle that was useful for analysis.

4.1. Participant's demographic information:

152 participants had Computing as their major area of study, which was 69.41% of the total population. 31 participants (14.16%) had Business, 15 (6.85%) had Arts, and two (0.91%) had Psychology as their major area of study. The remaining 19 (8.68%) included people having other areas of studies or combining two major areas such as Computing and Arts, Business and Computing, Cybersecurity, Software engineering, Information Technologies, Clinical Science, and Actuarial.

There were 62 female and 153 male participants, which were 28.31% and 69.90% of the total participants respectively. Only one participant selected the other option and identified as "Gender Fluid" and three participants didn't identify themselves with any gender. Participants were aged from 17 to 50 with an average age of 20.05 years. There were nine cultural groups to which the participants indicated they belonged. Participants were able to select more than one cultural group if they identifed themselves with more than one cultural group. Table 1 presents the cultural group with which participants identified themselves. Computing is the major area of study of the participants as shown in Table 2. Participants were asked to rank their knowledge about ethics in IT from values 1 to 5 (1=Terrible, 2=Poor, 3=Average, 4=Good, 5=Excellent) (mean 3.59). On average, participants

reported playing video games 2.75 hours per week. Personality scores are given in Table 3.

Cultural groups	Total	Percentage
Oceania (including Australian)	88	40.18%
South-East Asian	42	19.18%
Southern and Central Asian	22	10.05%
North-East Asian	12	5.48%
Northern-Western European	6	2.74%
Southern-Eastern European	7	3.20%
North African and Middle Eastern	15	6.85%
Sub-Saharan African	2	0.91%
People of the Americas	1	0.46%
Oceania & Northern-Western European	1	0.46%
Oceania & Southern-Eastern European	1	0.46%
Oceania & North African and Middle Eastern	1	0.46%
Oceania, South East & Central Asian	1	0.46%
No answer or do not identify	20	9.1%
Sum	**219**	**100%**

Table 1: Cultural Group Distribution

Main area of study	Total	Percentage
Computing	152	69.41%
Psychology	2	0.91%
Arts	15	6.85%
Business	31	14.16%
Others	19	8.68%
Sum	**219**	**100%**

Table 2: Participant's Area of Study

Personality traits (scale 1-7)	μ	SD
Extraversion	3.69	1.43
Agreeableness	4.51	1.00
Conscientiousness	4.70	1.18
Emotional Stability	4.43	1.37
Openness to Experiences	4.98	1.01

Table 3: Mean and Standard Deviation for TIPI

4.2. Pre and Post-test results

Table 4 provides the results comparing the pre- and post-test coded responses. This test is comparing each individual player's justification for their decision to the text-based scenarios provided before and after playing the game to see if their response has changed or not in terms of the use of ethical considerations.

	Pre-game			Post-game			
Scenario order	Ethical	Other	Total	Ethical	Other	Total	*P-value
Password Hack First	46	25	71	52	19	71	0.112
Ethical Worm First	44	27	71	56	15	71	0.007
Sum	90	52	142	108	34	142	0.004

Table 4: Pre and Post-Game Test Analysis using Paired T-test

4.3. Identification of the in-game ethical scenarios

A summary of correct responses to the reflection statements is shown in Table 5. Each player had to complete a reflection statement twice, once after the 2-factor authentication and again after the counter-attack scenarios. 92 participants (71.32 %) responded to both reflection statements and 37 participants (28.68%) only took part in the first set of reflection statements. Of the 129 participants who took part in the reflection part of the game, we found that 19 participants (14.73%) correctly identified less than 25 percent of the reflection statements, 72 participants (55.81%) identified less than half and more than 25 percent of the statements, and 38 (29.46%) correctly identified more than half of the reflection statements. We exclude those statements that were not answered by the participants.

Total no of participants	Percentage	% Of correctly identified statements
19	14.73	<25 %
72	55.81	25-50 %
38	29.46	> 50 %

Table 5: Correct identification of the Reflection Statements

Table 6 shows the number of times each ethical reflection statement had been correctly identified by the players. More players were able to correctly identify the statement related to Beneficence. On average, statements related to Beneficence and statements related to Justice were mostly identified correctly in the 2FA and counterattack scenarios, respectively. We saw some improvement in identifying the statements related to Justice. This can be found by taking the average of Justice-1 and Justice-2 in 2-FA (35.27%) and Justice-1 and Justice-2 from the counterattack scenario (51.09%). The improvement was 15.82 percent. Statements that were least identified correctly by the players were about Autonomy in the counterattack scenario as these statements were identified correctly only 16.85% times.

2-FA			
Ethical Principle Statement	N	Correct identification	
		N	%
Non-maleficence – 1	129	28	21.71
Non-maleficence – 2	129	43	33.33
Beneficence - 1	129	81	62.79
Beneficence - 2	129	37	28.68
Autonomy - 1	129	60	46.51
Autonomy - 2	129	28	21.71
Justice – 1	129	54	41.86
Justice – 2	129	37	28.68
Explicability - 1	129	56	43.41
Explicability - 2	129	39	30.23

Counterattack			
Ethical Principle Statement	N	Correct identification	
		N	%
Non-maleficence - 1	92	31	33.70
Non-maleficence - 2	92	20	21.74
Beneficence - 1	92	50	54.35
Beneficence - 2	92	23	25.00
Autonomy - 1	92	11	11.96
Autonomy - 2	92	20	21.74
Justice - 1	92	49	53.26
Justice - 2	92	45	48.91
Explicability - 1	92	29	31.52
Explicability - 2	92	25	27.17

Table 6: Frequency of correct identification of each reflection statement

4.4. Player experience

Mean and Standard Deviations for the player experience questions can be seen in Table 7. The results show that a greater number of participants thought that their understanding of the ethical issues in cybersecurity was improved after playing the game.

Reflections	**M**	**SD**
I felt competent at playing the game	5.31	1.43
The game was intuitive and easy to play	5.16	1.55
This game improved my understanding of the range of ethical issues raised by cybersecurity.	5.21	1.41

Table 7: Player Experience

5. DISCUSSION

As discussed above, 93% of cybersecurity breaches were caused by human error (Dunn, 2014). Not considering ethics in decision making is one of the causes of human error (Mohamad et al., 2005). Thus, providing training about considering ethics in decision making will reduce the cybersecurity breaches and this is the main contribution of the proposed game. We aimed to raise awareness of ethical reasoning in cybersecurity decision-making. To provide NPCs that helped players consider different viewpoints based on the importance of the five ethical principles and personality factors, we designed agents that had different personality behaviors based upon the Big Five personality model (Extraversion, Openness to experience, Consciousness, Emotional stability, and Agreeableness) and could provide different ethical perspective based upon five ethical principles (Beneficence, Non-Maleficence, Justice, Autonomy, Explicability) in the context of cybersecurity. The agents were embedded in a serious game to provide alternate ethical perspectives to increase the ethical awareness of the players. The goal of our study was to determine if interacting with the agents increased the player's knowledge about and awareness of ethical principles and how they impacted on cybersecurity issues and decision-making.

We recruited students enrolled in a first year cybersecurity unit, as these students will become IT professionals in the future, and we want to sensitise them to ethical thinking from the outset of their education and training. We observed that the gender imbalance in our study 69.90% (male) and 28.31% (female) corresponded with the gender imbalance in the technology industry, as reported by CompTIA (2020) the gender ratio in technology is 68% male to 32% female, which is very close to our gender ratio. The personality profiles of the cohort were not widely diverse. Extraversion has 1.43 SD, SD of agreeableness is 1.00, Conscientiousness has 1.18, emotional stability has 1.37 and openness has a standard deviation of 1.01. In general, we could characterize the cohort as tending towards introversion, agreeableness, conscientiousness, emotional stability, and openness to new ideas.

Answering our research question and study aim, the pre- and post-scenario

results show that, overall, there was a significant ($p < 0.01$) increase in ethical reasoning (12.68%) after playing the game. The results in Table 4 reveal that 63.38% of participants who responded to the pre-test scenario mentioned ethical issues, whereas 76.06% of participants mentioned ethical issues in justifying their response to the post-test scenario. Further, there were 33 (23.24%) participants who went from mentioning no ethical issues in the pre-test to mentioning ethical issues in the post-test. We provided two different scenarios to avoid learning effects (Georgiev, 2018; Wright, 1936) or other bias from using the same scenario twice. We note that regardless of which scenario was received first, the number of players expressing ethical reasons for their decision increased for both scenarios, but only the group that received the ethical worm scenario first significantly changed their reasoning. Possibly participants found it easier to identify ethical concerns with the password hack scenario than in the ethical worm scenario (this is supported by a higher incidence of ethical responses whether it was received first or second). The scenario differences demonstrate the difficulty of designing equivalent scenarios and the contextual nature of ethical reasoning. Further, according to (MOSHER, 2018) 90% of the small business owners and employees are worried about password hacks and 96% are concerned about viruses such as malware, worms, etc. But according to Spafford (1991), some people claim that some viruses are beneficial, such as ethical worms, but more people consider them as dangerous. According to these numbers, we can say that our results confirm that people seem to be more familiar with the concept of password hacking than ethical worms.

We further evaluate the knowledge of the player by providing reflection statements. The results of the reflection statements show that a large number of participants were able to recognize the ethical dilemmas and which ethical principle is best applied in this dilemma. Our analysis showed that nearly 30% could correctly identify half of the statements and principles correctly. This indicates that there is low familiarity with the application of ethical principle in cybersecurity decision-making. This encourages us to develop more effective training for ethical principles in our future studies and also identifies a need for cyber security professionals and researchers to focus on this area. Lastly, the participants acknowledged that the game was easy to play, and increased their

knowledge. Analysis of the 97 out of 142 participants who reported an increase in knowledge with their correct identification of the principles in the reflection statement and the post-test reported that 18 (18.56%) responses shifted from "other" to ethical, which supports their claim of increasing ethical knowledge. Moreover 44 (45.36%) of those participants were able to correctly identify more than 30 percent of reflection statements.

6. CONCLUSION, LIMITATIONS AND FUTURE WORK

We developed a serious role-playing game to help users to consider the ethical features of their cybersecurity decisions. The awareness of ethical principles was provided with the help of artificial agents that acted as cybersecurity professionals and provided their differing ethical perspectives. We conducted a study to analyze the impact of our game on the ethical awareness of participants. Our results verify the literature finding that observing the acts of other individuals can change one's behavior. According to our results, 12.68% of individuals shifted from a non-ethical to an ethical response when responding to our pre- and post-test scenarios after playing the game. This shows that our game has potential to educate cybersecurity professionals to become more aware of ethical principles and their application in their decision-making. The participants also acknowledged that the game increased their knowledge of cybersecurity ethics.

We acknowledge some limitations of our game and our study and we plan to address them in future studies. Firstly, the difference between participants pre- and post- test results and their player experience results might be because of the Acquiescence bias (Ross & Mirowsky, 1984), as the question was very straightforward and shows the aim of the study conducted so people tend to agree with the statement as this is easy way out. So, the player experience question could be improved to allow the participants to choose their own answer without any bias.Currently the agents designed in our game depict the personality and ethical inclinations separately. We aim to find the relation between personality and ethical inclinations so that more realistic agents can be designed. Moreover, the agents need to be dynamic and change their mental state according to

the needs of the environment or other agents. For example, an agent could observe if a player is low on a specific ethical principle and then provide tailored training or perspectives to that agent on that specific ethical principle. To create more realistic non-player characters (agents) in serious games, agents should be able to respond to organizational norms and policies (Dignum et al., 2009). Multi-agent interaction and communication (Dignum et al., 2009) is thus another milestone we aim to achieve to design more intelligent agents in serious games in a cybersecurity ethics context.

As far as our study is concerned, the types of participants recruited for the study was a limitation. All the participants were university students enrolled in the course of "Introduction to Cybersecurity". This is justified since these students were future cybersecurity professionals and providing them with training in ethics was vital. However, a wider range of participants should be recruited, ranging from early-stage students to experts in the domain of cybersecurity. Moreover, as reported in the results section, 92 participants were able to complete the game. It is unclear why other participants left the game before completing. This might be because they had less time to play the game and they wanted to return to the remaining part of the survey before the time ended as they only had 30 minutes in class to complete the game and study survey.

This is our first step in including agents in a serious cybersecurity game and we aim to make our agents more intelligent so that they can adopt the dynamic behaviors and reflect other agents accordingly. This should make the training even more effective training through using more intelligent agents. We plan to explore whether longer gameplay and more scenarios and reflection or multiple play sessions could make the game even more effective.

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CHAPTER 8

Serious Games, Stealth Interventions and Accounting Ethics

A reflective essay

DALE LINEGAR; GILLIAN VESTY; AND EVA TSAHURIDU

ABSTRACT

With the accounting profession actively seeking new ways to enhance ethics training in higher education as well as foster the ethical sensitivities of practicing professionals, there are mixed views on the effectiveness of current ethics training programs. It is generally believed that ethics training for practicing accountants is more effective when participants can have immersive experiences with ethical dilemmas in a natural setting. To date, enhanced immersive training experiences have largely been achieved through hypothetical scenarios, rather than real settings.

The argument for this paper is in the use of a newly designed serious game of ethics, Bogart, to provide players with an immersive and potentially impactful real world experience. Providing immediate feedback is a distinctive feature of serious games, which enables players to ascertain the consequences of each of their decisions. This is a particularly useful feature for ethics education. However, unlike most other games Bogart uses stealth interventions and misplaced rewards. While these were intentionally designed to add a further pedagogical dimension to the context and bring about interesting consequences, there were outcomes

that we had not foreseen. In this paper, we provide a personal narrative of the design choices and implications that only became obvious in the pilot testing phases and beyond. We draw on Kaufman and Flanagan's (2015) 'embedded design' approach to serious games design and the business ethics literature to reflect on the consequences of the design choices we made whilst developing Bogart.

While the game design choices followed pedagogically appropriate and peer-reviewed pathway techniques, we still encountered numerous implementation issues and a number of unintended ethical consequences.

INTRODUCTION

The field of business ethics and ethical decision making is receiving increased attention. Particularly, given the propensity for corruption and evidence of unethical corporate behaviour and illegal activities of individuals throughout the world. Fraud and corruption brings enormous costs, to not only consumers, employees, suppliers, shareholders, but all business and societal stakeholders. Efforts to mitigate this behaviour includes tightened legislation, increased surveillance, whistleblowing policies and ethics education. The accounting profession is active in monitoring accounting irregularities and unethical business behaviour through standard setting, auditing practices and codes of practice that guide professional accountants. Accounting educators argue that ethics training is essential in higher education (HE) and practice (Jackling et al., 2007; Ariail et al., 2020) and can impact the ethical sensitivity of graduates and practicing professionals (Martinov-Bennie and Mladenovic, 2015), particularly when combined with a positive work environment (West, 2017). Nevertheless, while ethics training might support students' awareness and ethical intentions, there are mixed views on the effectiveness of ethics training programs (Pierce and Sweeney, 2010; Cameron and O'Leary, 2015; Arfaoui et al., 2016). It is generally believed that ethics training for HE students, graduates and practicing accountants is more effective when participants can have immersive experiences with ethical dilemmas in a natural setting, however to date, enhanced immersive training experiences have generally been achieved through

adding detailed storylines in case study vignettes or hypothetical scenarios (Nguyen and Dellaportas, 2020).

In this paper, we argue that serious games can add value to ethics training by the way their digital gamified techniques are wrapped around pedagogical content and clever storylines that expose students to complex wicked problems. In communicating difficult subjects through a unique medium, serious games are ideal "for reflecting on social, ethical and political questions" (Darzentas & Urquhart, 2015, p.805). Serious games offer "a rich field for a risk-free, active exploration of serious intellectual and social problems" (Abt, 1987, p.13). We draw on Schwartz's (2016) ethical decision making processes and the serious games design choices that effect behavioural change. In particular, we use Kaufman and Flanagan's (2015) 'embedded design' framework of *intermixing*, *obfuscating* and *distancing* interventions in gameplay design, in the development of Bogart, our serious game of ethics.

We provide a narrative of experiences that reflect on the ramifications of our stealth design choices during the Bogart build and pilot testing phases. In revealing the potential effectiveness of this game in practice, we offer contributions to research, theory and practice along with numerous areas for further research.

LITERATURE REVIEW

Serious Games Design Features: Ethics, Stealth and Attitude Change

Serious games provide a unique pedagogical approach to help students build knowledge while joining in an immersive gamified quest for solutions. They also help address growing concerns in education for contextualised designs that can be used in 'authentic assessment,' which is assessment that requires students to "use the same competencies, or combinations of knowledge, skills, and attitudes, that they need to apply in the criterion situation in professional life" (Gulikers, Bastiaens and Kirschner, 2004, p.69). Serious games achieve experiential learning by allowing learners to perform tasks which are directly related to real-world practices (Herrington, Reeves & Oliver, 2013). That is, serious games can introduce

and prepare students for situations and challenges that they might never face (e.g. military, defence or aerospace maneuvers, healthcare crises or Enron-type corporate collapses), and can be used as part of routine training, before being let loose on expensive equipment, real patients or businesses. In addressing associated issues of engaging large numbers of students in the workplace for work-integrated learning (WIL) experiences, serious games can offer an individualised learning experience for large numbers of learners (Scavarelli & Arya, 2014). Contextualised design features enable individualised learning whereby each player/student can make decisions which result in storyline and gameplay consequences as a result of their unique pathway choices.

Serious games can add value to ethics education by teasing out the single normative rationalist-based reasoning, that might be a typical response in a training context or vignettes or hypothetical research survey scenarios, to embrace more non-rationalist-based responses involving intuition and emotion that intervenes in the drive to decision making. Serious game designs can engage the moments of interaction between the rationalist and non-rationalist approaches, and reveal a more nuanced 'integrated ethical decision making' approach (Schwartz, 2016). This gameplay feature gives the player time for reflexive contemplation (e.g. drawing on both rational and non-rational responses) which is critical in influencing ethical judgement and subsequent intention to act on that judgement. Importantly, serious games can capture the reflexive moments before the actual (un)ethical decision is made, providing far richer experiences than reading vignettes and responding normatively on opinions relating to ethical intentions or perceptions of what one might do in a given situation.

Design choices can also seek to tease out cultural nuances and/or sensitive issues that can be used to further enhance reality. This benefits the player (student or professional) who is rewarded with immediate real time feedback on their actions, providing a safe setting in which to experiment. The serious game can also benefit the academic researcher with the output of the serious game, a rich body of data on the reflexive actions of players.

In somewhat playing to the non-rationalist approaches in ethical decision making, Kaufman and Flanagan's (2015) 'embedded design' approach to serious games design claims that the use of *intermixing*, *obfuscating* and

distancing interventions are key to bringing about attitude and behaviour change. The logic behind these strategies is that often information alone isn't sufficient to bring about positive behavioural change and can often have the opposite effect (Cialdini et al., 2006). They also acknowledge that signalling the intent of an intervention, in targeting unconscious processes can diminish their efficacy (Kaufman and Flanagan, 2015). The three strategies devised by Kaufman and Flanagan (2015, p.3) are:

> (1) Intermixing: balancing "on-message" and "off-message" content to render the former less overt or threatening
>
> (2) Obfuscating: using framing devices or genres that divert expectations or focus away from the game's persuasive intent
>
> (3) Distancing: employing fiction and metaphor to increase the psychological gap between players' identities and beliefs and the game's characters and persuasive content.

The logic behind these strategies is that often information alone isn't sufficient to bring about positive behavioural change and can often have the opposite effect (Cialdini et al., 2006). That is, similar to the normative approaches to ethics training, the signalling associated with the intent of an intervention that targets a player's unconscious processes can actually diminish the efficacy of serious games (Kaufman and Flanagan, 2015). Kaufman, Flanagan and Seidman (2016, p.8) argue that "persuasive games that overtly telegraph their intended purpose of shifting attitudes and mindsets are likely triggering mindsets in players that hinder the game's enjoyability and blunt its potential positive impact." Sicart (2009) warns that the idea or right/wrong in game design needs more consideration and that the implicit or ignored values are really important serious game design features and require further research to correctly embed in practice.

We argue that serious games' design approaches in accounting pedagogy are improved when rationalist moments are integrated with non-rationalist moments in ethical decision-making (Schwartz, 2016). Their effectiveness is achieved by drawing the player to reflect on their gut-intuition-based reasoning, along with using other techniques proposed by Kaufman and Flanagan, (2015). For example, Kaufman, Flanagan and Belman (2015) found a metaphorical, zombie-themed infectious disease serious game

was more effective than one with real-life individuals. Flanagan and Nissenbaum (2014) similarly advise designers to contemplate the intended and unintended design features and the value-based touchpoints in serious games design which require designer attention. Together, this background opens up ideas for different design choices when addressing academic and industry calls for improved accounting ethics training with enhanced immersive experiences.

While the success of the digital pedagogy is directly related to the serious games design features, the issue of ethics in designed gameplay maneuvers and subsequent gameplay consequences is not necessarily explicit or so straight forward (Sicart, 2009). From the designer perspective, ethical issues can be addressed in a simplistic, systematic way. That is, from the player perspective, algorithmic design choices enable players to make winning gameplay moves that minimise or circumvent losses, while at the same time bypassing the need to deal with moral hazards or ethical dilemmas. Sicart (2013, p.33) further explains: "Choices are often presented as either/or, good/bad binaries with relatively predictable outcomes. In this sense, players have enough information to make strategic choices—they are able to minimax the game without necessarily making use of their ethical skills." Schut (2013) also raises the issue of taking an overly systematic approach to games design, with "...the phenomenon of points-based morality....that takes the issues of right and wrong seriously." (Schut 2013 p.37). This common phenomenon places ethical decision-making with the designer while the player recognises the designer's moral choices through the gameplay rules. Take for example, enemy-based shooting games with pop-up citizens to avoid.

While ethics and values can be completely ignored in serious games, some design choices can bring issues to the foreground and play an important role in revealing ethical dilemmas or making players themselves take a moral stance. This can be explicit or implicit in game design.

Ethical Decision Making in Designing Accounting Serious Games

Key to the operationalisation of ethical decision making in serious games designs, is the organisation's ethical infrastructure (Tensbrunsel et al.,

2003; Schwartz, 2016). This is one factor which is seemingly within the control of the game designer. With accounting positioned as a corporate governance mechanism, the rules of disclosure may appear obvious. Nevertheless, there are accounting choices, strategic intent and trade-offs that can be made. With a code of ethics directing rules of right and wrong, there is still room for impactful value-laden decisions, which may result in significant externalities, both positive or negative. Each brings certain values, for example, through ranked importance and choices made to achieve certain outcomes. Prioritisation of value may be placed on profitability and cash flows, with shareholders and other stakeholders part of the valuing and ranking of worth (Annisette et al., 2017). Valuing emerges from the ethics of different individual decision makers, which is not always easy to model in a serious game. Schwartz (2016) identifies the complexities associated with ethical decision making explaining the four steps that take place. These are:

> "(1) becoming aware that there is a moral issue or ethical problem or that the situation has ethical implications (also referred to as 'interpreting the situation,"sensitivity,' or 'recognition');
>
> (2) leading to a moral judgment (also referred to as 'moral evaluation,' 'moral reasoning,' or as 'ethical decision making');
>
> (3) establishing a moral intent (also referred to as moral 'motivation,"decision,' or 'determination'); and
>
> (4) then acting on these intentions through one's behavior (also referred to as 'implementation' or 'action')" (Schwartz, 2016, p.758).

The moral judgment stage comprises the key moral reasoning component of the ethical decision-making process, and is based on Kohlberg's (1973) rationalist theory of moral development. However, Schwartz model claims the rationalist approach should be entwined with the non-rationalist view of ethical decision making that posits "intuitive (i.e., gut sense) and emotive processes (i.e., gut feelings) tend to at least initially generate moral judgments" (Schwartz, 2016, p.758).

These factors are useful inputs to serious game design scenarios, so players can discover and respond to unfolding (ethical) situations. In our design approach, we believe some players would follow a more rationalist

approach, while others would respond on gut feelings, resulting in different game play choices. Of course, there are moderating factors, drawn from extant research across the field. These are beyond the game designer's control, but nonetheless impact on the pathway/s the player selects through their immersive journey. These include an individual's moral capacity, moral character disposition and personal context (Hannah et al., 2011; Kohlberg, 1973; Jackson et al., 2013; Albrecht, 2003); their integrity capacity (Petrick and Quinn, 2000), along with the ability to recognise ethical issues, their intensity, perceived importance and complexity (Jones, 1991; Butterfield et al., 2000; Robin et al., 1996; Street et al., 2001; Warren and Smith-Crowe, 2008). These attributes were used in the design of gameplay characters and intended to become part of post gameplay discussion.

These factors identified in the accounting research literature contribute to our accounting ethics education and serious game design. Using hypothesised scenarios provides players with the opportunity to practice in context. When modelling ethical dilemmas in business ethics training and research, Tsahuridu (2003) suggests that care must be taken with underlying assumptions of what students or research respondents might perceive as an ethical problem, or what holds for them in terms of moral values. In addition, Fowler (1995, p.80) explains "people are not good at predicting what they will do in circumstances they have not yet encountered". The same goes for a series of questions that ask students/ respondents to reflect on their own perceptions in terms of yes/no answers, ranking or scales. These questions prompt reflection on the researcher's reality (Marshall & Dewe, 1997). For example, Fritzsche (1995) used dilemmas to examine the relationship between personal values and the ethical decisions of managers, asking respondents what they would do in each situation. Respondents had to indicate on an eleven point scale (0 – definitely would not, 10 – definitely would). This approach is problematic in that it imposes the researcher ideals and does not enable the respondent to freely determine action (Marshall & Dewe, 1997; Randall & Gibson, 1990).

Thus, modelling serious game designs with this in mind requires careful consideration.

THE DEVELOPMENT OF BOGART, A SERIOUS GAME OF ETHICS

Bogart Technologies is a game we created to teach accounting practitioners about the new International Code of Ethics for Professional Accountants (Code). The Code was released by the International Ethics Standards Board for Accountants (IESBA) in April 2018 and became active in Australia as of June 2019. The Code applies to all global IFAC member accounting professional bodies, including the large professional bodies in Australia. The Code of ethics itself is a prescriptive 248-page document which includes a long list of directives. While targeted to accounting practitioners, the Code is representative of business ethics more broadly. The key thesis of the code of ethics is that accountants should accept responsibility to act in the public interest, they should act with integrity (straightforward and honest), objectivity (without bias), confidentiality (including data), competence and due care (discipline expertise) and professional behaviour, to avoid conduct that might discredit the profession. Thus, the target audience for developing the serious game is not limited to professional accountants but can be useful for educating accounting students and all business managers who need to understand the basics of professional/accounting ethics and the implications of breaching the Code. The aim of the Bogart game is not to make players memorise the Code, but to understand the intent of the Code by placing players under the same types of pressures that might be encountered in the real world, therefore creating lasting behavioural change.

In Bogart, the learner plays the role of the newly recruited accountant, invited to consider unfolding corporate governance issues and make decisions with ethical implications, while fulfilling the role in context. The gamified techniques help to navigate through the day-to-day activities of the company, with the potential for each player to determine their own adventure, based on the decisions they make at each stage throughout the game. The game platform, also designed as a pedagogical research tool, provides both designers and researchers with insights of ethical decisions that are being made by the individual players. Embedded within the game are multiple issues which are not unique to accounting but have implications for other professionals, hence useful for business ethics training purposes. The gameplay deals with challenging managers,

whistleblowing and the outcomes of dysfunctional performance evaluation.

In Bogart the learner plays the role of a newly hired senior accountant at a technology firm. Their primary role is to 'process' accounting reports that junior accountants in the firm have produced, however this involves absorbing sometimes conflicting data, along with deciding what the best course of action might be.

INTERMIXING

As identified by Kaufman et al., 2016, intermixing is central to the persuasive efficacy of serious games. In our design strategies we determined it was important to 'mix' the ethical decisions learners had to make in Bogart with other decisions. During the game learners listen to a range of persuasive voices, each taking different ethical perspectives. At the beginning of the game the learner is put through a brief induction course where ethics is mentioned in the briefest possible way. They are told that "*more detailed policies and procedures can be found on your console. You should read them before commencing work*" (Bogart gameplay). The player is then led to the CEO, Fred, an older gentleman who advises them that their performance targets are the most important thing they need to consider.

You will be shown how these performance targets work during your training, and it's important that these are at the forefront of your mind whenever you are making a decision. If you are achieving your performance targets, then you're doing your bit to help the company achieve our overall objectives.

Fred – CEO

This message is reinforced by the CFO, Jade, who explains the performance measures in more detail.

> Fred probably explained we have performance targets here – what I need you to be mindful of are two things. The first is teamwork – we are a close team, and it's our ability to work together which makes us stronger. I am sure you know the whole is greater than the sum of its parts. You would have seen the TEAM principle in your induction training – Together Everyone Achieves More.

> The second performance measure we have is bad debts. It's important we keep them to a minimum as in the technology space we are always needing to invest in research and development to make sure we keep up with the competition.
>
> Jade – CFO

The learner is then shown how to perform their 'job' by the senior accountant they are replacing, who slips in the first unethical decision point as part of business as usual during the training.

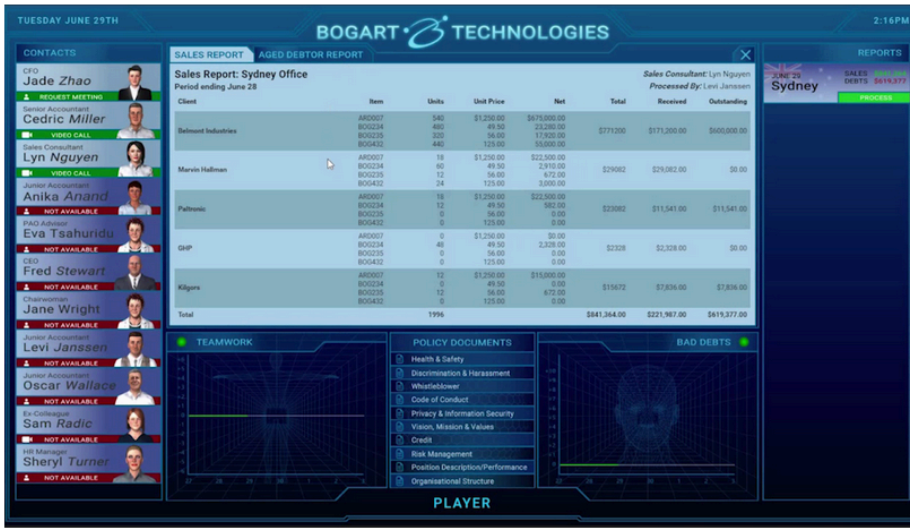
> As you can see the Belmont debt is over 90 days old. Belmont is one of our oldest customers and we do a lot of business with them all over the world, you will see that name pop up quite a bit. Both Fred and Jade have asked that we always give them a bit of leeway – which is good for you as otherwise it would be a bad debt and affect your own performance measures. So, click on 'Grant extension.'
>
> Cedric – Senior Accountant

This process continues throughout the game, with bad information and ethical decisions mixed in amongst routine conversations and business as usual. It is very easy for the learner to fall into the rhythm of 'playing the game' by making decisions they think will result in the best 'score,' which they can (wrongly) consider to be the performance measures on their game computer interface.

OBFUSCATING

One of the main ways that the true purpose of the Bogart game is hidden is through obfuscation of the true objectives. As explained, learners are told repeatedly that all they need to worry about is their performance measures. Even though they go into the game knowing it's about ethics, this is soon forgotten as they start to play the game and try to 'win'.

What they don't know is that these performance measures have been deliberately constructed to lead them away from making ethical decisions, and achieving the highest score will in fact result in them being deregistered and bankrupt at the end of the game.



The virtual computer interface that the learner engages with in the Bogart game, includes a live 'score' of their performance measures, teamwork and bad debts. This reinforces the obfuscating nature of the game with targets that are counterintuitive. The extent to which the student recognises this, determines the outcomes of their gameplay.

In Bogart a conscious effort has been made to make what can seem to be the strategically correct choice ethically incorrect. This mechanic is reinforced not only through the performance measures the learner can see on their virtual computer, but also through the feedback they receive from colleagues, in positions both above and below them. In fact, only one colleague acts ethically throughout the entire game, everybody else is driven by the performance measures and peer pressure from above, and advises the learner to do the same.

The company policy is for debts to be paid in 15 days. It has now been over 60 days. I have noticed that the same company has outstanding debts in several other countries. I have processed the report so you can see it on your console. I just thought you should know.

Anika – Junior Accountant

Our bonuses are tied to our performance metrics, so we need to keep those bad debts to a minimum. It doesn't do anybody any harm; it's just tweaking a few numbers. It's all a bit of a game, and Cedric knows how to play it, that's why he just got promoted. There is no reason to worry about it.

Levi – Junior Accountant

Another design decision that obfuscates the real purpose of the game is that there is very little in the way of a briefing before the game. It is considered good practice to conduct briefings before and debriefings after simulations or serious games but not in a way that will supplant the learning (Leigh and Kinder, 1999), so in this case the briefing is largely performed in game, and is designed to lead the learner astray. Debriefing activities, can be provided in the classroom by the instructor, or in interactive video content (developed as an extension to the serious game), which invites the learners to reflect upon their actions during the game, and connects what the learner experienced in the game to the new ethical standards and framework, using the game as a common reference point.

As Kaufman et al. (2016) suggest, "these findings illustrate the basic premise of the "embedded design" model: persuasive games that overtly telegraph their intended purpose of shifting attitudes and mindsets are likely triggering mindsets in players that hinder the game's enjoyability and blunt its potential positive impact."

By providing this subtle messaging to students throughout the game, it is not until the end that the full dynamics of the game is revealed.

DISTANCING

The process of psychological distancing according to Kaufman et al., (2016) creates a space between the learner and the topic of the game. This separates players from their real-life identities, allowing any reticence or reluctance to be circumvented, increasing the potential for the game to achieve behavioural and attitudinal change.

Distancing in Bogart is achieved through several methods.

The learner is automatically put into the 'first-person' role of an aspiring accountant who is being promoted to a senior position at a fictional technology firm in an undisclosed location. The building and computer systems used are deliberately futuristic, and although the nature of the

work is perhaps plausible for an accounting based game, it's not the type of work that any learners would actually be doing in their professional lives.

So the learners, although all either accounting students or professionals, wouldn't be doing this type of work in their professional lives. However the ethical issues that come up throughout the game are the types of things they need to be aware of in almost any role – including peer pressure from co-workers, poorly designed performance measures, and 'adjusting' numbers so they appear better than they are.

In addition to this, we designed the game believing the learner wouldn't be judged in a way that would create distress. The final scene of the game involves the Chair of Bogart Technologies calling a meeting with the key actors in the game play, including the student as Bogart's Senior Accountant. The CEO and CFO both end up in prison, escorted by prison guards. The worst that could happen to the learner is that they are deregistered from the accounting profession, described as broke and struggling to find another job.

OBSERVATIONS AND REFLECTION

The three 'embedding' strategies presented by Kaufman et al., (2016) provides an interesting and useful way to look at games designed for attitude and behaviour change.

Overall, our initial pilot testing and early use of the game suggests that these strategies worked. Our observations suggest the majority of players do the 'wrong' thing in the game – that is, make unethical decisions, resulting in them losing their role as Senior Accountant at Bogart. This came as a shock, all done in an overly dramatic fashion. In our experience, this is accompanied by the learner laughing and putting their head in their hands, or calling out that they have been sacked! Another, who did all the 'right' things, had his hands across his face at the end, believing he would be sacked by the Bogart CEO. As Day 3 in the game unfolded, he was delighted to see his efforts paid off, and he was promoted to CFO. We were pleased to see the early stage success of this immersive experience. Given these early observations, we propose formal experimentation conducted on the effectiveness of Bogart, a serious game of ethics. We believe this could touch on a number of points.

First, from an intermixing perspective, we turned up this strategy by building an intensity to the messaging. We used the computer agents and non-player characters (NPCs) to increasingly exert pressure on the behaviour of the player. In Bogart, this was done by using the virtual employees to establish a 'business as usual' that wasn't ethical, as may be the case in a real world situation a professional might encounter. We believe this had a strong effect on the effectiveness of Bogart. However, several players reported that even though they knew the story line and what was going to happen, they still experienced anxiety when the CFO became increasingly angry with them. This only happened when the player attempted to do the 'right' thing. Whether this insight can be used to help build resilience in players, and train them to deal with the discomforts of unethical work situations, or, whether we need to downplay this anger in the game, is an area for further research. This is of particular concern, given wellbeing in the workplace is topical for both employers and employees alike. This game attribute could be used to the advantage of educators,

before sending students to the workplace. Furthermore, there is a plethora of research supporting both the positive and negative effects that peer pressure can have, particularly on students (Bursztyn et al., 2016), which can be harnessed to produce behavioural change in a game setting by using NPCs. Xu and Lombard (2017, p.159) found that "users' actual behavior would not change unless they perceive these computer agents to be intelligent and appear to have human characteristics," which in the case of Bogart was relatively limited, as the learner only had a limited range of choices (for example to process or reject a report) and the NPCs would respond in accordance with these choices. In future with technologies such as AI, NPCs may be able to play a greater role in promoting positive or negative behaviours and attitudes to those playing the game. However, this needs to be managed with trained educators to ensure wellbeing issues are appropriately addressed during gameplay.

Second, from an obfuscating perspective, the computer agent used in Bogart was the performance measures or 'scores,' which combined with peer pressure by NPCs was presented to the learner as the most important aspect of the game. Game scores can be seen by players as a measure of whether a particular in-game action is good or bad. Did the players who lost the game succumb to the computer agent (rewards for bad behaviour) or the pressure from the NCPs, resulting in preferences not to go against the boss. and just blindly follow instructions? Research on the choices players make at different parts of the game would be useful to determine the effectiveness of the different types of intermixing messaging. This ties back to the attributes of the player, and their own moral capacity, moral character disposition, personal contexts, integrity capacity and the ability to recognise ethical issues, their intensity, perceived importance and complexity (Schwartz, 2016). Understanding the game play outcomes in terms of the moral/ethical attributes of players would be an interesting area to further explore.

Third, from a distancing perspective, research could determine the extent to which this played a role in the level of immersion in the game. The level of distancing in Bogart was not as extreme as one serious game example mentioned by Kaufman et al., (2015) where a metaphorical, zombie-themed infectious disease game was more effective than one with real

life individuals. Our storyline development was supported by an expert in forensic accounting. We wanted a story that was more likely to happen in the workplace, subtle enough that the players would not instantly recognise the unethical behaviour. Perhaps there is room for Bogart to be further distanced from reality, although this may have commercial implications, both in terms of getting funding and selling the game to a professional audience. Nevertheless it could be argued that the game does not require specific accounting expertise. Use with non-accounting game players may reveal a heightened sense of distancing, with players from the outset knowing they would never be working in this type of role.It would be interesting to explore how experiences of non-accounting players differ from accounting students who might not notice the distancing effects, as much as others. Another area would be to explore the game with users who have experienced similar difficult situations in the workplace, and whether the level of distancing is perceived to be as strong. Exploring the combination of the three embedded strategies in different cohorts would provide serious game designers with interesting evidence.

Building serious games to teach ethics education is not without challenges. Scenarios need to be realistic enough for pedagogical benefit, but subtle enough to immerse the learner into a situation where they are not an outsider making judgement from a distance, but caught up in the unfolding moral and ethical dilemma, contributing to the situation at hand as an agent. Using stealth game interventions is somewhat at odds with the lessons being learned in the serious game as it involves a degree of deception, but it is this deception which creates an engaging and unpredictable experience for the learner.

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CHAPTER 9

Climate Resiliency for Our Habitat Through Cross-Reality Technologies

YÉTINDRANATHSINGH VIPIN DHUNNOO

ABSTRACT

With the effects of Climate Change leading to adverse repercussions such as soil erosion, flooding and coastal displacement, at a macro scale, it is evident that our living spaces must be made resilient. With the detrimental effects of climate change not yet fully appreciated, there is an urgent need to model, illustrate and communicate climate change impacts. People living in vulnerable regions and coastal areas are at the ones at greater risk of climate change, particularly exposed small island developing states and coastal areas. The argument for this paper is for real-time mechanisms to help understand climate ramifications to mitigate and adapt the built environment. Advancements in Cross Reality (XR) technologies, such as Virtual Reality (VR) and Augmented Reality (AR), have led to promising multidisciplinary applications. With their unique interactive propensities, these technologies can be powerful aids at bridging the gap between actual and theoretical understanding of impending climate impacts. Drawing on experimental psychology and environmental research, this novel medium of visualisation can be utilised to strengthen communication and provide future resiliency. By leveraging the benefits of immersive technologies, this

novel communication medium can transcend traditional language and accessibility barriers. This paper investigates the development of XR media as an innovative visualisation and effective communication instrument for climate resilience.

KEYWORDS:

Climate Change, Environment, Cross Reality (XR) Technology, Visualisation,

INTRODUCTION

Global warming has altered weather patterns with many countries experiencing some form of extreme climatic event, including flooding, mudslides, heatwaves and fire (Lindsey, 2021). There is an urgent need for quick and effective means of providing a clear understanding of the future consequences of the climate crisis (Ripple et al., 2021). With traditional media not necessarily driving the desired climate urgency, there is a call for innovations that provide idiosyncratic experiences on such effects. Cross Reality (XR) technology has the ability of replicating such encounters due to its immersive nature. XR is an umbrella terminology for immersive technologies which predominantly include Mixed Reality (MR), Augmented Reality (AR) and Virtual Reality (VR) (Flavián et al., 2019). Immersive technologies, traditionally used in the games industry, have begun to be adopted in other fields of work, for instance to visualise land ecosystems (Ahn et al., 2016), marine environments (Fauville et al., 2020), psychology (Roswell et al., 2020) and in medical sectors (Burkhardt et al., 2016; Won et al., 2017). Consequently, this investigative study will explore the possibilities of XR, as a visual instrument, to raise urgent awareness about critical climate action.

CLIMATE CHANGE AND THE IMPORTANCE OF VISUALISATION

The impacts of Climate Change will have long lasting repercussions on our living environment. Coastal areas are the most vulnerable, with these areas accommodating some 600 million people. With about 10% of the world's population living at less than 10 metres above sea level (United Nations,

2017) livelihoods will need to be adapted to new norms. Coastal cities and small island developing nations, which depend on limited resources for their livelihood and rely on tourism for their economy, will require constant infrastructure review and maintenance (Betzold, 2015). Furthermore, by 2100, a large number of homes in developed countries will be at risk of flooding and evaluated as being 'uninsurable' by the end of the century (Ting et al., 2020).

To build resiliency and extend communication to all stakeholders, urban experimentation is encouraged with greater contextualisation and collaboration (Madsen & Hansen, 2019). There are not enough questions being asked by the diverse stakeholders to challenge the current management of city and coastal assets. Valuable data can also be obtained when local know-how is tapped into and combined with scientific information (Bai et al., 2018). Learning from past climate occurrences can help prepare for future disasters and adapting such techniques with modern technology can provide improved mitigative nature-based solutions to climate issues. In spite of extensive research interest, there is limited real-world application of such knowledge (Robinson, 2020). Support in visualising to develop contextual action plans are therefore imperative to safeguard these nations (Petzold & Megnan, 2019).

Traditional methods of communicating phenomena to a population in the form of text and imagery (Lehtonen et al., 2019) are not always effective, especially with issues of magnitude like climate change (Ahn & Bailenson, 2011). Following calls, by distinguished organisations such as the National Aeronautics and Space Administration (NASA) and National Oceanic and Atmospheric Administration (NOAA), to improve climate literacy, it is argued for rapid information propagation with multiple media formats (Cooper, 2011). Having first-hand experiences have shown to increase awareness and to have more of an impact (Ahn & Bailenson, 2011). Visual anchors are a crucial element to climate literacy as they allow emotions to be evoked by creating a connection with Climate Change literature and its depictions (DiFrancesco & Young, 2011). With 65% of people being visual learners (Bradford, 2011) perception has a significant role to play.

One area which can benefit from comprehensive frameworks and tools to help make sense of climate change information is city planning (Sheppard

et al., 2011). As such, disruptive and automated technologies can help map our infrastructure and develop real time urban modelling data to accelerate knowledge sharing of climate change repercussions (Bai et al., 2018). Integration of traditional know-how with advanced technologies can yield substantial benefits, especially with issues related to climate adaptability.

HIGHLIGHTS OF XR TECHNOLOGY

New immersive technologies have the potential of improving accessibility and reach of research information. XR technologies can better assist collaborators in their decision making: envisioning risks by visually stimulating natural calamities via computer-generated modelling (Vamvakeridou-Lyroudia et al., 2020). The research work by Vamvakeridou-Lyroudia et al. (2020) forecasted the erosion rate of beaches worldwide until the year 2100 and this modelling technique showed the potential dangers of future erosion and highlighted vulnerable areas. Similarly, three-dimensional time-based visualisations, with the assistance of Geographic Information System (GIS) (Seenu et al., 2019) and based on historical data, have been utilised to simulate flood risks under a number of scenarios. The study by Seenu et al (2019) used the city of Hyderabad, in India, as a flood simulation location. Thirty years' worth of rain data was replicated using a Storm Water Management Model (SWMM) and a four-dimensional geographic information system (4D GIS). When cross-examined with a flooding event which occurred in 2009, the modelling produced the same outcome, which demonstrated its efficacy. This method of mapping can also be useful especially where tourism is of economic importance (Chen et al., 2018). Immersive three-dimensional virtual environments have shown to have a better influence on users (Fauville et al., 2020) and immersive XR technologies can also offer a safer environment to learn of a site's challenges (Elghaish et al., 2020). To enhance user retention and improve awareness, inclusion of virtual interactions has proved to be advantageous (Markowitz et al., 2018) and along with the synthesis of Building Information Modelling (BIM), digital collaboration can be reinforced (Elghaish et al., 2020). Additionally, virtual environmental mimicry has allowed for better public participation by making complex infrastructural projects more approachable to the masses

and has shown to provide sustainable outcomes (Stauskis, 2014). A summary of the studies discussed can be found in Table 1.

XR devices have been used in other fields of work which can provide a glimpse of their adaptability for climate action. The novel MR platform, Microsoft Mesh, which makes use of a head mounted display (HMD), allows individuals regardless of their geographical location to meet and collaborate via 'holoportation', a state of virtual holographic representation interacting with the same three-dimensional model (Langston, 2021). OceanX, a non-profit organisation, has been using the Hololens MR headset to help create awareness of ocean decay from the comfort of their offices (Langston, 2021). This new storytelling medium can thus provide immersive experiences without physically being on a hazardous site.

VR, a technology providing complete virtual immersion by means of a headset and controllers, has several advantages over other digital technologies. It possesses enhanced interactive attributes with its diverse built-in sensorial technologies (Fauville et al., 2020) and VR also allows for a technological dyad embodiment which enables the user to be physically part of a hybrid virtual setting (Flavián et al., 2019). As such, VR can help in fields which are highly technical and bring them to an understandable visual form. This makes it accessible to the general populace and has the benefit of providing experiences regardless of a user's geo location (Fauville et al., 2021). Additionally, VR can be used to increase empathy (Herrera et al., 2018; Roswell et al., 2020) which can subsequently give rise to positive behavioural changes (Nelson et al., 2020). This is attributed to the increase in emotional engagement, as the 360 exposure brings forth a unique point of view (Engberg & Bolter, 2020). Use of PC tethered VR devices, such as the Oculus Rift combined with Leap Motion, a technology which detects hand gestures, has shown multi-level immersion and enhanced collaboration (Nguyen et al., 2016).

Where HMD-based XR experiences shields to some extent the real world, AR overlays virtual assets over the physical environment (Klopfer & Sheldon, 2011). Implementation of AR has been undertaken via serious games such as TimeLab 2100. TimeLab 2100 is a multi-epoch game with the goal of managing a population's adaptation in a future affected by Climate Change. The AR component attempts at connecting players with

their surroundings, thereby increasing their educational propensity within their environment by blending virtual and real worlds (Klopfer & Sheldon, 2011). Another such AR experiment is P.E.A.R, a serious game which aims at raising awareness of climate issues via a series of mini-games (Wang et al., 2021). These ecological mini-games allow participants to expand their knowledge of sustainability and know-how on climate issues (Table 1).

Institutions have been experimenting and encouraging the use of XR technologies to drive awareness of Climate Change through the Sustainable Development Goals (SDGs) framework. One such event, organised by the United Nations, is the SDG Global Festival of Action which aims at highlighting predetermined global targets. The SDGs are a set of 17 predefined goals which countries will have to align with by the year 2030, for the safeguard of the planet (UNDP, 2022). Submissions and presentations for this noteworthy yearly gathering range from serious games, AR, VR and also two-dimensional media (United Nations, 2021). The aim being to experiment with better methods of information sharing and promote the actions being undertaken worldwide for the welfare of our environment and people's wellbeing.

Studies have shown that immersive technology constantly outperforms its two-dimensional counterpart, in both assimilation and intuitive interpretation (Coburn et al., 2017) and immersive technology should be considered when the imperceptible needs to be made perceptible (Pantelidis, 2009). Ultimately, XR technology has the ability to place the user in situations which would otherwise be inconceivable or unfathomable (Pan & Hamilton, 2018). One study showed that the ability to provide real-time data can shorten time frames and improve participatory activities when used in the context of master-planning (Jamei et al., 2017). The experiment by Jamei et al. (2017) demonstrated enhanced engagement with the public, crucial when designing climate adaptive cities (Table 1). The proliferation of XR technologies has the potential of rapidly democratising scientific data. These connected computer technologies enhance the physical world by virtually enabling idiosyncratic experiences (Ziker et al., 2021) and these digital devices allow improved information assimilation to strengthen climate awareness (Markowitz et al., 2018).

Table 1

Summary of key papers investigating the use of XR technology for climate perception and for the creation of sustainable environments.

Research	Method and Characteristics	Successes	Failures	Efficacy
Sandy coastlines under threat of erosion. (Vamvakeridou-Lyroudia et al., 2020)	2100 computer modelling projection of beach erosion along coastal zones on continents and islands nations, worldwide.	Effectively showed real dangers of climate impact on shorelines. Regions of higher beach rate loss were earmarked, such as North Australia and South Asia.	Erosion, induced by intermittent storms, was not taken into consideration in this study.	There is no global dataset on beach width to allow proper calculation of beach loss. Therefore, only beaches with expected sand loss of >100m

				were taken into consideration.
Visualisation of urban flood inundation using SWMM and 4D GIS. (Seenu et al., 2019)	Simulation of flooding using Storm Water Management Model (SWMM) and four-dimensional geographic information system (4D GIS), for the city of Hyderabad in India. Thirty years of rainfall data was used for this study.	This provided an enhanced overview of flooding complexities for an urban environment. An intensity-duration-frequency relationship was created along with the simulation of an inundation map to identify flood prone zones. This helped to foresee the adaptation and mitigation measures required for these areas.	Lack of adequate historical data was an issue, making modelling a challenge.	The simulation experiment was compared to a flooding event in 2009 and the simulation corroborated with the past occurrence, thereby demonstrating the validity of the study.
Towards digitalisation in the construction industry with immersive and drone technologies. (Elghaish et al., 2020)	Literature review on the use of Unmanned Aerial Vehicles (UAVs) and immersive technologies in the construction industry.	The progress of a project can be coordinated with better efficiency using UAVs in tandem with 4D BIM software. Immersive technology can allow remote and risk-free management of construction projects.	Costs of these technologies are high and can be out of reach for small businesses. Development and training for these cutting-edge devices can be time consuming.	Only few researches are available on the use of UAVs and immersive technology. This specific study was limited at finding the shortcomings in an ideal scenario without any cost implications.
Development of methods and practices of virtual reality as a tool for participatory urban planning. (Stauskis, 2014)	Using virtual reality (VR) for public participation in a sustainable urban planning exercise for the city of Vilnius, Lithuania.	The use of VR and spatial modelling via gaming platforms provided an innovative tool for public collaboration. This subsequently led to a better use of resources and a more sustainable method of urban design.	Having the proper software and technical assistance is essential for the development of such virtual projects.	This allowed a more accessible way of communicating urban projects with increased reliability in the results.
Augmenting your own reality: Student authoring of science-based	Gamification of Climate Change repercussion between past and future scenarios, using AR and the	Participants were provided first-hand experience of what-if scenarios which increased their awareness of	The main challenges to developing such immersive AR experiences are limited	This study challenged people to think differently about their living environment, by

augmented reality games. (Klopfer & Sheldon, 2011)	MIT campus as the ground for the experiment.	environmental climate impacts. This also allowed the participants to explore and look at their everyday environment from a different perspective.	resources of cost and time. Additionally, specialised know-how on programming is required to create such a project.	directly integrating virtual elements onto their physical surroundings. This greatly engaged the users and was creatively educational.
Evaluating the effectiveness of an augmented reality game promoting environmental action. (Wang et al., 2021).	An immersive educational game promoting sustainable environmental action using geolocation and AR technology.	Enhanced the knowledge of participants on topics such as sustainability and Climate Change. This was achieved via a series of questions before and after playing the quests in a series of mini-games.	The game only had sustainability as the primary focus and did not measure the participant's actual impact on their surroundings following their interaction with the game.	There was a significant decrease in player engagement as the game progressed which was potentially due to the game design.
Investigating the role of virtual reality in planning for sustainable cities (Jamei et al., 2017)	Study on the capacity for VR\to visualise the impact of natural calamities on cities, via material modelling and simulation.	This study found that VR allowed solutions for urban issues to be visualised in real time, promoted efficient communication with all stakeholders and enabled sustainable designs within a better time frame.	Cost of VR headsets and its related computer peripherals, along with the expertise in software integration, have been the main challenges to adapting the process for real world use.	Using VR for planning has shown that the immersion successfully replicated real-world scenarios, which provided seamless interaction and holistic design outcomes.

CHALLENGES OF XR TECHNOLOGY

Despite the promises of immersive technology as an instrument for climate change visualisation, the technology currently has some limitations. Real-time engines are utilised for the development of immersive experiences. As such, they proportionately possess similar visual elements to that of video game design (Kitatus, 2019). The pessimistic connotations related

to certain games including, aggression induced by gaming competition (Dowsett & Jackson, 2019) and dangerous behaviours (Chang & Bushman, 2019) can potentially stimulate unconscious prejudice on behalf of users, when attempting to use such a digital environment for education (Wilson & Soranzo, 2015). Additionally, the experience associated with immersive technology can negatively impact assimilation and critical thinking as a result of its unfamiliarity (Velev, & Zlateva, 2017). The software used in the creation of real-time experiences are game engines, such as Unreal Engine and Unity. These have been predominantly developed with game programmers as the main demographic (Brookes et al., 2020) and as a result, the use of these software in cross-disciplinary fields can yield a lengthy learning curve for scholars trying to create interactive environments for research (Brookes et al., 2020).

Due to the novelty of XR systems, interactive frameworks within the virtual environment can be complex. For instance, the current way to navigate in VR is by the teleportation technique, where the user jumps to a chosen location, which unfortunately detracts from real world movement simulation (Ramirez, 2018). Screen latency is also known to induce nausea, or sickness, (Korolov, 2014; Pan & Hamilton, 2018; Saredakis et al., 2020) and disorientation (Kim et al., 2018). Besides, such avant-garde technologies can take away from the actual message being presented, especially among an audience not used to technology, thereby tempering with the intended experiment's outcome (Markowitz et al., 2018). Furthermore, the novel factor and adaptation time for people to get used to the technology can be a considerable hurdle (Ylipulli et al., 2013).

The intrinsic nature of most XR platforms is immersion via a wearable HMD and this unequivocally shields the physical world from the user. There is also growing evidence that shows a correlation of decreasing capabilities and questionable credibility (Slater, 2009) when undertaking simulated activities whilst being in a state of physical imperception (Pan & Hamilton, 2018). There is additionally the issue of "uncanny valley", the condition of being preternatural, when attempting to digitally recreate human bodies (Pan & Hamilton, 2018; Ashtari et al., 2020; Engberg & Bolter, 2020). Compared to traditional experiments, certain XR devices demand a new type of setup and its recommended limited exposure in

maintaining virtual presence poses a challenge for lengthy experiments (Pan & Hamilton, 2018). Correspondingly, AR compatible devices are not made for prolonged use, which can result in the device overheating, battery degradation and ergonomic issues with prolonged usage (Ilanković et al, 2020). As it is still early stages for certain XR technologies, some are either too expensive (Karthika et al., 2017), require extensive setup times (Karthika et al., 2017), solely intended for large organisations (Bohn, 2019) or discontinued due to lack of consumer interest (Altman, 2015).

Software development is key when creating immersive experiences for XR devices. However, these require specific knowledge and learning materials, along with technical support, are often challenging for the uninitiated (Ashtari et al., 2020). Additionally, frequent software updates often lead to compatibility issues during development (Ashtari et al., 2020). Compared with traditional two-dimensional media, immersive environments pose no control over participant navigation and activities, which can be a problem when attempting to predict a user's virtual conduct (Ashtari et al., 2020). Furthermore, there is a plethora of unknowns in XR development and as a result, Ashtari et al. (2020) indicates that developers spend most of their time bug fixing and attend to other technical complications, which compromises end user evaluation and user experience.

FUTURE OF XR TECHNOLOGIES

Advancements within the realm of XR development is essential to successfully adapt advanced environmental impact simulation on our urban spaces. Good interactions within a virtual environment contribute towards a positive immersive experience and as such, manoeuvering within an XR space using input devices like controllers can be unfamiliar for some. With Oculus Quest's new update, the built-in camera can now utilise hand tracking (Oculus Blog, 2020), without any additional piece of hardware. Such an implementation can provide a better natural interaction and be more appealing to the masses.

Use of other senses in XR environments can further enhance immersion. For instance, the potential use of the olfactory system within the virtual space can add an extra dimension of spatial perception, for instance the

stench during a flooding scenario can accentuate specific emotions. Ericsson is investigating enhanced sensorial communication by an 'Internet of Senses' framework within the next decade (Ericsson ConsumerLab, 2019). This will allow integration of intangible abilities, such as detection of digital aroma and flavour, to proliferate using rapid 5G data transfer.

A major limitation of XR, especially MR and VR, is that it is still a niche product and unless it is widely adopted, dissemination of climate change information via this immersive platform will remain restrictive. One way of promoting public endorsement is by enhancing collaboration within an XR environment. Enabling multi-user access within the same digital XR realm can significantly drive mass adoption, thus promoting participation and cooperation regardless of the user's location.

Future development of XR points to a merger of technologies. In its current form, AR is accessible either via smart devices or glasses. A ground-breaking wearable tech from a company called Mojo Vision created and tested a smart contact lens with the ability to display AR content (Koetsier, 2022). Such a seamless blend of wearable devices with the human body could potentially make bulky XR headsets redundant and provide a streamline content experience. Moreover, the visualisation potential of XR can be further enhanced with the integration of Artificial Intelligence (AI). Merging these two bespoke technologies can create new possibilities and opportunities unfathomable by human minds, yet within the reach of AI systems (Reiners et al., 2021). Such a system can have tremendous positive impact and crucial time gain, especially with the current unpredictability of future climate scenarios.

With the proliferation of digitised content, the creation of a digital twin powerful enough to simulate the physical world can provide real-time simulative solutions to climatic problems. This would allow opportunities at finding answers to age old climate issues. One such programme is Nvidia's Earth2 project, which uses its Omniverse simulation engine (Sprinzen, 2022) and climate forecasting digital twin, ForeCastNet (Freund, 2022). Earth2 could be the portal where future solutions to urgent climate issues are harvested and subsequently assist with deployment. With the convergence of AI, machine learning and XR technologies, an almanac of Earth's ersatz could be generated which has the potential of being the

reference for climate explorations and investigations. As the Founder and CEO of Nvidia, Mr Jansen Huang, framed it; With this technology, "what takes a classical numerical simulation a year, now takes minutes"(Freund, 2022). Such a revolutionary merger of technologies can greatly assist with the ever-growing urgency of Climate Change.

CONCLUSION

This paper explored the use of XR technologies and its potential as a tool for climate change awareness. A range of current XR technologies were explored, along with their advantages and constraints discussed. Studies on the uses of XR showed that immersive technology can have positive implications in the field of urban design, environmental planning and education. The upcoming developments in XR technology were also appraised, which offered a promising outlook on enhanced immersion and information dissemination pertaining to climate action. However, challenges to the adoption of such technologies revolved predominantly around the cost of acquisition and expertise required for the creation of digital applications for XR devices. It requires considerable time to custom make digital assets and virtual environments for simulation, an uncharted domain for many scholars.

Nonetheless, from the insights gathered there seem to be an opportunity for XR technologies to be pivotal in driving awareness of climate action. As such, prospective multidisciplinary investigations can explore integration of historical data to assist with adaptive and mitigative designs for our living environment, with future climate issues in mind. With the unique abilities of immersive technologies, these simulation devices can be influencing agents for climate change perception and can provide the required impetus for the safeguard of our planet.

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