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Serious Games as Technical Artifacts Mediating Learning Objectives

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Abstract

The purpose of this thesis is to analyse the serious game, PluriCards, and investigate whether the technical artifacts of the game mediate its learning objective - to learn about sustainability and ideate potential futures through dialogue with the opposing players. To understand what games and serious games are, the problem analysis provides a brief overview followed by an introduction to PluriCards.

The problem formulation is as follows:

How does the serious game 'PluriCards' perform as a technical artifact for mediating learning objectives?

Throughout the analysis, different theories of learning are presented to provide the reader with an understanding of how learning processes occur. Thereafter, the same theories are used in an evaluation of PluriCards. The analysis concludes that PluriCards performs effectively during game mode one, the conversation starter. However, during game modes two and three, the game rules frustrate the players and hinder the learning objectives from occurring frequently and favorably. To tackle this issue, three possible solutions are proposed, encompassing new rules and new cards.

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Preface

I have always been fascinated by games such as football, card games, and video games which will always have a special place in my heart. A place where I try my best. A place where I have fun. A place where I socialise. And a place where I learn.
I am grateful for getting the opportunity to work on the topic of serious games, meshing my professional competencies with my personal interests. Writing this thesis has provided me with reflection on my own life and enhanced my understanding of my own psychology and behavioral patterns.

I was raised with the notion that I had to do hard work before I was allowed to have fun, and I always looked for alternative ways of doing things smarter, faster, and more joyful. When I was a kid, I often helped my father with gardening, renovating the house, or mowing the lawn. However, the lawn was 3600 m2 and took between 1½-2 hours to lawn on a lawn tractor, so like most boys, I would rather play football or have fun doing something else. But of course, there was no way around getting it done. So, I came up with a way of enjoying the lawn mowing. I would gather all the apples that had fallen off the apple tree and were not edible into a bucket, and for every round I mowed, I threw an apple after a big tree. The number of apples that hit the tree would determine how successful the lawn mowing had been, at least to me it did. I would also draw patterns on the grass with the trail of the wheels and adjust the height of the cutting deck, making the lawn almost royal-looking. I am confident that these self-invented minigames not only made me enjoy mowing the lawn but also made me make a real effort out of it. I enjoyed it so much that I, with few exceptions, was the only one to mow the lawn in 10 years, even throughout my tedious teenage years. This is for me evident, that it is possible to make the most mundane tasks engaging and fun by incorporating elements of games. However, I too believe that open-mindedness and imagination are required to enable alternative ideas to flourish and mature to be able to challenge the accustomed status quo.

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1.0 Introduction

As a Techno-Anthropologist, I am concerned about the profound impact that the emergence and diffusion of technology have on humanity. As a society, we face one of the biggest, if not *the* biggest challenge, humanity has ever encountered - the exploitation and dependency on Earth's resources in conjunction with increasingly complex and interconnected social systems and rapid technological change. This new era of irreversible human influence on the earth's systems has been named the Anthropocene and has been an epoch since its onset in the early industrialisation at the beginning of the 1800s (Stevens et al. 2008). The roots of tensions regarding resource use, population growth, and environmental pressures prominently emerged in 1950, and 28 years later, in 1978, the term "*sustainability*" was first used in a United Nations document (Kidd, 1992). The most widely used definition of sustainability was formulated by the United Nations Brundtland Commission in 1987, which defined sustainability as *"(…) development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland, 1987). To comprehend the definition of sustainability from the Brundtland report, John Elkington introduced in 1994 the sustainability perspective recognised as the Triple Bottom Line (TBL). This perspective integrates three sustainability dimensions including environment, society, and economy, often referred to as the 3 P's: people, planet, and prosperity (Elkington, 2004). The three P's has increasingly become a more integral part of long-term strategies of organisations, where the main driving forces are as Bettley and Burnley summarises:

"(…) competitive pressures arising out of the recognition of the cost advantages of reducing materials and energy consumption and waste production and the resulting economic benefits of environmentally friendly behaviours; perceived marketing advantages; legal obligations to limit the impact of human activities on the environment and on third parties; the demands of investors seeking long-term reliability; and finally, internal ethical values, which change in parallel with external shifts".

(Longoni, 2014, p. 6)(Bettley and Burnley, 2008).

Since the early 2000s Higher Educational Institutes (HEI) around the world have been researching how to integrate the sustainability concept into their practices and goals. However, several studies of HEIs have shown that engineering students do not possess the proper skills of systemic thinking and holistic knowledge upon graduating within the general social development competencies (Goni et al. (2017). It is important to accentuate TBL perspectives in a variety of disciplines in HEIs since HEIs hold a unique position in society in the transition towards sustainability as they are a critical place of knowledge creation, -diffusion, and -continuation. However, if HEIs want to commit effectively to societal challenges, they must re-orient themselves through incentivised internal and

external changes in their system (Goni et al. (2017). Stephens et al. (2008) raise four categories of how HEIs might contribute to the societal transition toward sustainability.

(1) *"higher education can model sustainable practices for society; this view is based on the premise that sustainable behavior should start with oneself and by promoting sustainable practices in the campus environment, learning related to how society can maximize sustainable behavior is accomplished."*

(2) "*higher education teaches students the skills of integration, synthesis, and systems-thinking and how to cope with complex problems that are required to confront sustainability challenges."*

(3) "*higher education can conduct use-inspired, real-world problem-based research that is targeted to addressing the urgent sustainability challenges facing society."*

(4) "*higher education can promote and enhance engagement between individuals and institutions both within and outside higher education to resituate universities as transdisciplinary agents, highly integrated with and interwoven into other societal institutions."*

Different innovative methods have been proposed as potential renovation approaches of educational tools used to teach and transmit knowledge of social development. Many of those approaches involve making use of digital technology, which is getting exponentially increasingly advanced. Digital technologies leave some parts of the reality of the world in which we live to the past as new technologies create new realities and practises (Greenfield, 2017, chap. 10). An example of this is how paper and pencils were replaced by personal computers, which had a huge effect on education practises. With the myriad of new possibilities brought to light by the computer revolution, new tools and practises of education emerged. One of these tools is serious games, which have been praised by researchers for decades as holding great potential in transforming learning experiences due to the engaging and intrinsic motivating elements that games inherently offer (Liberona et al., 2021, p. 138-148)). This thesis seeks to shed light on the field of serious games and their potential to be used in HEI as a technical and socially responsible solution to societal challenges based on the existing research and a case study of the serious game, PluriCards.

2.0 Problem analysis

2.1 Initial problem formulation

How does learning occur in the Serious Game, 'PluriCards'?

To answer the first part of the initial problem formulation, the problem analysis will first and foremost concern the concepts of play and games and the history and development of video games and serious games, to provide the reader with background knowledge. Throughout the problem analysis, different types of games will be discussed with the aim of providing insight into the diversity of games and what they have to offer. Finally, the serious game, PluriCards will be introduced.

2.2 Play and games

To be able to understand what a serious game is, it is necessary to cover the most central element of games itself: play. The Dutch cultural historian and professor, Johan Huizinga, wrote the book 'Homo Ludens' in 1938, which translates to 'the playing human', in which he discusses the meaning of play in culture and society through long descriptions of the characteristics of play in a phenomenological approach. Huizinga describes play as a cultural phenomenon, as a function of life, as serious, as voluntary, and as being a meaningful purpose of its own even though it is perceived as unnecessary relative to human vitalities such as food and shelter. Furthermore, Huizinga regards play as an intrinsic character of humans as well as animals, which is why the question of why we play is less interesting to him than the question of what it is about playing that makes it interesting for us as humans (Huizinga, 1938, p.1-27).

The French scholar Roger Caillois critically proceeded the work of Huizinga and defined play in his book 'Man, Play, and Games' from 1951 as *"(…) an activity which is essentially:*

1. *Free: in which playing is not obligatory; if it were, it would at once lose its attractive and joyous quality as diversion;*
2. *Separate: circumscribed within limits of space and time, defined and fixed in advance*

3. *Uncertain: the course of which cannot be determined, nor the result attained beforehand, and some latitude for innovations being left to the player's initiative;*
4. *Unproductive: creating neither goods, nor wealth, nor new elements of any kind; and, except for the exchange of property among the players, ending in a situation identical to that prevailing at the beginning of the game;*
5. *Governed by rules: under conventions that suspend ordinary laws and for the moment establish new legislation, which alone counts;*
6. *Make-believe: accompanied by a special awareness of a second reality or of a free unreality, as against real life."*

(Caillois, 1961, p.9-10).

Caillois criticises Huizinga for ignoring the differences in different types of play and games and their meanings. Caillois emphasises competition much further than Huizinga and characterises four principles of play; *'agon'*, *'alea'*, *'mimicry'*, and *'ilinx'*, which he groups into two main categories; *'ludus'* and '*paidia'*. Paidia refers to the purposeless, free, and improvised aspects of games, such as playing ball with a friend or dog, where no consensus of any rules is established. Ludus refers to the organized and rule-driven aspects of games, such as those recognised in sports, board games, video games, or simply playing ball with tacit knowledge of a common format. Agon and alea refer to competition and chance respectively, mimicry refers to an imaginary universe and make-believe, and ilinix refers to disorientation creating a temporary disruption of perception (Caillois, 1961, p.71). This report subscribes to Caillois' definition and distinguishment between play and games, where the games inspected in this thesis are under the category of ludus. Rules are followed by players, but they also push against them, testing the limits of the system (Salen, 2008, p. 9), like football players arguing against the referee's offside decision. But when did humans invent games?

2.3 History of games

From game boards of ancient civilisations to computer games of the Modern eras, the history of games is deeply intertwined with the history of humanity and technological progression. Throughout thousands of years of evolution, games have been an expression of cultural identity as they reflect, preserve, and transmit cultural knowledge, values, beliefs, and traditions of the society in which they are created and played.

The earliest archaeological evidence for games comes from an excavation at ʿAin Ghazal, Jordan in 1989, where archaeologists found a game board made from limestone in an abandoned Pre-Pottery Neolithic house which can be dated to approximately 5870 BC, see fig 1 (Simpson, 1990) (Rollefson, 1992). The game resembles the ancient African game, *Mancala*, which is still played today under the modern variation, *Kalah*. Mancala was originally used for "*war, trade and numerous other situations in which goods or people change hands, resulting in the pieces being called soldiers, cows, money, prisoners or wives"* (Spanos, 2021, p.41). The game was strategic without any element of chance, which made it possess political- and social power. Even though it is believed that some ancient games, such as Mancala, where also being used for having fun and competing, archaeologists proclaim that the genesis of games derived from serious intentions, such as in this case. Other games, such as *Senet*, an ancient Egyptian board game that dates back at least 3000 BC, is understood to be a way of communicating with the dead through one's soul with the purpose of acquiring personal gratification by unlocking the secrets of life (Konstantakos, 2022, p.466). Just like board games, sports are also defined by their rules and score systems of the participants' performance. Athletic games such as those of the Olmecs, Mayas, and Greeks, evolved from war and hunting into more formal competitions, such as the Greek Olympic Games, which had its inception in 776 BC and was held continually each year for over a thousand years (Miller, 2020, p.14-16). All these games are a testament to a human tendency that has been a natural part of civilised human existence for thousands of years – we create games. Fundamental human activities such as running, swimming, or throwing different objects are admirable to us as humans despite their simplicity and repetitiveness compared to more rule-induced games. We tend to create games out of non-game activities from our own lives, but also the lives we dream of, for example, bouldering, which is a safe indoor miniature version of dangerous rock climbing (Egenfeldt-Nielsen et al., 2020, p. 62). In 600 AD, the classic board game Chess was invented in northern India where it diffused to the rest of the world (Spanos, 2021, p. 144). Chartugana, the precursor to chess, was originally a military game where each player's board represented two armies, and the objective of the game where to develop effective war strategies to spare as much blood as possible. Chess was also a game of politics between the elites of different nations. For example, chess was used by the ruler of the Indians as a tool for measuring the intelligence and wisdom of the Iranians (Wilkinson, 2016) (Spanos, 2012, p. 145-147). Chess is still regarded as an intellectual game – from being one of the five arts that a Chinese scholar must practice (Caillois, 1961,

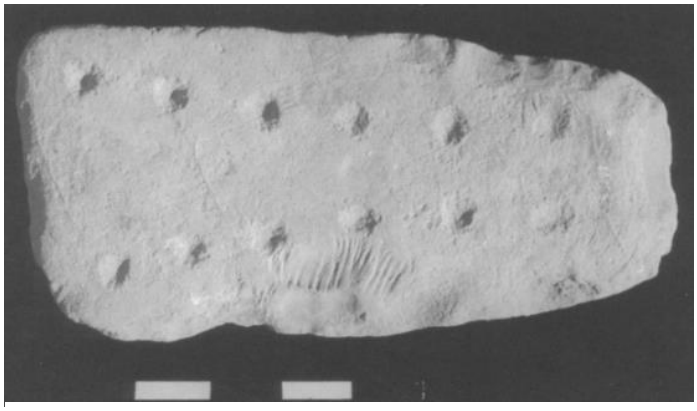

Figure 1 – Game of Mancala, 5870 BC

p. 84), to being a benchmark of human intelligence when testing and developing artificial intelligence such as Deep Blue, which was an IBM computer system that defeated the chess legend Garry Kasparov in 1997 (Igami, 2018).

The Landlord's Game, the predecessor of Monopoly, was the first board game of the modern format of today's board games. It was created in 1904 by Elizabeth Margie to be a *"practical demonstration of the present system of land grappling"*, with the anti-capitalistic objective of demonstrating how rents impoverish tenants and enrich the property owners. However, The Landlord's Game was rejected by the publisher due to it being too complicated and was therefore first available on the shelves in 1913. A socialist professor of economics named Scott Nearing who lived in the same city as Margie used the game in his teaching and as students made up their own rules, different versions of the game emerged, including Monopoly (Dodson, 2011). Monopoly, which sold over 200 million copies worldwide, contributed to establishing board games as an activity between families and friends (Egenfeldt-Nielsen et al., 2020, p. 63). Commercially produced board games became an established part of cultures around the world by the mid-twentieth century, and it did not take long before the analog was challenged by the digital.

In 1958, the American nuclear physicist William Higinbotham designed what is often credited as the first video game, Tennis for Two. The game functioned on a 5-inch oscilloscope, which is an instrument that measures electric signals and visualises them as a graph on a screen to create a 2D visualisation of tennis. In 1971, the first home video game console was created, the Magnavox Odyssey, by the electronics engineer Ralhp Bear in collaboration with the electronics manufacturer Magnavox (Wardyga, 2018). A total of 28 games were made for the Odyssey, including game titles such as *Football, Brain Wave,* and *Haunted House*. The first generation of video games saw a lot of success, especially in 1976, with the release of the game console Coleco Telstar and their range of games which e.g., included rifles as joysticks for shooting games. This was the beginning of video games in private households which has continued to evolve into what we know

Figure 2 - Tennis for two

Figure 3 - Coleco Telstar

today – globally distributed and social games with interfaces integrated into screens rather than game controllers. “App stores” offer small games primarily for mobile devices, and platforms such as Steam offer more memory-demanding games suitable for regular PCs or “gaming PCs” (Egenfeldt-Nielsen et al., 2020, p 111). Today video games have become less about winning and more about constant progress making players stick around longer with incremental increasing difficulties as players climb the ranking systems, downloadable content, and customisation of one’s character, car, weapons, etc.

Even though contemporary commercial video games do not represent the resources available for a game design in the context of Aalborg University, they do offer insight into how serious games can be researched and designed, since they open up for experimentation and innovation (Wilkinson, 2016). That is because they are designed to contain the greatest degree of engagement possible, which is a valuable property of learning. Another reason why commercial video games can be investigated in relation to designing serious games is that the video games market is a significantly larger industry with a projected global revenue reaching 384.9 billion dollars in 2023 (Statista, 2023), whereas the global industry of serious games is 10 billion dollars in 2023. Even though serious game development constantly improves and innovates game design and its applications, the thirty-doubling revenue of the video game industry makes video game developers capable of investing more resources into their game design processes. In combination with the exponential development of computing processing, games are getting more and more immersive with photorealistic graphics and technologies getting more and more advanced and accessible. One of those technologies is virtual reality (VR), which is *“going to be a huge area of application and one of the driving forces of the industry”* (Slater & Sanchez-Vives, 2016). A recent example of a VR game is the hyper-realistic game, Unrecord (Steam, 2023b), which lets the player control a tactical police officer from the perspective of the body camera. Even though Unrecord is designed as an entertainment game, it does a good job of showcasing state-of-the-art realism in video games and the potential of immersiveness. The game is very similar to existing police and military simulations, where the player is exposed to a mission in which the player’s actions will be evaluated before conducting a similar mission outside the game. Such simulation games make use of the most realistic and immersive technologies such as extended reality (XR) and accessories such as guns, tanks, and clothing. XR, or extended reality, is an umbrella term that encompasses technologies that alter reality by adding digital elements to the physical or real-world environment to any extent, including

augmented reality (AR), mixed reality (MR), and virtual reality (VR)(Dörner, 2022, chap. 1).

Figure 2 - Mechdyne training simulator

Figure 2 shows a VR training simulation for the military, developed by a company called Mechdyne. The design consists of a VR headset, which makes the game the only visual input for the player, an omni-directional treadmill and motion tracking which translates the movement of the player into the game, finger- and weapon tracking to accurately translate weapon movement, and a computer to run the advanced 3D imaging software (Mechdyne, nodate). As such technologies mature and the technological equipment gets more affordable, game companies will look to implement more and more immersive technological elements into games, which blurs the boundaries between simulation, serious games, and entertainment games. As mentioned earlier, simulation games were the first kind of video games, and are to this day, still one of the most popular categories (Statista, 2022). Game developers such as Bethesda Game Studios have invested big in realism, as they have spent the last 25 years building their new game Starfield. Starfield, which was released on the 1st of November 2023, takes place in a futuristic universe where humans are a multi-planetary species traveling between planets containing their own unique resources, gravity, and time measurement based on data from the National Aeronautics and Space Administration (NASA). The game lets players build and customise their own spacecraft and spacesuits, crafted from resources and materials mined by exploring the planets varying from vast rocky deserts to planets populated by humans and extraterrestrials (Bethesda, 2023). Even though the game is a science fiction

entertainment game, it offers insights into engineering, physics, biology, and space exploration, and raises philosophical questions along the way.

Figure 5 - Starfield

2.4 A new generation of learners

The American educator, game designer, and author, Marc Prensky, describes today's students as a new kind of generation unprecedented to previous generational shifts. Prensky calls this new generation *digital natives*, who are a result of *"the arrival and rapid dissemination of digital technology in the last decades of the twentieth century"* and having "*(…) spent their entire lives surrounded by and using computers, video games, digital music players, video cams, cell phones, and all the other toys and tools of the digital age"* (Prensky, 2001, p.1). The result of this ubiquitous digital environment and its immense volume of human interaction makes digital natives process information and thereby thinking patterns fundamentally different from previous generations, as different kinds of experiences lead to different kinds of brain structures. The term, digital natives, refers to the students of today who are native speakers of the digital language of computers, video games, and the internet. The rest, Prensky refers to as *digital immigrants* who adapt to their environment yet always retain their "accent", being their foot in their past (Prensky, 2001, p.1-2). Prensky states that digital immigrants think that learning cannot be, nor should be, fun and that they cannot know since they spend their

formative years learning in a completely different manner and thereby are fundamentally different. Pensky calls out digital immigrant educators, saying they must change and invent new educational methods that mesh with the capabilities of the generation of digital natives. Prensky uses his own preference as an example of such, which is inventing computer games for the most serious content and involving students for guidance (Prensky, 2001, p.5). Prensky cites different neurological studies that support the belief that the kind of input the brain gets throughout life physically alters the human brain, which contradicts the long-lasting belief in the academic field of neuroscience that the brain does not undergo much change after the age of three, which turned out to be incorrect. Prensky also cites research from social psychology which throughout many years took it for granted that all human thought originates from the same basic processes. This appeared to be wrong as well, as different research evidently has shown that the environment and culture of people fundamentally determine many of their thought processes (Prensky, 2001, chap. 2, p. 5-7). In 1984, the American psychologist Patricia Greenfield conducted an early study on the effects of video games and wrote the book, 'Mind and Media: The Effects of Television, Video Games, and Computers'. Greenfield found that video games can enhance cognitive skills, such as critical thinking, problem-solving, hand-eye coordination, reaction times, and spatial reasoning abilities. Greenfield also addresses the negative effects of video games, namely that violent video games can increase aggression, and that excessive use of video games may lead to a lack of physical activity, a sedentary lifestyle, and addictive symptoms in one's time-managing (Greenfield, 1984) (Subrahmanyam & Greenfield, 1994) (Ferguson, 2007).

According to (Jukes et al., 2010), the authors of the book; Understanding the Digital Generation: Teaching and Learning in the New Digital Landscape, teachers commonly thought they understood kids because they were once kids too and had gone through many of the same things. This is no longer the case, as the experiences available to kids in this digital world are so radically different than it was for previous generations, even though they too had televisions and radios (Jukes et al., 2010, p. 9-10). The authors argue that this gap in understanding causes students to tune out because *"the adults in control of the systems are making decisions based on an outdated idea of what growing up is like"* (Jukes et al., 2010, p. 10). This is an everyday growing crisis for the modern world as the digital natives are changing, growing, adapting, and innovating exponentially. However, it is just as important for educators to focus on digital immigrants as digital natives since they are unfamiliar with the new and complex digital world. The lack of digital literacy leads to frustration and anxiety when e.g., learning a new software, which could be eased by using the informal educational medium of serious games. Jukes et al., argue that similarly to not being able to live or work in another country without learning its language, customs, and culture, educators may not be able to speak the digital language, customs, and culture of their students, which results in a digital disconnect between them (Jukes et al., 2010 p. 16). Contrary to the stigma Generation Z is often

imposed, they too possess skills worth acknowledging and adopting, such as their ability to problem solve. When people from previous generations problem solve, they are most likely to read manuals, talk face-to-face, read a book, consult an expert, or use digital tools with limited success. When people from the new generation problem solve, they are more likely to use and experiment with digital tools or search for help online. The big difference however exists in their attitude towards failure. The new generation perceives failure as useful and as an indicator of their learning curve, whereas older generations operate under the assumption that all failure is bad (Jukes et al., 2010, p. 16). To be able to shape a brighter tomorrow, the authors request an understanding of the new generation instead of trying to "fix" them. They also request an understanding of the older generation as they need to be the ones "*to use and build the skills they bring to the classroom"* (Jukes et al., 2010, p. 16). Additionally, the older generation who were taught to value tradition might believe the skills of the digital generation are not as good as their own, since they do not appear to value the same literacies. The point is, that the world has changed drastically, and it will probably continue to do so, therefore, adaptation is a necessity.

2.5 Serious games

The term serious game was first coined by the American researcher Clark C. Abt in 1970 in his book "Serious Games" where he defines serious games as having *"an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that serious games are not, or should not be, entertaining"* (Abt, 1970, p.9). Although Abt was only concerned about board- and card games, the term has been used in a vast variety of fields ever since, such as corporate games for training and simulation purposes such as flight simulators and educational games concerning health, cultural heritage, architecture and planning, and social and environmental awareness to name a few (Dörner et al. 2016, p.9).

The ongoing emergence of serious games is a field consisting of learning theories and instructional design principles to increase the success of learning. This thesis will only concern serious games as Dörner et al. (2016) define them in the textbook "Serious Games", namely as *"(...) a digital game created with the intention to entertain and to achieve at least one additional goal (e.g., learning or health)".* As the quote states, serious games are a combination of entertaining gameplay characteristics and applied theoretical elements to enhance the learning outcome through a digital platform (Goni et al. 2017). The first digital versions of a serious game were in the 80s where e.g., exercise games for the Atari 2600 and the Nintendo NES. However, the number of serious games were few up until the beginning of the 21st century, when Ben Sawyer and David Rejeski

popularised the term with their 2002 article "Serious Games: Improving Public Policy through Game-based Learning and Simulation", in which the authors called to use technology and knowledge from the entertainment video game industry for more educational means. Within the same year, Sawyer and Rejeski founded the Serious Games Initiative, whose purpose was to help organise and accelerate the adoption of computer games for non-entertainment purposes (Djaouti et al., 2011)(Smith, 2013). 2002 was also the year of the release of the serious game 'America's Army', which made the year 2002 the starting point of the current wave of Serious Games.

An example of a learning game is *Enercities*, by Paladin Studios in which the player is set to build a sustainable city balancing people, planet, and profit (Paladinstudios, 2021). Enercities is developed for the players to have fun while playing from the comfort of their homes, whereas a game such as *Newt & Byte - Climate Adventures*, by Serious Games Interactive, is developed, and tested for schools only, making it a pure educational game. Serious Games Interactive has also developed a game called Ways2Sort, which targets children's understanding of waste sorting, and includes a web editor allowing municipalities to manage the sorting data used in the game (Serious Games, 2023). This positions Ways2Sort in the grey zone between being a learning game and an educational game, depending on the context of use. In the entertainment-based video game industry, simulation games are among the most popular categories with games such as Cities: Skylines 2 and Terra Nil. Cities: Skylines 2 is about *"planning, constructing, and developing a city"*, including management of everything from the education system, housing, infrastructure, and electricity- and water supply, see figure 6 (Paradoxinteractive.com, 2023). Terra Nil is a "(…) *environmental strategy game concerning transforming a wasteland into a thriving, balanced ecosystem"* by (…) "*purifying soil, cleaning oceans, planting trees, and reintroducing wildlife"* (Steam, 2023). Even though Cities: Skyline 2 and Terra Nil are entertainment games, they are still crammed with insight and knowledge which is presented in a welcoming and exploratory way, which are important elements of engaging players in taking on challenges. However, if such simulation games were categorised as being a serious game, the game

Figure 6 - Water and sewage status, Cities: Skylines 2

companies would probably not sell as many copies, according to Dörner et al., who states that some players get demotivated by the oxymoronic nature of the term *serious game* itself which might trigger the same reaction in the player as chocolate-coated spinach (Dörner et al. 2016, p.5). It is therefore important for the facilitators of serious game and game designers to not only integrate gamification elements in the learning medium but also to perceive and design it as such from its very inception throughout its maturation and iteration processes of advanced prototypes. Furthermore, one's attitude toward all kinds of video games might also be compromised through social commentators regarding video games acting as a breeding ground for anti-socialism, violent behavior, or simply just a waste of time (Giumetti & Markey, 2007) (McGloin et al., 2016) (Baek, 2008).

Throughout the field of research on serious games, there is a knowledge gap in empirical studies investigating the effectiveness of serious games (Annetta et al., 2009)(Wrzesien & Raya, 2010)(Heiney et al., 2011) (Girard et al., 2013). As emphasised by Obikwelu & Read, recent studies of serious games have adopted constructivism in their learning environments. Constructivism, which will be further elaborated on in the analysis, is a learning theory whose basic tenets are individual representation of knowledge, active learning through exploration, artifacts as a pedagogic approach, and social interaction and collaboration. An overwhelming acceptance of constructivism in serious games has occurred, but due to the broad nature of constructivism, the conclusions are rather ambiguous (Obikwelu & Read, 2012). However, in my research on constructivism and serious games, I found that technological artifacts most often were some kind of ICT learning environment, like a computer or a whiteboard (Seraji & Musavi, 2023) (Girard et al., 2013) (Polin, 2017) (Kafai & Burke, 2015). Therefore, this thesis will investigate another kind of technological artifact - playing cards, more specifically PluriCards. Moreover, how PluriCards facilitates and mediates different ways of learning, which encompasses different learning theories and therefore will be elucidated throughout the analysis. Moreover, since most research on the topic of serious games revolves around children, the case study of PluriCards, which targets adults in HEIs, reinforces its relevance in the academic literature.

2.6 Introduction to PluriCards

PluriCards is a serious card game developed by the 'Centre for Sustainability and Digital Transformation' (TECH4SDT, 2023) at Aalborg University, Denmark, which purpose is to facilitate and articulate different sustainability concepts among teachers and students in an interdisciplinary environment within the TECH faculty (Aalborg University, 2023). The title of the game derives from the theoretical framework behind the game, which is based on interviews and the book 'Pluriverse: A Post-Development Dictionary' by (Kothari et al.,

2019). The book explores alternative visions and practises of development beyond conventional economic models and seeks to reimagine development as pluralistic and acknowledge the complexity and diversity of human experiences and values.)

The game was first and foremost developed as a physical card game, but due to the organisational changes of more and more digital tools used in the education system, especially after COVID-19, the developers also created a digital version of the game. This thesis will only concern the physical card game and how the PluriCards, game rules, and game mechanics perform in terms of its learning objective, which is to envision various sustainable futures through collaborative ideation.

2.6.1 Game rules and game mechanics

Game rules and *game mechanics* are two key concepts in game design. Game mechanics refers to the ways to interact with a game under the game rules and the specific situation, which govern and guide the player's actions, e.g., jumping over obstacles in a game. Game rules are *"regulations and settings constraining the game. They typically take the form of if-then relation"* (Dörner et al. 2016, p.12). Examples of this is e.g., if you hit two matching dice, you may hit again.

In a complete set of PluriCards there exist 78 cards in total, encompassing 48 PluriCards and 30 Resource Cards in the colors yellow, green, and blue. Blue cards are economic cards, green cards are environmental cards, and yellow cards are social cards.
There are three different game modes for PluriCards: the first game mode is an informal conversation starter, the second is a 2-player game mode with game rules, and the third is a three-player mode where the players persuade a facilitator with good arguments (TECH4SDT, 2023).

Figure 7 - Social card

In the first game mode, the conversation starter, each player takes turns drawing a random PluriCard, reading its content, and conversing around it. The players share their thoughts regarding the content of the card in relation to their vision of a sustainable future, but also how their professional expertise can contribute to achieving the philosophy of the card. This could for example be an urban architect drawing the card 'Space For Living' and sharing how his/her expertise can be used to create a more healthy or exciting environment inside a city park. This game mode is suitable for the beginning of a playing session as it opens up dialogue between the players and gets them introduced to the concepts in a risk-free manner.

The second mode is a two-player competitive mode that includes specific game rules. The players can now play multiple PluriCards at once to earn the most points. Each card has a cost, which is 0, 1, or 2, indicated in the top left corner. The cost of each card indicates its difficulty and determines how many resource cards you must use to play them and how many points are given. The resource cost of each card is equivalent to its cost, and the points awarded for each card are equivalent to its cost plus one. For example, if a one-cost card gets played in combination with a two-cost card, the play uses all three available resource cards that round but can potentially generate 5 points. To earn the 5 points, the player must argue how the concepts of the two cards in combination can contribute to a sustainable future. The 'Spaces For Living' card would for example go hand-in-hand with a card like 'Buen Vivir', which translates to life in harmony. The argument of the urban architect could therefore now be that the design of the city park could entail a focus on biodiversity by not only designing healthy living spaces for people but for animals as well. This game mode is about gathering as many points as possible before three rounds have passed by using argumentation skills to make the opposing players accept the play. If they do not accept the proposed argument the player does not receive any points. Figure 9 is an example of how the game can be set up.

Figure 8 - Environmental card

Figure 9 - Example of setup (TECH4SDT)

In the third mode, which is a 3-player mode, players present and argue for their envisioned future to a facilitator who awards points based on self-determined criteria. Therefore, it is important to know what is important to the facilitator and create persuasive arguments to receive points. After the cards have been presented to the facilitator, the round ends and each player draws cards until they have two of each PluriCard color. In this game mode, the PluriCards can be played freely, as the Resource Cards are not used. The 3-player game mode encourages the players to think beyond their own perspectives, fostering reflectiveness and deep engagement (TECH4SDT, 2023).

3.0 Problem formulation

How does the serious game 'PluriCards' perform as a technical artifact for mediating learning objectives?

4.0 Methodology

The purpose of the methodology chapter is transparency regarding how the research of this thesis has been conducted to answer both my initial problem formulation and my final problem formulation. Furthermore, the purpose is also to secure full transparency in favor of future researchers' interest in interdisciplinary studies of this nature.

4.1 Literature search

To answer my initial problem formulation, I first conducted a structured literature search consisting of keywords apparent at the beginning of the process of writing this thesis. Even though the process was iterative since I was acquiring new insights and knowledge along the way, this is what my initial literature search string consisted of:

	Emper* OR Evaluation* OR Assessment*
AND	"Usability test*" OR "User test*"
AND	"Serious game*"
AND	Sustainab*

(Figure 10)

I first used Elsevier's abstract and citation database Scopus, which primarily contains natural- and social sciences, which gave me 14 hits, but due to the interdisciplinary nature of this project, I had to play around with the keywords in different scientific databases, such as ACM (Association for Computing Machinery), which only gave me one result from the initial search string. Therefore, I had to refocus my literature search by using keywords such as "serious game*", and "usability test" and exclude keywords such as sustainability to achieve a more favorable result on the technical aspects of the project.

While reading literature, new perspectives and terminologies within the field appeared to me, which led to an iterative research structure of exploring information, evaluating the information, and either keeping or discarding that information based on its relevance. I found the iterative search structure to fit the project in its exploratory phase to get as good a grasp of the current research field of serious games and learning as possible.

The process of literature delimitation consisted of tracing the documents, by conducting the literature search, then filtering those documents by title, abstract, and full-text reading, and lastly evaluating the remaining documents in relation to the scope of this study.

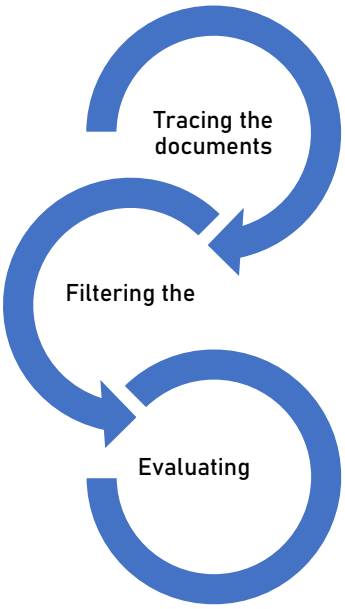

Figure 11 - Literature search process

4.2 Disclaimer

PluriCards is developed by my associated university, Aalborg University, by the research group 'Centre for Sustainable and Digital Transformation', which is led by one of my former professors and current supervisor, Maurizio Teli. My evaluation of PluriCards is solely my analysis of an accessible study of interest. I have not been taking part in the development of PluriCards, but I have participated in a few meetings to understand the game and have also been granted access to documents regarding the design of the game cards, rules of the game, transcripts of interviews, and facilitation plans and evaluations.

4.3 Philosophy of science

The philosophical stance of this thesis is based on the interdisciplinary field of STS which studies the relationship between science, technology, and society. STS has its roots in the late 1970's by a defining study on the daily activities of laboratory scientists called Laboratory Life was published by the French philosopher and anthropologist Bruno Latour and the British sociologist Steve Woolgar. Laboratory Life acts as a critique of scientific practises by emphasising the entanglement between human and non-human actors in the production of scientific knowledge and arguing that laboratory equipment is a result of complex social processes (Latour, 2013). The entangled relationship between humans and technology is also a central theme in the philosophy of post-phenomenology. Post-phenomenology challenges the radical split between humans and technology in the study of objectivity imposed by the notions of phenomenology. Phenomenology originated in the work of the German philosopher, Edmund Husserl, in his book "*Ideas*" from 1913. In the book, Husserl focuses on the subjective elements of consciousness to study phenomena, essence, and appearance, to understand the underlying structures and meanings that shape our experiences. Phenomenology suspends preconceived judgements and assumptions and challenges traditional notions of objectivity by highlighting the importance of personal perspective (Husserl, 2002). Martin Heidegger, Jean-Paul Sartre, and Maurice Merleau-Ponty, are a few of the contributors to

phenomenology, introducing aspects of existence, reality, freedom, responsibility, and the relation between the body and mind (Heidegger, 1927; Sartre, 1943; Merleau-Ponty, 1945). Don Ihde, the "father" of post-phenomenology builds upon phenomenology by acknowledging the role of technology in the shaping of our experiences and understandings. In post-phenomenology, empirical data is used to understand how technology mediates the human-world relationship (Ihde, 1990) (Ihde, 2009, chap. 1). STS and post-phenomenology have provided me with a valuable lens to look through when examining the relationship between humans and serious games since it can explore how the design of serious games influences players' experiences, decision-making, and learning outcomes.

4.3 Qualitative data collection

Informant of the TECH4SDT used in this thesis:

Informant 1 – Environmental scientist working with the Department of Planning researching industrial ecology

Informants from my workshop and interviews:

Informant 2 – Camilla – Tender consultant

Informant 3 – Helene – Biomedical laboratory scientist

Informant 4 – Marie – Architecture & Design, Aalborg University

The purpose of the interview conducted by the TECH4SDT was to map the state-of-the-art and potentially see different ways in which sustainability and digital transformations can be framed and approached. The interview conducted by the TECH4SDT had been transcribed before being handed to me, which naturally saved me some time, but also provided me with a limited understanding of the informants and their perspectives, since I could not read their facial expressions or hear the tone in their speech, etc. The interview of the TECH4SDT is in the appendix.

4.4 Workshop and interviews

The analysis and evaluation of PluriCards is based on my theoretical choice of using learning psychology as a central measure of the effectiveness of the game. I tested the effectiveness of the game by playing it myself and hosted a workshop to test the game with my girlfriend and a couple of friends to get an idea of the beginner-friendliness of the game.

To gather qualitative empirical data about PluriCards, I hosted a workshop for three people, my girlfriend, and two of our friends. The reason for choosing informants from my personal life was to get an impression of how effective PluriCards would be if the participants of the game had little to no experience with sustainability. At the time of the workshop, I did not have the PluriCards in physical form, so we played the game using two laptops so each player could have three cards in front of them. This made the participants turn the screens of the laptops to be able to show the cards when talking about them and click on the laptop when drawing or using cards. Besides the physical implications the physical cards version would cause, the game was played in accordance with the developers' ruleset of the game (TECH4SDT). During the workshop, all three game modes were played with me as facilitator, so I could observe and take notes. However, due to difficulties in understanding how the cards were meant to be played, my role as a facilitator and observer shifted back and forth between that and being an active participant. This gave me the opportunity to both make sure that the game progressed by stepping in if nothing happened and observing by stepping out and taking notes. The participant observation is about being present with focused attention where the body of the anthropologist is used as an active tool to observe (Mogensen & Dalsgaard, 2018, chap. 10). However, participant observation is oxymoronic, since it is not possible to fully do both things simultaneously. Therefore, it is important to find the appropriate balance between the two depending on the situation. To do that, I did my best to stay out of the game as much as possible but interfere when they needed help or inspiration (O'Reilly, 2009, chap. 26-27). The notes taken during the workshop were taken by pen and paper due to its advantage compared to computers when *jottings* are the optimal type of notes. Jotting is writing down keywords used to describe a situation briefly to be able to remember it later when there is time to expand it (Mogensen & Dalsgaard, 2018, chap. 3). As patterns of behavior emerged during the workshop, meta-notes were also used, which were analytical reflections on the connections between theory and practise.

Figure 12 - Workshop

After the workshop, a focus group interview was conducted with all the participants. The focus group interview was unstructured and informal, due to it taking place right after the workshop. During the focus group interview, I asked questions based on the initial

purpose of the workshop, but also questions based on what I experienced during the workshop. For example, *"what was your thoughts on the game?"* and *"which cards helped you the most in the game, and why?"*. The total time of the workshop was three and a half hours including breaks with food and drinks. A few days after the workshop, I held a follow-up interview with one of the participants, informant 6, based on analytical reflections regarding my theoretical scope and her experience.

4.5 Coding through thematic analysis

The qualitative data collected were then coded using the thematic analysis by Braun and Clarke, which *"(…) is a method for identifying, analysing and reporting patterns (themes) within data"* (Braun & Clarke, 2006, p. 79). There are many ways of approaching thematic analysis (e.g., Boyatzis, 1998; Alhojailan, 2012), but the reason for choosing Braun and Clarke's thematic analysis is that it is very flexible due to it being a method rather than a methodology, is that it is not epistemological or theoretical constrained. The thematic analysis is a great way of effectively identifying and interpreting patterns in qualitative data, even though my generated qualitative empirical data was limited. I followed Braun and Clarke's guide when conducting the thematic analysis which consist of five steps: 1: Familiarise yourself with the data through re-reading the data, transcriping the data, and taking notes along the way with initial ideas. 2: Generating initial codes by reviewing the data systematically. Initial codes are the precursors of themes. 3: Searching for themes by reviewing the codes and looking for patterns and overlaps. 4: Reviewing the themes in relation to their codes – do they make sense? 5: Define and naming the themes, and 6: producing the report and relating the themes back to the research question and literature.

Two overall themes were dominantly occurring within my empirical data generation – experiences and improvement proposals, and the subthemes will be presented throughout the analysis and evaluation of PluriCards. The result of the themes and subthemes are somewhat influenced by myself, as I had informed the participants about my project, the purpose of the workshop, and interviews and was present and partly active during the workshop. The result of the qualitative data collection is too small of a sample size to be generalising of any kind. The data represent a small case study that probably would not have turned out exactly the way it did if other informants or a greater number of informants were used.

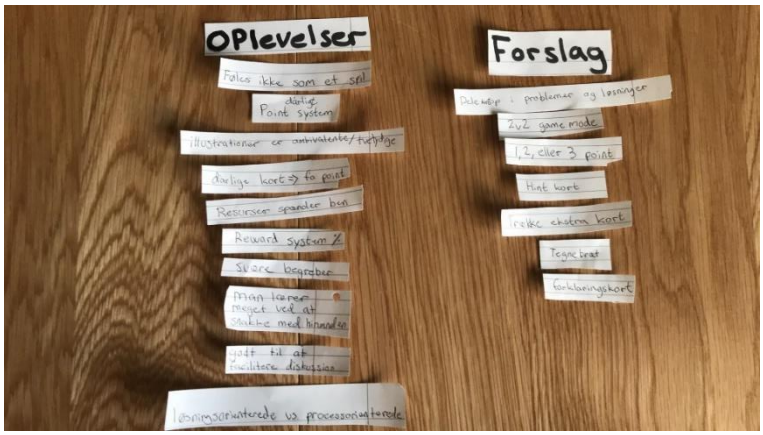

Figure 13 – Themes and subthemes

5.0 Analysis

The analysis will consist of introducing learning theories from psychology and examples of how they are presented in games. Thereafter, those same theories will be applied to the case of PluriCards.

5.1 Behaviorism

In 1913, John B. Watson published the article "Psychology as the Behaviorist Views It", in which he first coined the concept of behaviorism (Watson, 1913, p. 1), which continues to be influential in research e.g., regarding educational media such as serious games (Egenfeldt-Nielsen, 2006). The following characteristics are essentials of behaviorism: Learning is manifested in a change of behavior caused by external stimuli in the environment, not by the individual, and success is a question of contiguity and reinforcement. Contiguity refers to how close in time two events must be to create a bond, and reinforcement refers to increasing the likelihood that an event will be repeated (Merriam et al., 1999, p. 278). The idea of stimulus-response was applied to learning through the work of the American psychologist Edward L. Thorndike, whose monograph 'Animal intelligence' published in 1898, explains the mental processes of different animals through observations and analysis (Thorndike, 1898). In practise, Thorndike placed a cat in a box, and outside of the box was a scrap of fish. The cat learned to pull a lever to be able to escape the box and eat the fish. The time it took the cat to pull the lever decreased as the cat learned to associate the lever with fish (Thorndike, 1898). This was the birth of the concept *law of effect*, which states that *"behavior that is followed by pleasant consequences is likely to be repeated*" (Slussareff et al., 2016). We seek responses with positive effects, strengthening the relationship between a stimulus and the response. Thorndike added an element to his theory called the law of exercise, which states that frequent connections strengthen that connection, which he later discovered was not necessarily true if the response leads to an unsatisfying effect or punishment, but also that the connection does not necessarily get weakened every time the subject gets punished either. Furthermore, Thorndike added another element to his theory called *readiness to learn*, which states that if the subject is not interested or ready to learn, it will not connect stimulus and response as strongly as if the subject is eager and excited (Thorndike, 1898) (Merriam et al., 2007). These three laws, which are commonly referred to as *S-R theory* (stimulus-response theory), have set the foundation of most of the developed theories within behaviorism. The link between Thorndike and educational video games is interpreted by scientists such as Simon Egenfeldt-Nielsen, who founded the previously mentioned Serious Games Interactive, who links the two based on what Thorndike writes in his work: *"If, by miracle of mechanical ingenuity, a book could be so arranged that only to him who had done what was directed on page one would page two*

become visible and so on, much that now requires personal instruction could be managed by print" (Egenfeldt-Nielsen, 2006, p. 191). He argues that the quote attests to the link between behaviorism and educational games, as it is possible in contemporary video games or educational software to change the feedback of rewards, which he calls "*the manifestation of Thorndike's dream"*. Moreover, the behavioristic approach is not fixed within a specific genre of games, but rather as a sharing point for certain assumptions about learning, motivation, and game design (Egenfeldt-Nielsen, 2006, p. 191). The laws of Thorndike inspired other psychologists such as Burrhus Frederic Skinner, who believed that learning can be strengthened through positive reinforcement, which means to *"reinforce what you want the individual to do again"* and *"(…) ignore what you want the individual to stop doing"*. Behaviorism is commonly used in serious games by rewarding the player for every right answer or move the player makes. However, this reward system is identified as also having a *weak response rate* and *fast extinction rate*, meaning that the player would lose interest and become disengaged if the predictability of causality is too high (Skinner, 2015, chap. 2) (Slussareff et al., 2016). Nevertheless, *variable ratio reinforcement*, which refers to the reinforcement of behavior after a random number of occurrences, has a *strong response rate* and *slow extinction rate*. This is due to the excitement the unpredictable reward provokes, which can possess the same addictive nature as, for example when the player opens a "chest" or "loot box", which is a reward system adopted by many games, which contains random rewards such as various items, weapons, or "skins" gambling (see figure 14) (Hodge et al., 2022) (Zendle & Cairns, 2018). This approach of game design is not a behavioristic learning approach, but an approach of behavioristic engagement, which is a repetitive criticism of behavioristic learning, as it ignores the thought processes occurring in the mind and solely focuses on the repetitive behavioral patterns of the human biological machine (Slussareff et al., 2016) (Ang et al., 2008). The implementation of behaviouristic concepts in games also contributes to making players "*grind"*, which is a term referring to the process of spending time (most often a lot of time) doing mundane and repetitive activities to 'level up' or receive some kind of reward (Ryall, p. 432). However, behaviorism has beneficial implications for instructional designs where mastering a set of predictable and reliable behaviors is desired, such as training and simulation games, e.g., a flight simulator for upcoming pilots, where there are specific goals to be met (McLeod, 2003). However, if something out of the ordinary happens, the subject might stop

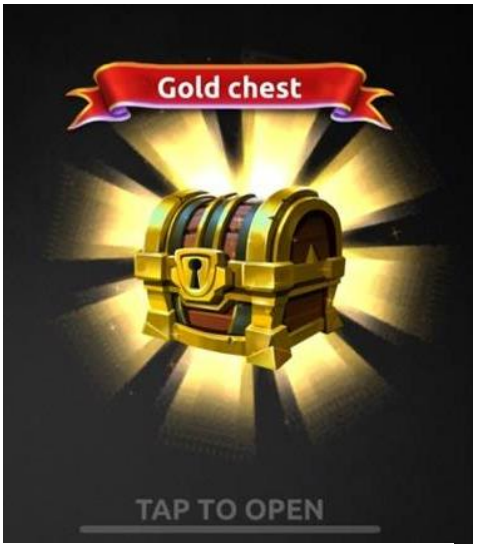

Figure 14 - Example of a loot box

performing, which Skinner identified as a burden of the maintenance of reinforcement imposed by the instructor (McLeod, 2003) (Merriam et al., 2007, p. 279).

5.2 Constructivism

The second learning theory, constructivism, is a theory developed primarily by the respectively Swiss and Russian psychologists, Jean Piaget and Lev Vygotsky. Their work is based on the work of the American philosopher and psychologist John Dewey, who is most known for his pragmatic hands-on approach and his slogan "*learning by doing*" (Slussareff et al., 2016, p. 193) (Dewey, 1916, p. 217). Constructivism is an umbrella term consisting of three different positions, namely *social constructivism*, *cognitive constructivism*, and *constructionism*. *Social constructivism* - the notion of Vygotsky, which refers to the social construction of knowledge. Lev Vygotsky postulates that individuals are active participants in creating their own knowledge which is a process of constructing meaning through cultural and social interactions and processes (Merriam et al., 2007, p. 291) (Davis et al., 2017, p. 60). *Cognitive constructivism* - the notion of Piaget, which refers to the internal construction of mental structures known as *schema*, where learning refers to the increasing number and complexity (Slussareff et al., 2016, p. 192). *Constructionism* - the notion of Seymour Papert, who was an American mathematician, computer scientist, educator, and a former student of Piaget. Constructionism refers to artifacts as a pedagogic approach, which is a modern extension of constructivism since it customarily concerns computers. The main difference between social constructivism and constructionism is that the first focuses on the individuals' learning as a result of social interactions, and the latter focuses on artifacts that are created through social interactions and processes in which learning takes place (Papert, 1980) (Kafai & Burke, 2015).

Due to the three areas often being conflated with no universal boundaries or definitions for their paradigms, I have adapted Dimock and Boethel's overview of constructivist learning theory from their article 'Constructing Knowledge with Technology', to keep it unambiguously. Dimock and Boethel outlined the following six major concepts of constructivist learning theory:

1. Learning is an adaptive activity that involves synthesising new experiences into what we have previously come to understand. The activity is not one of acquiring a fixed body of knowledge, but one of building concepts and explanations that allow us to function effectively in a specific context if the concepts prove to be adequate to the individual.
2. Learning is situated in the context in which they were created and is never independent from that context. Memorising definitions and formulas can reduce students' capacity to learn and apply that knowledge since the context of learning becomes passing a bar or getting by in a classroom.

3. Knowledge is produced by the learner, who is not a passive recipient of information, but rather a local, situated path in which the knowledge is navigated and constructed.
4. The role of experience and prior understandings. The process of developing new understandings is based on our past experiences and knowledge. When we encounter new experiences, we internally evaluate, compare, and filter them through our previous experiences and understandings. When our current understanding is contradicted, learning opportunities emerge.
5. Resistance to change. Individuals will seek explanations that do not require a shift in well-established understandings when discrepancies to their consisting understanding arise. There must be a good reason for the individual to make a shift in thinking because the old understanding must be discarded.
6. The role of social interaction. Where cognitive constructivism emphasises the individual problem-solving and construction of ideas, social constructivism posits that social interaction is essential in cognitive development. However, cognitive constructivists agree that social interaction is an important element since thinking is always dialogic which helps the learner to test and refine ideas and negotiate limits on idiosyncratic conceptions. This leaves the role of social interaction dependent on different scenarios – social interaction such as dialogue can both open the mind to new perspectives and help emerging ones, but it can also interrupt and deconstruct incipient understandings.

(Adapted from Dimock & Boethel, 1999, p. 2-7)

Considering the exclusion of the role of technology in these major concepts of constructivism by Dimmock and Boethel, I will introduce Seymour Papert, who contributed to the field of constructivism and the role of technology and software in education theory, which indubitably is a vital component of constructivism regarding this thesis. In his book; 'Mindstorms: Children, Computers, and Powerful Ideas', from 1980, Papert discusses his work on the programming language 'Logo' and his approach to learning in conjunction with computers serving as instruments of explanations and change (Papert, 1980, p. 208-209). Papert argues that the simplicity and interactivity of software such as Logo make it an ideal tool for children to learn and express their ideas through constructing technology such as microworlds, which are programmable models of real-world environments. According to Papert, microworlds allow children to become actively engaged in their own learning, due to the opportunity to build a world based upon their own mental models and understandings of different concepts, such as the Newtonian laws of motion (Papert, 1980, p. 122).

Papert addresses the following design criteria to overcome roadblocks in achieving more favorable outcomes in the microworld: Children should start out by learning about more simple laws of motion, the concepts available should be within most people's experience

of the world, and the microworld should possess the possibility of activities such as games (Papert, 1980, p. 126). The focus in microworlds is on the construction process and making the player engage with the material in the game through open access and participation, which break up the boundaries between players and designers (Kafai & Burke, 2015). Beyond learning about the content and coding of the micro-world, the process of creating a game also enhances metacognition, or reflection, as the creators are learning about learning (Kafai & Burke, 2015). The work of Papert and Kafai, who are the primary contributors to the area, is focused on educating children. However, other studies on how adult students can learn by designing engaging learning games, have been conducted. The findings suggest that the current learning design comes partway toward facilitating learning and making the experience engaging, and in order to deepen the learning experience, the adult students would benefit from a teacher-initiated discussion. The discussion would concern *"(…) concepts of learning goals, learning processes, learning activities, and evaluation processes, in order to better qualify the students to become the designers of their own learning experiences"* (Weitze, 2014). For these ideas to become reality, Papert believes that *"(…) we need to advance the art of meshing computers with cultures so that they can serve to unite, hopefully without homogenizing, the fragmented subcultures that coexist counterproductively in contemporary society. For example, the gulf must be bridged between the technical-scientific and humanistic cultures"* (Papert, 1980, p. 183). Examples of contemporary microworlds are game titles such as 'Minecraft' (Egenfeldt-Nielsen, 2016) and the previously mentioned 'Cities: Skyline 2', which arguably encompasses both the technicality and humanistic cultures that Paper requested in 1980.

But how do *social constructivism*, *cognitive constructivism*, and *constructionism* couple with serious games? Cognitive constructivism postulates that for teaching to be effective *"(…) we must understand the mental models that students use to perceive the world and the assumptions they make to support those models"* (Ang et al., 2008). In cognitive constructivism, each player constructs their own understanding of the game rules by using their own set of logic, which makes the gameplay and its outcome rely on how the player chooses to play the game.

In social constructivism language and communication become the focus of learning due to the perception of a collective construction of knowledge through social processes which is mediated through cultural artifacts such as pedestrian road signs, or the home/menu symbol used on remote controllers (Ang et al., 2008). These cultural artifacts are adopted into the design of games as an instructional tool for guiding the player through the structure of the game. In games, players are interacting with either other players or the game environment. In the case where players are teaming up the more advanced player can help the less experienced player understand the rules in order to achieve a shared goal. The collaboration and interaction between players have the

potential to create new rules which over time are agreed upon by all players (Ang et al., 2008).

The constructionist perspectives of Papert and Kafai have focused their efforts on providing students with tools that enable them to construct their own games and, in that process, construct new knowledge and develop new ways of thinking based on those tools, rather than embedding knowledge directly into games (Kafai, 2006). These perspectives are present in games with opportunities for modification and personalisation. An example of elements of this concept can be found in games like The Sims, where the players are able to create an entire family with different personality traits in e.g., emotional, social, and lifestyle. When playing with the characters it can be experienced how the social dynamics of the simulated family play out and result in different outcomes and futures. Another example is a game called Gary's Mod which is a physics simulator game where the player can experiment with different physics and objects. The key takeaway in both instances is that the players have agency in how the game is played out. Implementing technology into a learning environment provides new tools for both the student and the teacher that can facilitate new roles and new instructional strategies. Dimmock and Boethel argue that *"ordinary application software such as word-processing, spreadsheet, graphics, presentation, and database software; problem-solving software; simulations; electronic mail; and the Internet are technology tools"* also fit into this category as they all both construct and represent knowledge (Dimmock & Boethel, 1999). The premise of technology in constructivism is that students learn *with*, not *from* or *about*, technology.

5.3 Experientialism

The experiential learning theory, touches on the relationship between experience and learning, most famously through the American Philosopher, John Dewey, who proposed that the process of learning is *"learning by trying to do something, making mistakes, and then figuring out how to fix them"* (Shaffer & Gee, 2006), or more commonly articulated, *learning by doing*. This approach, however, has not been adopted into mainstream education due to the possible risks associated with providing an environment to the learner, due to it being too difficult to put fully into practice (Monke, 2009). Shaffer & Gee, argue that games are interesting to educators *"(…), because they can be used to create progressive learning environments where young people learn by doing things they are interested in"* (Shaffer & Gee, 2006). Dewey also argued that words *"(…) convey nothing but sensations of their own shape and color – certainly not a very instructive kind of knowledge"*, which detached him from the traditional teacher-classroom dynamic into a more student-centered approach open to other, more instructive, practises (Dewey, 1916, chap. 20, p. 245). The American educational researcher David Merrill identified five principles of instructional design by reviewing various theories. The five principles are that learning is promoted:

"(a) When learners are engaged in solving real-world problems.
(b) When existing knowledge is activated as a foundation for new knowledge.
(c) When new knowledge is demonstrated to the learner.
(d) When new knowledge is applied by the learner.
(e) When new knowledge is integrated into the learner's world"

(Merrill, 2002, p. 43).

Merrill states that for experiential learning to be effective, it must have problem-solving at its core and that incrementally increasing complexity is a must. Problem-based learning is a popular approach in serious games due to opportunities for active inquiry, added contextual meaning to the learning content, and additional levels of engagement (Slussareff et al., 2016, p. 194).

5.4 The concept of flow

The incremental increase in complexity correlates with the concept of flow, which was developed by the Hungarian-American psychologist Mihaly Csikszentmihalyi. In his book *"The Ecology of Adolescent Activity and Experience",* Csikszentmihalyi describes how he through his research found out that out of the 11 most common activities in the daily lives of the adolescents in his study, games/sports were ranked number as the best activity based on certain mood variables (see figure 15). Games/sports had the overall most positive subjective experiences as the subjects perceived themselves as being most

Table 12.5 Mean ratings on selected mood variables, by major activity categories[a]

Activities	Number of observations	Strong-Weak		Active-Passive		Free-Constrained		Excited-Bored		Happy-Sad		Friendly-Hostile		Sociable-Lonely	
		Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Total	542	4.27		4.20		4.22		4.18		4.82		4.75		4.57	
Talk with peers	111	4.34	4	4.32	5.5	4.65	3	4.59	4	5.25	1	5.32	2	5.05	7
Talk with adults	31	4.28	6	4.14	7	4.39	6	4.71	2	5.14	2	5.48	1	4.96	3
Watching TV	80	3.95	11	3.63	10	4.10	8	3.80	9	4.44	10	4.35	10	4.10	10
Games/sports	33	5.48	1	5.58	1	4.94	1	4.78	1	4.85	5	4.39	9	5.09	1
Eating	36	3.97	10	3.57	11	4.31	7	4.09	7	5.06	3	4.89	3	4.79	5
Grooming	39	4.18	7	4.39	3	4.49	5	4.64	3	5.00	4	4.85	4	4.47	6
Walking	34	4.50	2	4.82	2	4.56	4	4.29	5	4.62	9	4.59	7	4.38	7
Work	30	4.41	3	4.34	4	3.93	9	4.00	6	4.28	11	4.28	11	3.70	11
Reading	43	3.98	9	3.70	9	4.71	2	3.70	10	4.53	8	4.62	6	4.17	9
Studying	66	4.16	8	4.11	8	3.62	10	3.97	8	4.78	6	4.47	8	4.30	8
Class	39	4.29	5	4.32	5.5	3.58	11	3.42	11	4.76	7	4.63	5	4.95	4
F values[b]		4.47[c]		5.83[c]		5.54[c]		3.87[c]		2.59[d]		4.35[c]		4.50[c]	

[a] Higher numbers indicate more positive moods
[b] Significance computed by one-way ANOVA, df = 11.531
[c] $p < 0.001$
[d] $p < 0.01$

Figure 15 – Csikszentmihalyi, 1977, p. 289, study results

strong, active, free, and excited. (Csikszentmihalyi, 1977, p. 290). Games/sports, however, made the subjects feel more hostile than friendly, which possibly can be ascribed to the competitive nature of games/sports. Likewise, can the medium score on the happy-sad category be ascribed to the frequent emotional outcome of winners and losers.

Csikszentmihalyi also found that adults scored higher on intrinsic motivation, affect, and challenge when involved in games/sports than when reading (Csikszentmihalyi, 1986, p.174). The emotions and behavioral patterns when playing games are much more desirable features for individuals to possess when engaging in learning. The optimal behavior of individuals when performing activities is, according to Csikszentmihalyi and his studies conducted since 1970, when the individual is in the state of flow, in which the individual operates at full capacity. The research of flow originated from a desire to understand the "*phenomenon of intrinsically motivated, or autotelic activity: activity rewarding in and of itself, (…) quite apart from its end product or any extrinsic good that might result from the activity.*" (Csikszentmihalyi, 2014, p.240). The state of flow is often referred to by people as being *"in the zone"*, an enjoyable state of full immersion where time flies. The state of flow is a dynamic equilibrium between boredom/relaxation and anxiety/vigilance, where the challenges must not exceed the skills of the individual, nor must the skills exceed the challenges, see figure 16. A, C, and E, in figure 17, are enjoyable states of increasing complexity that hold the greatest potential for learning to happen (Csikszentmihalyi, 2014, p.28. p240). It is also crucial that the individual has clear goals and gets immediate feedback about the progress. These are the conditions to be able to enter the state of flow, which can be characterised by the following six subjective experiences:

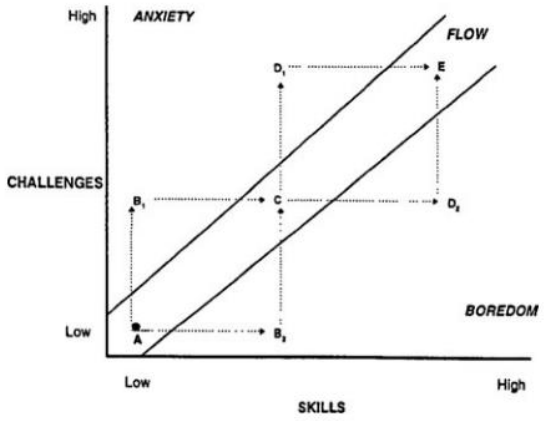

Figure 16 - Corridor of flow

- *"Intense and focused concentration on what one is doing in the present moment*
- *Merging of action and awareness*
- *Loss of reflective self-consciousness*
- *A sense that one can control one's actions*
- *Distortion of temporal experience*
- *Experience of the activity as intrinsically rewarding"*

(Csikszentmihalyi, 2014, p.240)

These characteristics of flow increase the capacity to learn and should therefore be every serious game developer's goal to implement. The balance between anxiety and boredom in games is also known as *game flow* or *dual flow,* which Jeff Sinclair introduces in his 2011 article *"Feedback control for exergames"*, where he argues that the concept of dual flow is a balance of both effectiveness and attractiveness. It is crucial to strive to accomplish this dual goal in serious games and devote attention to both the user interface being visually recognisable and appealing while also balancing the difficulty of the tasks with the users' skills appropriately, which correlates with both behaviorism,

cognitive constructivism, and experientialism (Dörner et al. 2016, p.11-12). A typical way game designers implement this dual goal is through elements that give the player a sense of purpose, such as levels and rewards. Levels have the ability to keep the player in the desirable diagonal corridor of flow (figure 17), where the player enjoys being and learns the best. Rewards have the ability to motivate players to try their best in order to get benefits in the game, such as additional lives, better weapons, etc., or to gain points to compare your overall performance to the opponents or a high-score list.

5.5 Evaluation of PluriCards

The evaluation of PluriCards will cover two aspects:

A. Game experience: The ability of the game to provide an effective game experience through game artifacts, game rules, and game mechanics.

B. Learning objectives: The ability of the game to engage the players in learning about the three facets of sustainability; people, planet, and profit.

During my workshop and interviews, multiple similarities to the workshop and interviews conducted emerged. Firstly, when starting out introducing the players to the game, the players had difficulties understanding how to play and what the purpose of the game was, even though it had already been explained. The participants of my workshop expressed confusion regarding whether they should perceive the cards as problems, solutions, or perspectives for arguing, and therefore had a difficult time figuring out card combinations. In the first round of game mode number 2, the following three cards were drawn; 'commoner's code', 'the native lifestyle', and 'the capitalist conquers'.

Figure 17 - Yellow, green, and blue PluriCards

The participants were confused about how to make a connection between centrality of economics, democratising coding, and mother nature, which is reasonable as they speak in three very different directions. Since it was also the first round of the game, the participants might have been more reluctant in speaking due to uncertainties about the game and self-doubt. However, unplayable combinations of cards occurred multiple times during the workshop, meaning that either the cards are too difficult to understand properly, or that some game mechanic is in need to get implemented. Additionally, the participants who did not have experience with the terms on the cards would need an introduction to many of the terms. As one of the participants of my workshop expressed *"I think the cards are too difficult for someone like me to understand since I don't have any experience with this kind of stuff"* (Informant 5). At the beginning of the workshop, there were difficulties in establishing dialogue due to confusion about the rules and purpose of the game. The participants found the term sustainability ambiguous, as there exist so many facets that it can feel overwhelming. Indeed, sustainability is a very complex topic, which is a shared opinion even among those working in the field, as an informant states in an interview (informant 1, p. 5-6). The informant emphasises the subjectivity of sustainability as a term and its objectivity in the form of the sustainable development goals, which were also a concurring topic during my workshop, as the participants repeatedly would talk about their interpretation of sustainability and look up the different sustainability goals on Google to grasp the different aspects. As one of the participants of my workshop articulated it: *"I don't think I know what sustainability actually means, I mean, I think I have a pretty good idea, but it just feels so flighty"* (Informant 5). However, when the terms and concepts were explained, all the participants engaged in the discussions, and ideas of potential sustainable futures arose. The discussions seemed to be nudged by the illustrations on the PluriCards, which is a double-edged sword because the illustrations are meant to inspire the players and point the player toward a certain direction of thoughts, which they are very effective in doing. But they can also hinder other thoughts from emerging, which was present when playing cards such as 'technological fix'. The card fostered a dialogue consisting of technological deterministic perspectives on planet Earth without zooming in any further. The debate consisted of philosophical and existential discussions on the future of human society, leaving out less developed parts of world. The techno-optimistic mentality of the card is well presented, but the pluralistic intentions of the game might also be hindered due to the illustration of a robot hand holding the destiny of planet Earth in its grasp. Another example of this is the card 'the end justifies the means', which illustrates a windmill in the middle of the

Figure 18 - Green PluriCard

streets. The card makes use of the controversy of building windmills close to residencies, as an example of justifying technological expansion with a utilitarian argument. The PluriCards, as technological artifacts, are effective tools to engage players in a dialogue concerning the sustainability aspect behind each card. However, due to the guiding and inspiring nature of the illustrations of the cards, players might go down some of the same paths, which can be a good thing, if those paths are intended or desirable. If the goal is to create more pluralistic discussion among the players, it is my evaluation that other elements should be added to the game, such as new game mechanics or game rules. A game rule discussed during the workshop was giving out points based on the depth of the answer. For example, if the player explains the concepts of the combination of cards in basic terms – one point is received. If the player can link the combination of cards to his/her profession – one additional point is received. If the player can also link the combination of cards to a real-world problem – one additional point is received. This would incentivise players to put in more effort, as it would create positive reinforcement for going into depth with the concepts. The additional layer of points can also foster more competition between players, which makes the game more challenging and contributes to the game mechanics of the game. As an informant stated *"It doesn't really feel like a game. It just feels like we're talking, and I miss something from the game that recognises and appreciates good moves over bad moves"* (Informant 4). The additional points could result in the point system feeling less random and situations of unjust do not occur, e.g., when drawing cards with few or nonintersecting topics, or when arguing very well, but losing anyway because of randomly drawn low-cost cards. To deal with the latter issue, a participant requested that they draw another card so they could play the game. Since we had already played the game with the original game rules, I thought it would be interesting to see the players discuss alternative game rules. This is social constructivism in practise since the players refined their own understanding and ideas of the game by entering a dialogue with the other players. When the players entered the dialogue, they reflected upon the other players' understanding of the game, compared it to their own, and communicated toward consensus, as one of the informants stated in an interview: *"(…) the game was a bit difficult to understand at first, but then we figured it out as we talked about it"* (Informant 6). One of the things where the players found consensus was concerning the frustration of not being able to play one's cards. The players agreed that if they were not capable of playing any cards, they may draw a "lifeline" card, but it automatically gives them minus one point and is only available once during the three rounds of the game. This exemplifies the players using the concepts of both social constructivism to learn through dialogue

Figure 19 - Blue PluriCard

and constructionism to create rules and technical artifacts such as the "lifeline" card in collaboration. The talk of new rules accumulated into another idea from the players – inspiration cards. Inspiration cards were suggested to be drawable in every round to feed the players with information concerning sustainability. This could for example be in the form of "Did you know", followed by a fact such as *"(…) over 780 million people living under 5.50$ per day face high flood risk"* (McDermott, 2022), or a projection such as *"the global resource use will double by 2060"* (European Environment Agency, 2023). An integration of such would increase the game's emphasis on real-world problems, which is at the core of previously mentioned Miller's instructional design principles and inspire the players with real-world scenarios for the current or incoming game rounds. The remaining four of Miller's principles of learning are all met in PluriCards: The players' existing knowledge is activated as a foundation for new knowledge, as the players are conversing based on their existing knowledge of sustainability and their profession. Players apply new knowledge and integrate it into their own world when reflecting on sustainability concepts in relation to their own profession and demonstrate the new knowledge to the opposing players when arguing. By now it should be clear that PluriCards is supported by the concepts of constructivism and experientialism, but how does it perform according to behaviourism and flow? As mentioned previously, PluriCards lack game mechanics that reward the player, which would make players more engaged. This behaviouristic principle correlates with the theory of flow since one of the ways to achieve the flow state is to get immediate feedback about the progress. However, if the feedback is not appropriate to the progress made, it may skew the perception of success in the game and lead to undesirable outcomes such as playing certain cards together with a silly argument to score the most points. PluriCards should either look to implement more game rules and game mechanics to emphasise the gaming aspect of the game or abandon the elements of gaming and use the cards as in the first game mode - dialogic. Overall, the PluriCards are very effective technological artifacts for establishing a dialogue concerning sustainability, but the game rules of game modes one and two seem to produce more barriers than opportunities for the players in terms of acquiring new perspectives and knowledge.

6.0 Conclusion

The conclusion serves to answer the problem formulation:

How does the serious game 'PluriCards' perform as a technical artifact for mediating learning objectives?

Throughout academic literature and empirical qualitative data, I can conclude that PluriCards, as a technical artifact, successfully mediates the learning objectives of the three aspects of sustainability: people, planet, and profit in game mode number one. The game draw concepts of social constructivism as a main approach for learning during the game. However, the other game modes of PluriCards, where game rules are introduced, are not successful in their performance. The game's ability to engage and motivate players by implementing different game rules appears inadequate throughout the empirical material from the conducted workshop. This is evident in the lack of game rules and flexibility. During the workshop, I found little to no correlation between the point system of the game and the performance of the player. To deal with these issues, I present three possible solutions for PluriCards to feel more like a game, rather than merely a conversation-starting tool.

- Implement *lifeline card*
- Implement *inspiration cards*
- Implement a point system that rewards depending on the depth of the answer

These solutions will make the game easier and more rewarding to play and thereby make PluriCards more fun and engaging and less frustrating and static. The solutions are supported by key concepts of behaviorism, constructivism, experientialism, and the theory of flow, and are generated by players playing the game, meaning that the solutions are developed through social interaction to solve a practical problem.

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